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THE DOLPHIN *KENTRIODON FUCHSII* FROM THE NEW SARMATIAN VERTEBRATE LOCALITY OF FÂNTÂNELE (TRANSYLVANIA, ROMANIA)

CODREA A. Vlad, HORGA Marius, VENCZEL Márton, TRIF Nicolae, VAIDA D. Lucian, BORDEIANU Marian

Abstract. The small sized kentriodontid dolphin *Kentriodon fuchsii*, as well as an isolated indeterminate dolphin vertebra, are here reported from the new Sarmatian *s.s.* (late middle Miocene, latest Bessarabian) locality Fântânele (Bistriţa-Năsăud District). The fossils were unearthed during some archaeological excavations carried out in the place named "La Gâța", in the northeastern area next to Fântânele. There, sands bearing sandstone concretions indicative for the Feleac Formation are cropping out. The isolated status of the bones is suggestive for a dynamic hydrotaphonomy, probably in a litoral environment, with shallow water. This discovery documents the presence of this dolphin on the eastern side of the Transylvanian basin. It completes the list of similar findings from Romania, but also the regional distribution in Paratethys Sea.

Keywords: cetaceans, dolphin, late middle Miocene, Central Paratethys, Romania.

Rezumat. Delfinul *Kentriodon fuchsii* din noua localitate cu vertebrate sarmațiene Fântânele (Transilvania, România). Delfinul kentriodontid de talie mică *Kentriodon fuchsii*, precum și o vertebră a unui delfin indeterminabil sunt semnalate aici din noua localitate sarmațiană s.s. (Miocen mediu tardiv, Bessarabian terminal) Fântânele (Județul Bistrița-Năsăud). Fosilele au fost dezgropate pe parcursul unor săpături arheologice efectuate în locul numit "La Gâța", în aria nord-estică a localității Fântânele. Acolo aflorează nisipuri cu concrețiuni indicative pentru Formațiunea de Feleac. Apariția izolată a oaselor sugerează o hidrotafonomie dinamică, probabil într-un mediu litoral, cu ape puțin adânci. Această descoperire dovedește prezența acestui delfin în partea estică a Bazinului Transilvaniei. Se completează lista cu descoperiri similare din România, dar de asemeni și distribuția în Marea Paratethys.

Cuvinte cheie: cetacee, delfin, Miocen mediu tardiv, Paratethys Central, România.

INTRODUCTION

Geologically, several distinct superposed, incongruent and partly recurrent sedimentary basins developed in time on the actual Transylvanian Depression area (BALINTONI et al., 1998). They are mainly documented by the cores recovered from numerous boreholes drilled for methane gas pools. The beginning of the last of these sedimentary basins is middle Miocene (early Badenian), when marine waters transgressed a very heteroclite basement. In early Sarmatian *s.s.*, mostly in littoral areas, brackish waters replaced the former Badenian salty marine ones. Probably these tendencies even increased in the fluvial freshwater discharge areas, where deltaic sediments accumulated in dominance (KRÉZSEK & BALLY, 2006). At that time, the Apuseni Mountains area was an archipelago with islands and largely opened passage ways, allowing free communication between water and the marine biota between the Transylvanian and Pannonian realms (RÖGL & STEININGER, 1984).

When comparing different neighboring sedimentary basins, the knowledge about the middle Miocene vertebrates – both marine and terrestrial – is obviously uneven, with scarcer data in the Transylvanian basin vs. richer ones in the Pannonian basin and its related sub-basins from the western Apuseni Mountains side. In the Pannonian basin realm there are several Badenian and Sarmatian vertebrate localities (overview and taxa reassessments, in HÍR et al., 2016, 2017) with illustrative assemblages at Miniş, Tauţ and Comăneşti in the Zărand sub-basin (FERU et al., 1980, VENCZEL & ŞTIUCĂ, 2008), Tăşad and Stracoş in the Beiuş sub-basin (KÓKAI et al., 2001; HÍR et al., 2002; KAZÁR & VENCZEL, 2003) or Subpiatră in the Vad-Borod sub-basin (VENCZEL et al., 2005; HÍR & VENCZEL, 2005; VENCZEL, 2007; KESSLER & VENCZEL, 2009).

Extremely poor data is known about marine and Badenian vertebrates. These fossils are almost rare in Transylvania, as in the whole Romania. The Sarmatian *s.s.* vertebrate localities are somewhat more numerous. On the western margin of the basin an example of such locality is Cluj-Napoca, where dolphin remains were collected during the mining works for clay extraction carried out several decades ago in the former Iris quarry (Iris Formation, late Volhynian–early Bessarabian; MÉSZÁROS et al., 1991). These fossils are hosted in the paleontological collections of the Babeş-Bolyai University (CODREA, 1996; KAZÁR et al., 2004). Apart from cetaceans, we mention here in the same locality a few post-cranial bones from a fragmentary skeleton of a young chalicothere (unpublished; VAC *personal observation*). Not far from Cluj-Napoca, another find documents the presence of cetaceans at Vâlcele, near Feleacu (Cluj District) where a dolphin vertebra was recovered embedded in a so-called "Feleacu concretion" (CODREA, 2008). This kind of sandstone concretions is very common in the Feleacu Formation (latest Bessarabian; KOCH, 1884; CHINTĂUAN et al., 2018).

Therefore, if the Sarmatian *s.s.* marine mammals were reported on the western border of the Transylvanian middle Miocene basin, similar fossils were never mentioned on the opposite, eastern border. Some years ago in the locality of Fântânele (commune Matei, Bistrița-Năsăud District) a few fossil dolphin bones were unearthed from Sarmatian *s.s.* rocks due to archaeological works carried out by the Grăniceresc Năsăudean Museum of Năsăud. Apart from the cetacean bones, the same level yielded two vertebrae and some rib fragments of indeterminate large mammals, as well as skeletal fragments originating from a rather large sized fish (Teleostei indet.). Fântânele is a village located ca. 26 km in straight line from Bistrița, the capital of district. According to the geological map *folio* 11 Bistrița L-35-VII of the Geological Institute of Romania scale 1: 200000 (RĂILEANU et al., 1967), exclusively Sarmatian *s.s.* deposits are exposed in the whole area of this locality. On this geological map, the Volhynian and Bessarabian deposits are mapped as a single unit (Fig. 1).

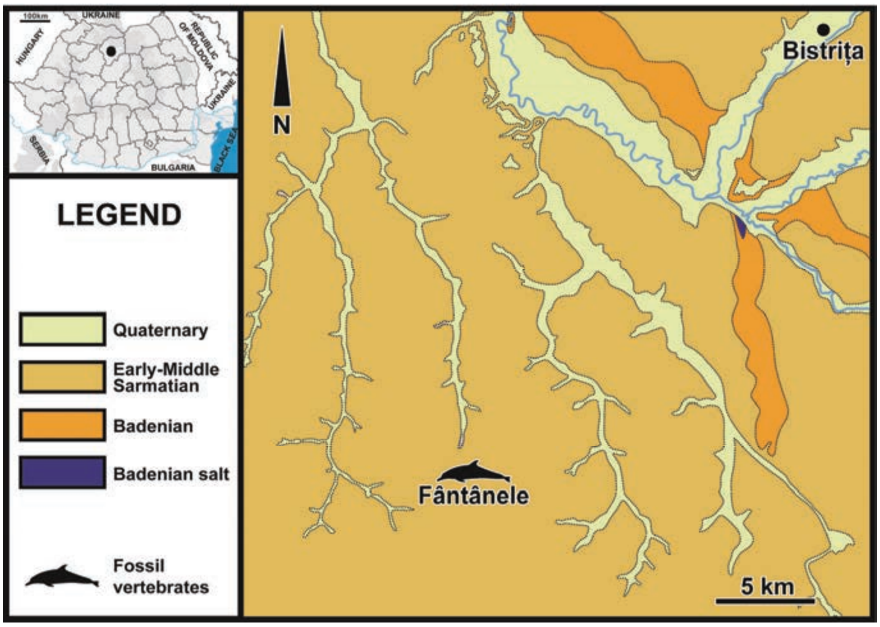

Figure 1. Location of the Fântânele vertebrate locality in Romania and on the geological map of the studied area (redrawn simplified, after the geological map of the Geological Institute of Romania, scale 1:200000).

The bones were found during the systematic archaeological diggings for the Celtic and Scythian necropolis from this locality. The Celtic necropolis was named the Necropolis from Fântânele – ”La Gâța” (named after the nick name of the land owner; VAIDA, 2008), located on Iușului Hill (Iuș = Szászújős, former name of Fântânele). The dominating rock in this location is the yellowish quartz sand. This sand deposit is laying ca. 30 cm under the soil. The bones were recovered at ca. 80 cm in depth, into this rock (Fig. 2). The presence of sandstone concretions (called by local people "stones of sand") is important because they are indicative for the Feleac Formation.

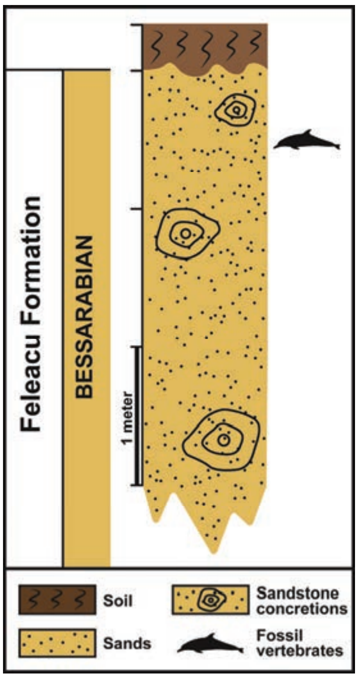

Figure 2. The lithostratigraphic sequence of the site ”La Gâță” at Fântânele, Bistrița-Năsăud.

MATERIAL AND METHODS

The dolphin fossils from Fântânele hosted in the paleontological collection of the Grăniceresc Năsăudean Museum are a vertebra and a humerus. The bones were collected by one of us (LDV) during archaeological excavations. The fossils did not need special preparation, they were just cleaned by washing out the adherent sand. Photographs were captured taken at the Babeş-Bolyai University of Cluj-Napoca with a D700 Nikon camera and 105 mm Sigma lens, on a professional tripod, then processed in Adobe Photoshop@CS2, Version 9. The measurements were taken using a professional caliper of 150 mm. Measurements follow KAZÁR & VENCZEL (2003).

Common English terms and the standard anatomical orientation system are used throughout this paper. The anatomical nomenclature of dolphins follows ABEL (1931), SLIJPER (1936) and ROMMEL (1990). The taxonomic assignation is based on references and on direct comparisons with similar finds hosted in the Ţării Crişurilor Museum Oradea, Natural Sciences Department, and the Babeş-Bolyai University Paleontological Museum from Cluj-Napoca.

Institutional abbreviations: **GNM**, Grăniceresc Năsăudean Museum, Năsăud; **BBU**, Babeș-Bolyai University of Cluj-Napoca, Paleontological Museum; **UBFG**, Laboratory of Paleontology, Faculty of Geology and Geophysics, University of Bucharest; **TCM**, Țării Crișurilor Museum Oradea.

RESULTS

Systematic paleontology
Order Cetacea Brisson, 1762
Suborder Odontoceti Flower, 1867
Infraorder Delphinida de Muizon, 1984
Superfamily Delphinoidea Gray, 1821
Family Kentriodontidae Slipjper, 1936
Kentriodon fuchsii (Brandt, 1873)

Material. Left humerus (GNM 6668; Fig. 3 a-e).
Geological age and locality. Sarmatian *ss.* (late Bessarabian), Fântânele, Bistrița-Năsăud District.
Description. The humerus is well preserved. Only a portion of the lesser tubercle was broken. This bone, as in other finds from the Romanian Carpathian area (Table 1) is short and stout. The bone broadens after the neck portion, the distal end being the broadest portion in lateral view. In this manner, the anterior (near straight, faintly convex) and posterior margins are diverging from the neck area to the distal margins. The distal margins are marked by strong asymmetry, the radial border being by far broader compared to the ulnar one. The facet for the oleocranon process is well marked on the posterior margin, like in the specimen BBU 14943. The attachment of the deltoideus muscle is faintly marked on the lateral side of the bone – it could be result of the hydrotaphomony, the bone being probably dragged on the basin bottom by marine currents and waves -, but the scar is clearly visible on the distal portion of the anterior margin. The neck appears in lateral view as a strongly constricted portion, compared to the epiphysis and the head of the humerus. The infraspineous fossa is well expressed, relatively deep, oval (largest diameter ca. 7 mm). The head and the lesser tubercle share same morphology with the ones reported from Cluj-Napoca or Domașnea (KAZÁR et al., 2004; CODREA & SEREȚEAN, 2004).
Measurements (mm).

Table 1. Comparative measurements of various fossil Kentriodontidae humeri from Romania.

Collection Inventory no.	**GNM 6668**	**UBFG[1] 223/1**	**UBFG[1] 223/2**	**TCM[2]**	**BBU[3] 14943**	**BBU[3] 15029**	**BBU[4] V411**
Length of the humerus	55.2	51.0	51.5	41.5	54.0	-	41.8
Anteroposterior diameter of the head of the humerus	21.0	18.0	(19.5)	16.0	19.5	-	-
Dorsoventral diameter of the head of the humerus	20.0	20.0	20.5	17.0	22.5	-	16.7
Mediolateral width of proximal epiphysis	35.0	28.0	30.0	26.5	30.0	-	23.0
Anteroposterior width of proximal epiphisys	25.0	20.0	22.5	-	-	-	-
Anteroposterior extension of the humerus neck	21.6	19.5	20.0	20.0	21.0	-	15.0
Mediolateral extension of the humerus neck	16.5	16.5	17.5	14.5	18.0	-	10.0
Anteroposterior extension of the distal epiphysis of the humerus	32.5	28.0	29.0	26.5	33.0	26.5	-
Mediolateral extension of the distal epiphysis of the humerus	14.5	13.0	15.5	12.0	14.5	12.5	-

[1] GRIGORESCU & KAZÁR, 2006: *"Champsodelphis" fuchsii* BRANDT, 1873, Comănești 1, late Volhynian; [2] KAZÁR & VENCZEL, 2003: Kentriodontidae indet. (unnamed n. sp.), Tășad 2, Volhynian (MN 7+8); [3] KAZÁR et al., 2004: *Atocetus*(?) *fuchsii* (BRANDT, 1873) Cluj-Napoca, Iris open pit, late Volhynian; [4] CODREA & SEREȚEAN, 2004: Kentriodontidae indet., juvenile, Domașnea, late Volhynian-?early Bessarabian.

Figure 3. *Kentriodon fuchsii* (Brandt, 1873), left humerus (GNM 6668). a – lateral view; b – medial view; c – dorsal view; d – posterior view; e – anterior view.

Odontoceti Flower, 1867
Odontoceti indet.

Material. Isolate thoracic vertebra of a small sized specimen (GNM 6669; Fig. 4 a-b).
Geological age and locality. The same as above.
Description. Only the centrum of this vertebra is preserved. In spite of its small size, it originated from an adult specimen. Both articular facets are slightly concave and sub-ellipsoidal. The base of the neural channel is broad. Probably, this thoracic vertebra had a rather anterior position in the vertebrae series.
Measurements (mm): length of centrum – 18.0, anterior width – 22.0, anterior height – 19.5

Figure 4. Odontoceti indet., thoracic vertebra (GNM 6669). a – posterior view; b – anterior view; c – ventral view; d – dorsal view.

DISCUSSIONS

The problems related to the taxonomy of the dolphin species "*Champsodelphis*" *fuchsii* (BRANDT, 1873) were discussed by KAZÁR et al. (2004) and GRIGORESCU & KAZÁR (2006), as long as DE MUIZON (1988) practically restricted this genus only to the type species, *C. macrogenius* Fischer, 1829. KAZÁR (2006) reconsidered *"C." fuchsii* as *Kentriodon*. We follow here her viewpoint, but as the humerus from Fântânele is very close both in morphology and size (Tab. 1) to the one described by KAZÁR et al. (2004) from the Iris open pit in Cluj-Napoca. In turn, we also consider the possibility that the fossils from the Transylvanian basin could document a distinct species of odontocetes, as KAZÁR (2006) herself presumed.

GRIGORESCU & KAZÁR (2006) mentioned a first middle Badenian (ca. 14.7-13.6 Ma) invasion event of marine mammals in the Central Paratethys (Austria and Hungary) including kentriodontids, followed by another one in Sarmatian. For instance, in Romania, there is no evidence about Badenian representatives, but one may presume their existence. This situation could be explained by the absence of the middle Badenian marine deposits on the eastern margins of the Pannonian basin and its related sub-basins from Romania. In Wieliczian (middle Badenian) in the basin of Transylvania, a peculiar regional marine paleogeography (PAUCĂ, 1967; 1968; 1968a; 1978; BALINTONI & PETRESCU, 2002) lead to salt deposition and probably this environment was not convenient for marine mammal exigencies. However, it is also possible that these fossils were neglected by the geologists who focused mainly on various other faunal groups (mainly molluscs and other invertebrates) very abundant in some Badenian deposits of Romania, or it was plain and simply a collecting bias. It is worth recalling that other Badenian marine mammals as the sea-cows are also very rarely reported, although all these marine mammals were probably part of the diet of the large sharks as *Otodus megalodon* (TRIF et al., 2016, 2018; TRIF & CODREA, 2017). A single locality seems to have yielded Miocene sirenian remains, Zorlenţu Mare in southwestern Romania (Banat), where a rib fragment was briefly described and illustrated by FLOREI (1962; p. 69, Fig. 3). However, the author himself doubted the sirenian origin of the bone in the figure caption. We could not find this fossil in the BBU collections, for a revision.

Nevertheless, small sized kentriodontidae dolphins are recorded in the Sarmatian *s.s.* deposits both in the Pannonian and Transylvanian basins (Table 1; Fig. 5).

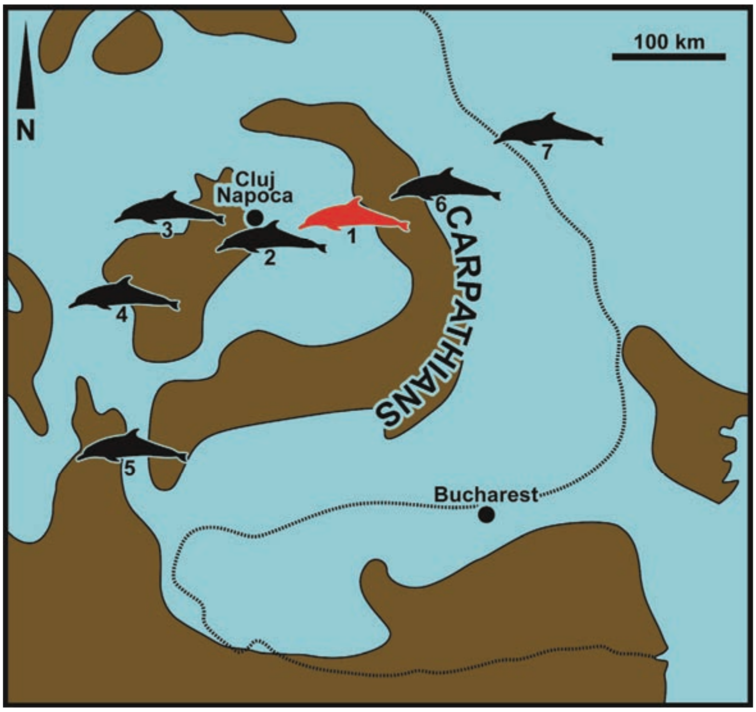

Figure 5. Sarmatian Kentriodontidae localities in Romania (paleogeography after RÖGL & STEININGER, 1984; redrawn and simplified). 1- Fântânele (late Bessarabian; this work); 2 – Cluj-Napoca (late Volhynian; CODREA, 1996, KAZÁR et al., 2004); 3 - Tăşad (Volhynian; KAZÁR & VENCZEL, 2003); 4 – Comăneşti-1 (late Volhynian; GRIGORESCU & KAZÁR, 2006); 5 – Domaşnea (late Volhynian-early Bessarabian; CODREA & SEREŢEAN, 2004); 6 – Basarabi (Volhynian; CODREA et al., 2014); 7 – Darabani, Ghireni, Cordăreni (Volhynian; CODREA et al., 2014 and references therein).

Since the lowermost Sarmatian, the sharks vanished in this area of the Central Paratethys, as long as there is no record of these fish in Romania. Probably sharks were unable to adapt to the environmental changes occurred in this sector of the Paratethys Sea after the Badenian/Sarmatian boundary, when geological events modified the Carpathian paleogeography. Due to the tectonics of the Eastern Carpathians and the erection of the Sub-Carpathian thrusting nappe (an intra-Volhynian event; SĂNDULESCU, 1986) the connections of the outer-Carpathians marine realms with the basin of Transylvania gradually vanished. The salinity of water decreased and sharks probably were unable to adapt to this environmental challenge. One may consider that the absence of these top predators favoured small dolphin communities to increase their populations. Probably, the Sarmatian dolphins were able to spend episodes in water of low salinity, as it can be presumed for the Iris Formation at Cluj-Napoca. However, after Sarmatian s.s. the salinity of water continued to decrease and these dolphins vanished from this region.

CONCLUSIONS

Here we report the presence of the small sized kentriodontid dolphin *Kentriodon fuchsii* on the eastern side of the Transylvanian Middle Miocene basin, in the Feleacu Formation, from the new vertebrate locality of Fântânele. The fossil documenting this dolphin species originated from this formation, based on the peculiar regional lithology of the deposits the bone originated from. The isolated humerus allows the presumption that in the late Bessarabian this area of the sedimentary basin was covered by shallow waters, with dynamic hydrotaphonomy. Apart from the dolphin bones, few bones of indeterminate, probably terrestrial large sized mammals, as well as an indeterminate bony fish were found in the same rocks. The presence of the mammal remains is evidence of the influence of fluvial water streams that carried the bones from land into the Sarmatian marine basin. This find completes the list of vertebrate localities and the paleogeographic distribution of dolphins in the inner Carpathian region, revealing the abundance of these mammals in Sarmatian.

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Codrea A. Vlad, Bordeianu Marian
Babeş-Bolyai University, Faculty of Biology-Geology, Department of Geology 1, Kogălniceanu Str., Cluj-Napoca, RO-400084, Romania.
E-mail: vlad.codrea@ubbcluj.ro

Horga Marius
Bistriţa-Năsăud Museum Complex, 19, Gen. Gr. Bălan Str., Bistriţa, Romania.
E-mail: horgaro@yahoo.com

Venczel Márton
Ţării Crişurilor Museum, Department of Natural History 1/A, Armatei Române Str., Oradea, RO-410087, Romania.
E-mai: mvenczel@gmail.com

Trf Nicolae
Natural History Museum, Brukenthal National Museum, Sibiu, Romania.
E-mail: nicolae.trif@brukenthalmuseum.ro

Vaida D. Lucian
Muzeul Grăniceresc Năsăudean, 10, Grănicerilor Bd., Năsăud, Romania.
E-mail: muzeu_gr@yahoo.com

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Cercidiphyllum crenatum (UNGER) R. BROWN 1935 FROM THE BOZOVICI BASIN, SOUTH CARPATHIANS, ROMANIA

CĂLIN Alexandru Gabriel, POPA Mihai Emilian, PIRNEA Roxana, PARASCHIV Valentin

Abstract. *Cercidiphyllum crenatum* (Unger 1850) R. Brown 1935 (Magnoliophyta, Cercidiphyllaceae Engl.) is reported from the Badenian coal-bearing deposits of the Bozovici Basin, South Carpathians. Although it is a common species in the European Mio-Pliocene deposits, *Cercidiphyllum crenatum* is a rare species in the Romanian fossil flora, as it was previously collected and described from only two Pontian localities in Transylvania (GIVULESCU, 1964; GIVULESCU & GHIURCĂ, 1969; GIVULESCU, 1984). This is the first record of *Cercidiphyllum crenatum* in the Miocene continental formations of Romania. From a palaeoecological point of view, *Cercidiphyllum crenatum* lived in a warm-temperate climate, associated with gymnosperms belonging to the genera *Abies*, *Sequoia* and to angiosperm genera such as *Acer*, *Salix*, *Betula*, *Juglans*, *Fagus*, *Carya* and *Quercus* (PREDA et al., 1994; PETRESCU, 2003).

Keywords: Cercidiphyllaceae, *Cercidiphyllum crenatum*, Miocene, Bozovici Basin, Romania.

Rezumat. *Cercidiphyllum crenatum* (Unger) R. Brown 1935 din Bazinul Bozovici, Carpații Meridionali, România. *Cercidiphyllum crenatum* (Unger 1850) R. Brown 1935 (Magnoliophyta, Cercidiphyllaceae ENGL.) a fost găsită în depozitele badeniene din Bazinul Bozovici din Carpații Meridionali. Deși este o specie des întalnită în depozitele mio-pliocene din Europa, *Cercidiphyllum crenatum* este o specie rară în flora fosilă a României, fiind colectată și descrisă doar din două localități ponțiene din Transilvania (GIVULESCU, 1964; GIVULESCU & GHIURCĂ, 1969; GIVULESCU, 1984). *Cercidiphyllum crenatum* este semnalată pentru prima dată în formațiunile continentale miocene din România. Din punct de vedere paleoecologic această specie trăia într-un climat temperat-cald, în asociație cu gimnosperme precum *Abies*, *Sequoia* și cu angiosperme precum *Acer*, *Salix*, *Betula*, *Carya*, *Juglans*, *Fagus*, *Carya* și *Quercus* (PREDA et al., 1994; PETRESCU, 2003).

Cuvinte cheie: Cercidiphyllaceae, *Cercidiphyllum crenatum*, Miocen, Bazinul Bozovici, România.

INTRODUCTION

The family Cercidiphyllaceae, Order Saxifragales, with a single extant genus *Cercidiphyllum* Siebold et Zuccarini 1846, is considered to be a member of the core eudicots (SOLTIS et al., 2007; JIAN et al., 2008; APG III, 2009). *Cercidiphyllum* is an archaic Cretaceous genus with peculiar morphology, considered illustrative for the evolution and development of plants (KRASSILOV, 2010). The genus *Cercidiphyllum* includes two extant species: *Cercidiphyllum japonicum* Siebold et Zuccarini 1846 and *Cercidiphyllum magnificum* (Nakai) Nakai 1920.

Cercidiphyllum japonicum is living in the following Chinese provinces: Henan, Zhejiang, Hebei, Shanxi, Shaanxi, Gansu, Jiangsi and Sichuan, as well as in the following Japanese prefectures: Shikoku, Kyushu, Hokkaido and Honshu, while *Cercidiphyllum magnificum* is living in Nikko and Honshu prefectures of Japan (SPONGBERG, 1979). *Cercidiphyllum japonicum* is a large canopy tree, reaching 25-30 m in height and 2-2.5 m in diameter, living in warm-temperate, deciduous forests of China and Japan. *Cercidiphyllum magnificum* is a small sized tree living in cool-temperate, subalpine forests of Japan (QI et al., 2012). Nonetheless, both species are dioecious and have very similar leaves, making it difficult to separate them morphologically.

The Cenozoic reprezentatives of genus *Cercidiphyllum*, mainly *Cercidiphyllum crenatum* (Unger) Brown 1935, are recorded from western North America, Europe and eastern Asia, occuring in Oligocene-Pleistocene continental formations (GIVULESCU, 1964; GIVULESCU & GHIURCĂ, 1969; GIVULESCU, 1984; MEYER & MANCHESTER, 1997; KOVAR-EDER et al., 1998; KVAČEK, 2008; MANCHESTER et al., 2008; DENK et al., 2017; KVAČEK et al., 2018). In Romania, *Cercidiphyllum crenatum* was reported from Transylvania, from two Pontian localities (GIVULESCU, 1964; GIVULESCU & GHIURCĂ, 1969; GIVULESCU, 1984). In this paper, we discuss a new record of *Cercidiphyllum crenatum* in Romania, from the Bozovici Basin, South Carpathians, Badenian in age.

GEOLOGICAL SETTING

The Bozovici Basin is a typical Alpine molassic, intramountainous basin of the South Carpathians (Fig. 1), formed during the post-Laramian Alpine phases. This Tertiary basin is sealing two significant tectonic units of the South Carpathians, the Getic Nappe and the Danubian Units (BALINTONI, 1997; IANCU et al., 2005). It occurs in the Caraș-Severin County, bordered by the Semenic Mountains to the North, the Almăj Mountains to the South and the Locva Mountains to the South-West. The Bozovici Basin has an irregular shape, having approximatively a NE-SW orientation. It is 40 km long and its maximum width is 7-8 km in the area of Bozovici and Eftimie Murgu towns. The Bozovici Basin was studied primarily mainly because of its coal seams (POP, 1959; RĂILEANU et al., 1963; PETRESCU et al., 1987; PREDA et al., 1994; POPA & PREDEANU, 2018; POPA & ANASTASIU, 2019), while its fossil plants were under-rated by stratigraphical and coal geology studies.

The sedimentary sequences of the Bozovici Basin are formally separated in two formations (Fig. 2): the Lăpuşnicul Mare Formation and the Dalboşeţ Formation (CODREA, 2001). The Lăpuşnicu Mare Formation includes two members: the Pârâul Lighidia Member, Eggenburgian in age, and the Valea Slătinicului Member, Badenian in age. The age of the two members belonging to the Lăpuşnicu Mare Formation was debated for a long time. The Eggenburgian age of the Pârâul Lighidia Member was established by GRIGORESCU (1985), based on the occurrence of the vertebrate remains assigned to *Brachyodus onoideus* Gervais. Also, the same age was confirmed by PETRESCU & NICORICI (1989) based on the results of the palynomorph study. The Badenian age of the Valea Slătinicului Member was suggested by CODREA (2001), based on micro-mammal remains.

The sedimentary sequences of the Bozovici Basin can reach up to 750 m and they consist mainly of sandstones, clays, marls and conglomerates, including up to nine interbedded coal seams with highly fossiliferous roof shales and tuff intercalations. An essential peculiarity of this flora is the occurrence of well-preserved permineralized trunks, both silicified and carbonatic (PREDA et al., 1994).

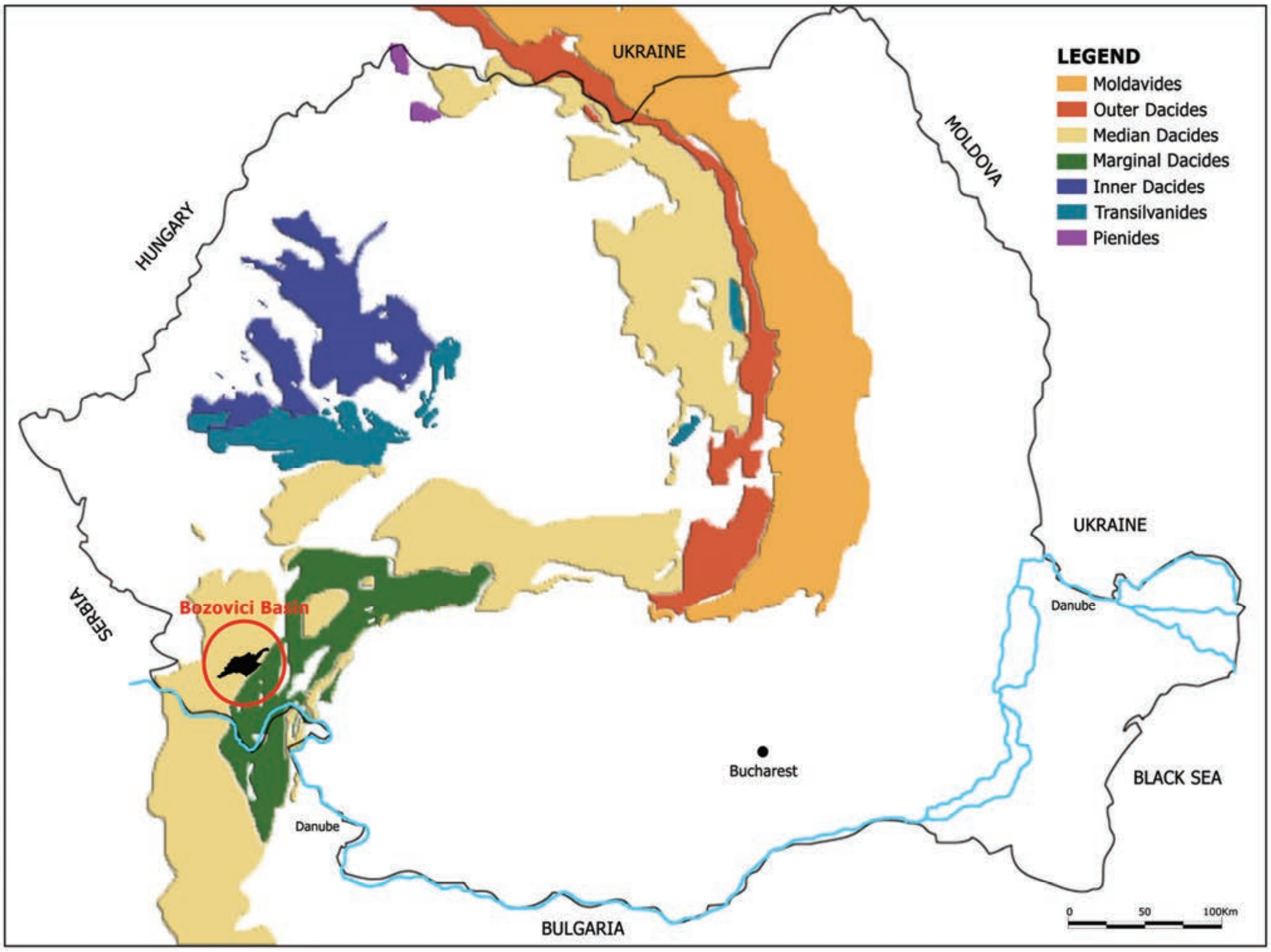

Figure 1. The simplified geological map of Romania and the occurrence of the Bozovici Basin in the South Carpathians (modified after SĂNDULESCU, 1984; POPA et al., 2017).

MATERIAL AND METHODS

The sample was collected from the Lighidia quarry by one of the authors (C.A.G.), an open cast mine located near the Bozovici town, during one of the several field work campaigns of 2015-2017. The stratigraphic position of the material is from the upper sequence of the Valea Slătinicului Member of the Lăpuşnicu Mare Formation. The sample, recorded in the field as Boz1, is preserved as an impression on red porcelanite. The sample is curated as 27626 at the National Geological Museum of the Geological Institute of Romania, in Bucharest. The macrophotographs were taken using a Canon EOS 60D digital camera with a Canon EF-S 18-55mm lens. More detailed photographs were taken using a Carl Zeiss Stemi 508 Stereo Microscope (Fig. 2).

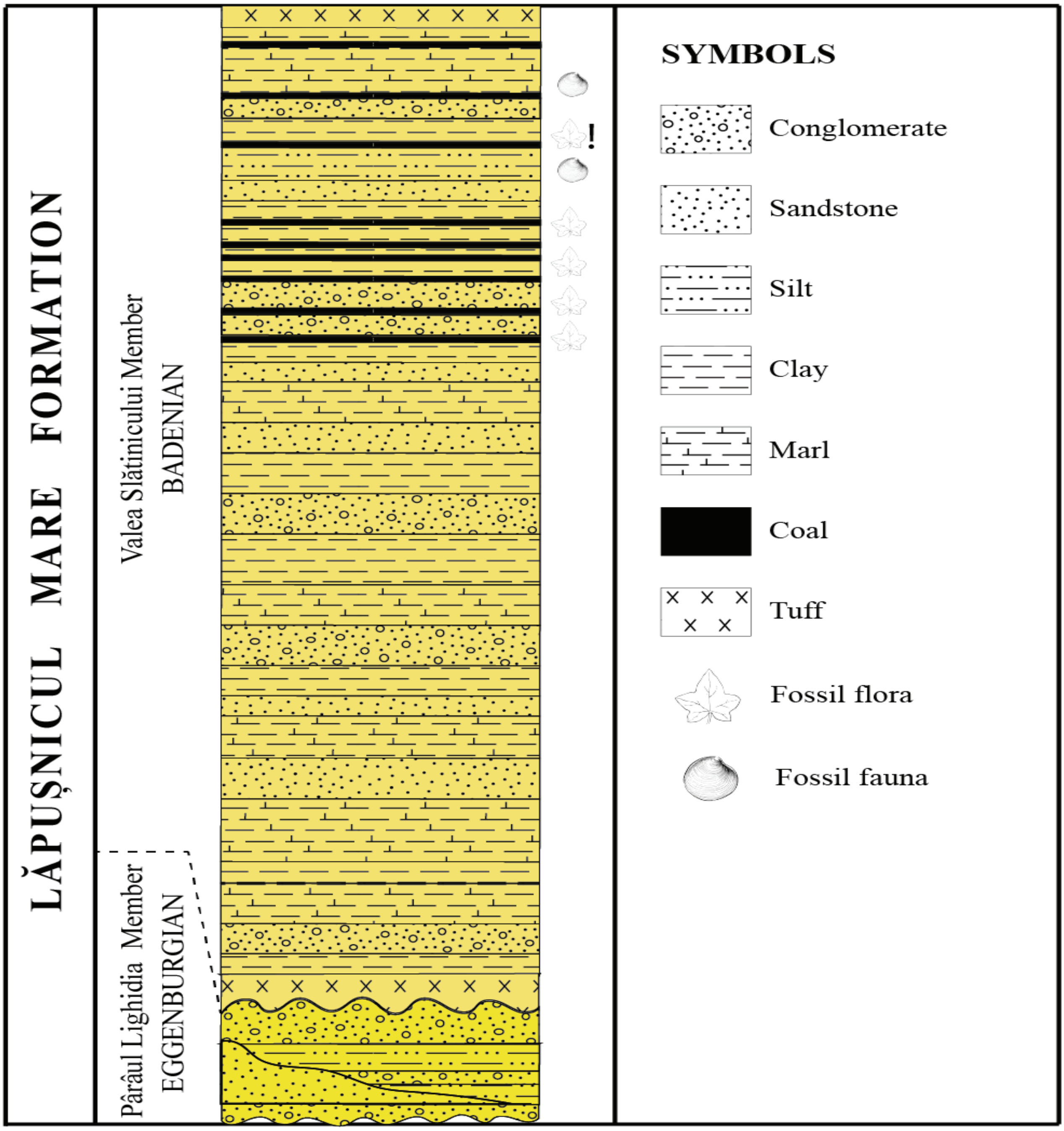

Figure 2. Stratigraphic synthetic column of the Miocene formations of the Bozovici Basin, with the stratigraphic position of *Cercidiphyllum crenatum* marked by a fossil leaf symbol (with the exclamation mark) (modified after CODREA, 2001; PIRNEA & POPA, 2018).

SYSTEMATICS
Phylum Magnoliophyta
Class Magnoliopsida
Order Saxifragales
Family Cercidiphyllaceae Engler 1907
Genus *Cercidiphyllum* Siebold et Zuccarini 1846
Cercidiphyllum crenatum (Unger) Brown 1935

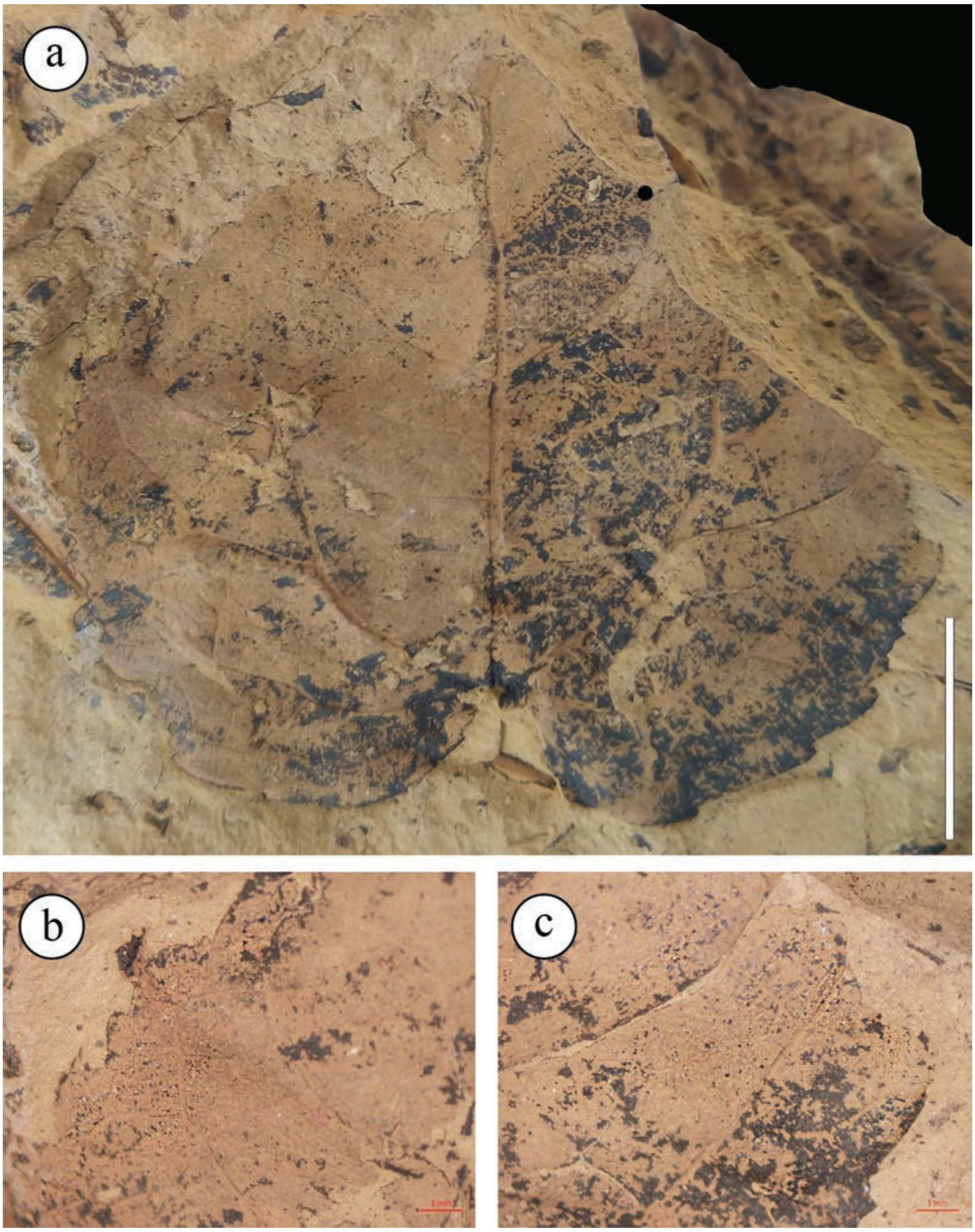

Figure 3. *Cercidiphyllum crenatum*, from Bozovici, Valea Slătinicului Member, Lăpușnicul Mare Formation, Bozovici Basin, Lighidia quarry. Sample 27626. a: general view; b-c: details of the leaf fragment showing the 2nd and 3rd vein category and the crenate-serrate leaf margins. Scale bar: 10 mm.

1935 *Cercidiphyllum crenatum* (Unger) R. W. Brown – Brown: p. 575, Pl. 68, Figs. 1, 9, 10
1964 *Cercidiphyllum crenatum* (Unger) R. W. Brown – Givulescu: p. 569, Fig. 1
1969 *Cercidiphyllum crenatum* (Unger) R. W. Brown – Givulescu & Ghiurcă: p. 21, Pl. 3, Fig.2
1977 *Cercidiphyllum crenatum* (Unger) R. W. Brown – Kasaphgil: Fig. 27
1984 *Cercidiphyllum crenatum* (Unger) R. W. Brown – Givulescu: 4 (72), Pl. 7, Fig. 17
1987 *Cercidiphyllum crenatum* (Unger) R. W. Brown – Manchester & Meyer: p. 116, Fig. 3G
1989 *Cercidiphyllum crenatum* (Unger) R. W. Brown – Zhilin: Fig. 1
1995 *Cercidiphyllum helveticum* (Heer 1855) Jähnichen, Mai et Walther – Meller: p. 46, Pl. 7, Figs. 1 – 4
1996 *Cercidiphyllum helveticum* (Heer 1855) Jähnichen, Mai et Walther – Meller: Table 1 – 2
1996 *Cercidiphyllum helveticum* (Heer 1855) Jähnichen, Mai et Walther – Kovar-Eder: Table1
1997 Cercidiphyllum crenatum (Unger) R. W. Brown – Meyer & Manchester: p. 73, Pl. 7, Figs. 2-8; Pl. 8, Fig. 1
1998 *Cercidiphyllum helveticum* (Heer 1855) Jähnichen, Mai et Walther – Kovar-Eder et al.: Table 5
1998a *Cercidiphyllum helveticum* (Heer 1855) Jähnichen, Mai et Walther – Meller: Tab. 7, Figs. 1 – 4

1998b *Cercidiphyllum helveticum* (Heer 1855) Jähnichen, Mai et Walther – Meller: Table 1, Figs. 3 – 5
1998 *Cercidiphyllum crenatum* (Unger) R. W. Brown – Kovar-Eder: Pl. 1, Figs. 23 – 24
2000 *Cercidiphyllum crenatum* (Unger) R. W. Brown – Kvaček & Hurnik: Pl. 3, Fig. 1, pl. 4, Fig. 10
2004 *Cercidiphyllum crenatum* (Unger) R. W. Brown – Kovar-Eder et al.: Pl. 2, Fig. 7
2017 *Cercidiphyllum crenatum* (Unger) R. W. Brown – Denk et al.: Pl. 12, Figs. 6 – 8
2018 *Cercidiphyllum crenatum* (Unger) R. W. Brown – Kvaček et al.: Pl. 5, Fig. 1

Description. The sample includes a single leaf fragment (Fig. 3a), a microphyll (933 mm^2) with 35 mm in length and 40 mm in width. The lamina is symmetrical, with a marginal position of the petiole's attachment. The leaf has an oblate shape and a length/width ratio of 0.9/1. The base of the leaf is cordate, with a reflex angle, and the apex is convex and obtuse. The leaf margin is crenate-serrate. The tooth spacing is regular with a single order of teeth and five teeth per centimetre. Each tooth apex is simple with convex basal and apical teeth and the sinus between teeth is angular (Fig. 3b). The first vein category is basal actinodromous, the major secondary vein category is semicraspedodromous with excurrent attachment. The interior secondary veins are present and the intercostal tertiary vein fabric is irregular reticulate (Fig. 3c). The major secondary vein spacing is irregular with an uniform vein angle.

DISCUSSION

Cercidiphyllum crenatum (Unger) R. W. Brown 1935 (Fig. 3) from the Bozovici Basin is characterized by a series of typical characters: crenate-serrate margin, basal actinodromous first vein and tertiary random reticulate vein. No fruit and flower fragments have been found.

Cercidiphyllum crenatum has been recorded from continental formations from all around the world, within the Oligocene-Pleistocene timespan. Its very first citation was given by BROWN (1935), from the Early Oligocene Bridge Creek flora of the John Day Formation, in north-central Oregon, U.S.A. *Cercidiphyllum crenatum* was also collected and described from Miocene continental formations of western North America, from Latah and Clarkia areas (CHANEY & AXELROD, 1959; SMILEY & REMBER, 1985; MEYER & MANCHESTER, 1997). Other reported occurrences of *Cercidiphyllum crenatum* come from Early Oligocene (Rupelian) continental formations of western Kazakhstan, in the Ashcheayrykian flora (ZHILIN, 1989), northern Ustyurt and Chagravan Plateau, in the Myneskesuekian flora (TOKAR & KORNILOVA, 1975) and in the Shintuzsay flora (KORNILOVA, 1950; KORNILOVA & TOKAR, 1973). From the Late Oligocene (Chattian), *Cercidiphyllum crenatum* was recorded in the Kumsuat flora (ZHILIN, 1989) from western Kazakhstan. In Russia, *Cercidiphyllum crenatum* was collected and described from the Dembi flora (Middle-Late Oligocene), Velikaya Kema flora (Middle – Late Oligocene), and Rettikhovsk flora (Early Miocene) (AKHMETYEV & BRATZEVA, 1973). Also, *Cercidiphyllum crenatum* was recorded in the Early Miocene (Aquitanian) from the following occurrences: a. northern Ustyurt, from the Baygubekian flora (ZHILIN, 1974, 1989); b. from the Orzhilansay flora (KORNILOVA, 1955, 1956, 1966; ZHILIN, 1974, 1989) and the Nausha flora. From the Guvem area, in northwestern Central Anatolia, *Cercidiphyllum crenatum* was found in lacustrine sediments of the Derekoy pyroclastics, early Miocene (Burdigalian) in age, associated with a humid temperate climate (DENK et al., 2017).

In Europe, the oldest occurrence of *Cercidiphyllum crenatum* is recorded in Early Oligocene of Usti Formation (Ceske Stredohori Mountains, Czechia) in Bechlejovice, Kundratice, Suletice, Holy Kluk, Markvartice, Zichov and Hrazeny areas (KVAČEK & WALTHER, 2001, 2003; KVAČEK & TEODORIDIS, 2007). It was also cited from the Decin Formation of Matry Hill around Sebuzin area, in the Ceske Strednohori Mountains pointing to a humid climate (KVAČEK et al., 2018). In the same region (North Bohemia), *Cercidiphyllum crenatum* was reported from the Most Basin from several occurrences: a. the Main Coal Seam (Middle Most Formation) in a few layers of the Vrsovice area; b. from the Upper Sandy-Clayey Beds (Upper Most Formation) in the pelitic layers of the Zelenky area and c. in the Overlying Beds (Upper Most Formation) from the Dolany area. All these occurrences are Early Miocene in age (KVAČEK & HURNIK, 2000). Another occurrence of *Cercidiphyllum crenatum* comes from the Early Miocene continental formations of Zug County, Switzerland (KOVAR-EDER et al., 1994). KOVAR-EDER et al. (2004) described a single specimen of *Cercidiphyllum crenatum* with subtropical climate affinities, from Karpatian/Early Badenian (late Early/early Middle Miocene) continental formations of Parschlug (Styria, Austria). In Poland, *Cercidiphyllum crenatum* was described from the Ruja lignite deposit, Middle Miocene in age, where it lived in a warm temperate climate (WOROBIEC et al., 2008). In Hungary, *Cercidiphyllum crenatum* was collected and described from Pannonian (Late Miocene) formations of Rudabanya, where it lived in a subtropical-warm-temperate climate (NAGY & PÁLFALVY, 1961; ERDEI et al., 2011). It was also collected from the Badenian continental formations of Nógrádszakál (KORDOS-SZAKÁLY, 1984).

In Romania, GIVULESCU (1964, 1984) and GIVULESCU & GHIURCĂ (1969) described *Cercidiphyllum crenatum* from Odeşti and Chiuzbaia sites in Transylvania, both Pontian in age. There, this species is associated with gymnosperms such as *Sequoia abietina*, *Glyptostrobus europaeus* and angiosperms such as *Liriodendron procaccini*, *Ceratophyllum* sp., *Platanus platanifolia*, *Alnus pseudojaponica*, *Betula pseudoluminifera*, *Carpinus cobălcescui*, *Fagus attenuata*, *Castanea cf. crenata*, *Quercus drymeja*, *Quercus praeprinus*, *Ulmus pyramidalis*, *Acer tricuspidatum*, *Populus populina* and *Populus gigantea*. The Chiuzbaia flora is one of the richest Pontian floras from Europe, while its fossil plants association indicates a mixed-mesophytic forest (GIVULESCU, 1990), in which *Cercidiphyllum crenatum* thrived.

The Bozovici flora was briefly studied and cited by the previous authors (POP, 1959; ILIESCU et al., 1967; PIRNEA & POPA, 2018). PETRESCU (2003) studied the palynology of the Bozovici Bazin and identified a series of gymnosperms such as *Abies*, *Picea*, *Pinus*, *Sciadopithys*, *Sequoia* and angiosperms such as *Magnolia*, *Juglans*, *Celtis*, *Engelhardia*, *Carya, Platicarya*, *Alnus*, *Betula*, *Carpinus*, *Ulmus*, *Nyssa* and *Quercus*. PIRNEA & POPA (2018) collected and described *Pronephrium stiriacum* from Valea Slătinicului Member, from the same sedimentary sequence where *Cercidiphyllum crenatum* occurred. *Cercidiphyllum crenatum* and *Pronephrium stiriacum* are associated in many sites of the European flora, especially in the Oligocene-Miocene continental formations (KVAČEK & HURNIK, 2000; KVAČEK & TEODORIDIS, 2007; KOVAR-EDER et al., 2004), with *Pronephrium stiriacum* indicating a warm-temperate climate. JÄHNICHEN et al. (1980) in KOVAR-EDER et al. (1994) pointed out the ecological shift of *Cercidiphyllum crenatum*, from a mixed-mesophytic forest during the Oligocene-Early Miocene interval to a mainly deciduous forest in a warm temperate climate during the Late Miocene-Pliocene timespan. The youngest fossil record of *Cercidiphyllum* comes from Pleistocene continental formations of eastern Asia (ONOE, 1989), where it found a refuge and therefore surviving during the Quaternary glaciations.

CONCLUSIONS

Cercidiphyllum crenatum (Saxifragales, Cercidiphyllaceae) is reported from the Lighidia Quarry, Bozovici Basin, within the Lăpușnicul Mare Formation, Valea Slătinicului Member, Badenian in age. Here, the collected fossil material has typical morphological characters which enabled its systematic identification. Although *Cercidiphyllum crenatum* is frequently reported from Miocene European floras, this is its first Miocene record in Romania.

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Călin Alexandru Gabriel
Geological Institute of Romania, National Museum of Geology,
Kiseleff Ave, No. 2, Sect. 1, 011345, Bucharest, Romania.
E-mail: calin_alexandru94@yahoo.com

Mihai Emilian Popa
University of Bucharest, Faculty of Geology and Geophysics,
Department of Geology, Laboratory of Paleontology, 1 N. Bălcescu Ave, 010041, Bucharest, Romania.
E-mail: mihai@mepopa.com

Pirnea Roxana
University of Bucharest, Faculty of Geology and Geophysics,
Department of Geology, Laboratory of Paleontology, 1 N. Bălcescu Ave, 010041, Bucharest, Romania.
E-mail: roxana.pirnea@gmail.com

Valentin Paraschiv
Geological Institute of Romania, National Museum of Geology,
Kiseleff Ave, No. 2, Sect. 1, 011345, Bucharest, Romania.
E-mail: paleovaly@yahoo.com

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THE CALLOVIAN SHARK *SPHENODUS* FROM THE SOUTHERN CARPATHIANS IN THE GEOLOGICAL NATIONAL MUSEUM COLLECTION

TORCĂRESCU Bogdan-Alexandru, TRIF Nicolae, CODREA A. Vlad

Abstract. The aim of this paper is to provide data about some of the fossil shark teeth hosted in the collection of the Geological National Museum. Two specimens were mentioned in previous papers. They were found in Horoaba Valley and Strunga and were briefly mentioned without any descriptions. Here, we also present an unprecedented tooth found in the Rucăr Valley, more specifically in the Purcărețului Valley. Our descriptions are in accordance with the descriptions reported by other authors for the species *Sphenodus longidens* Agassiz (1843), so we assigned this new tooth to the same species.

Keywords: Middle Jurassic, shark, *Sphenodus*, Getic Nappe, Southern Carpathians.

Rezumat. Rechinul callovian *Sphenodus* din Carpații Meridionali aflat în colecția Muzeului Național de Geologie. Scopul acestei lucrări este de a furniza date pentru câțiva dintre dinții de rechin fosil găzduiți în colecția Muzeului Național de Geologie. Două dintre specimene au fost menționate în lucrări anterioare. Acestea au fost găsite în Valea Horoaba și Strunga și au fost menționate pe scurt, fără măsurători sau descrieri. De asemenea, prezentăm un dinte nou descoperit provenind din Valea Rucărului, mai exact de pe afluentul său, valea Purcărețului. Descrierile noastre fiind în concordanță cu descrierile raportate de alți autori pentru specia *Sphenodus longidens* Agassiz (1843), am atribuit acest nou dinte aceleiași specii.

Cuvinte cheie: Jurasic Mediu, rechin, *Sphenodus*, Pânza Getică, Carpații Meridionali.

INTRODUCTION

In Romania, currently, our level of understanding when considering paleoichtyology is lower than that of Western Europe or the United States, as a consequence of the mismanagement of the collections that hosted many of the specimens labeled for study (TRIF & CODREA, 2018). Furthermore, when compared to the Upper Cretaceous or more recent relatives, the amount of knowledge is limited, due to a large disparity in the occurences and geographical distribution (REES, 2010). The aim of this paper is treefold: firstly, to provide descriptions for the fossil shark teeth of the genus *Sphenodus* housed in the National Geological Museum' collection; secondly, to bring to attention a new tooth found in Purcărețului Valley; thirdly, to provide data for a better understanding of the genus *Sphenodus* from the Jurassic of Romania. Two of the specimens were mentioned by PATRULIUS (1969) (P.3590a and P.3590b) while the third one (P.21540) is firstly reported.

GEOLOGICAL SETTING

Two of the fossil teeth described in this paper were found in the Bucegi Mountains, more specifically in Horoaba Valley (a tributary of the Ialomița Valley) and in Strunga (Fig. 1). These two areas belong to the Median Dacides (Getic domain), more specifically they represent a Mesozoic sedimentary area for the Getic Nappe (SĂNDULESCU, 1984). The deposits of the Horoaba Valley refer to the interweaving of carbonatic and detritic beds. The basal section comprises a level of micro-conglomerates and yellowish quartzitic sandstone, followed by a calcareous episode with pseudo-oolitic to oolitic limestones bearing limonite concretions (PATRULIUS, 1969). The upper part of the series consists of variegated, fine grained pink limestone, followed by massive pink and yellow limestone (PATRULIUS, 1969).

Rucăr is the other area where specimens of *Sphenodus longidens* teeth originated from. SIMIONESCU (1899) first found and described four specimens from the Lupului Valley (1899). They were found in a red, hard limestone deposit with *Reineckeia anceps*, i.e. Middle Callovian of *Anceps* Zone of ammonites. From this area originates the new tooth, from nearby Purcărețului Valley. There, one can follow more terrigenous deposits with centimetric marl and siltic beds of reddish colour, which are completed by numerous limestones and hardground levels (LAZĂR & GRĂDINARU, 2013; LAZĂR et al., 2014). The stratigraphic level of origin is the same as in the Lupului Valley, i.e. Middle Callovian – *Anceps* Zone (GRIGORE et al., 2015).

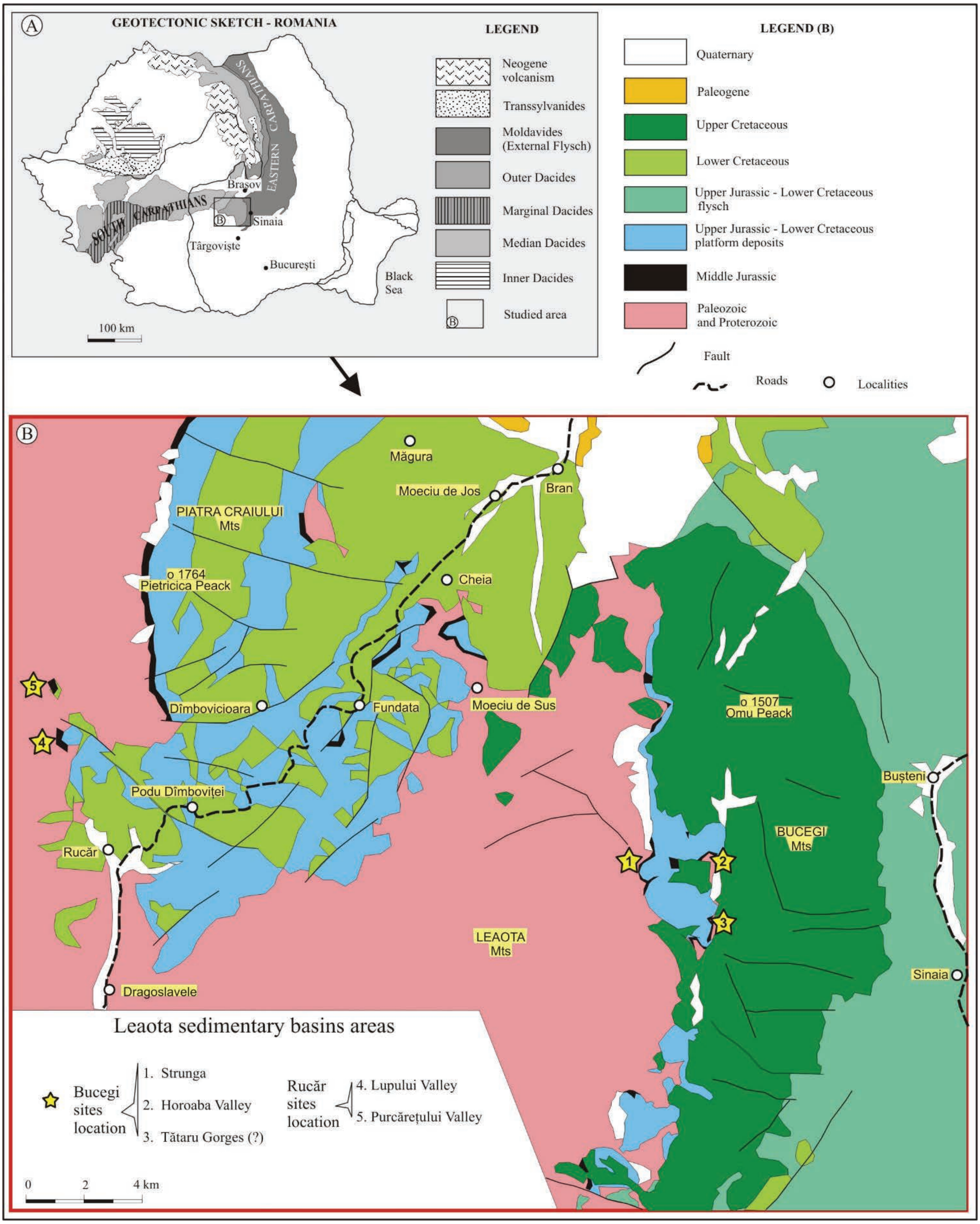

Figure 1. Location of the sites of origin for the shark teeth on a geological map – Leaota Mts. with Proterozoic metamorphic rocks and around the Mesozoic sedimentary basins (after PATRULIUS 1969, modified in GRIGORE et al., 2015).

MATERIAL AND METHODS

The studied material belongs to the National Geological Museum's collections, Bucharest (hereinafter abbreviated NGM). The teeth were taxonomically assigned by comparisons with other specimens reported in references. Also, morphometric measurements for the studied fossil teeth were taken using a digital calliper.

Abbreviations: L= length. W= width.

SYSTEMATIC PALEONTOLOGY

Class Chondrichthyes Huxley, 1880
Subclass Elasmobranchii Bonaparte, 1838
Cohort Euselachii Hay, 1902
Subcohort Neoselachii Compagno, 1977
Superorder Squalomorphii Compagno, 1973
Order Hexanchiformes Buen 1926
Family Orthacodontidae Glikman, 1957
Genus *Sphenodus* Agassiz 1843
Sphenodus longidens Agassiz 1843

Material. Three NGM teeth, inventory numbers: P.3590 (two specimens, P.3590a and P.3590b) from Bucegi and P.21540 (one specimen) from the Rucăr area.

Description: The first tooth (P.3590) (Figs. 2/1a-1b) exposes a long and slender cusp with its basal portion embedded in the host rock. Additional cusplets are not present. In the lateral view, the tooth has a sigmoidal shape, and a slightly visible torsion in the apical end. A strong lingual inclination can be noticed. The lingual side is much more convex than the labial one. Cutting edges present on the laterals of the tooth are very well developed and visible, running along the whole margin of the tooth's crown. The root is missing. The tooth is devoid of ornamentation, and the labial side is very smooth.

The second tooth (P.3590) (Fig. 2/2) also presents a single, long, slender cusp, without additional cusplets. Its root is also missing. On the lateral sides cutting edges running along the margin of the tooth can be observed. These cutting edges are well developed. The tooth lacks ornamentation, and on the labial side it has a smooth surface. The sigmoidal profile is slightly noticeable, with a slight torsion at the apical end. Its lingual side is embedded in the host rock.

The new tooth found in Purcărețului Valley (P.21540) (Fig. 2/3) also presents a single, long and slender cusp, with a sigmoidal profile, however, hardly noticeable. It is also fragmentary, embedded on its lingual side in the matrix. It also has very well-developed cutting edges, running alongside the tooth margins. On the labial side it presents a smooth surface, without any ornamentation (Table 1).

Table 1. Measurements for the shark teeth.

Specimen	L	W
P.3590 a	36.60 mm	7.67 mm
P.3590 b	28.33 mm	6.85 mm
P.21540	35.55 mm	6.32 mm

DISCUSSIONS

The exact systematic position of the genus *Sphenodus* is very disputed, the genus being included in either Lamniformes (WOODWARD, 1889), Hexanchiformes (CAPETTA, 1987), or Synechodontiformes (DUFFIN & WARD, 1993). However, after THIES (1993) identified a pseudopolyaulacorhize root pattern, there remains little doubt about the fact that the genus *Sphenodus* is related to Synecodontiformes, a relationship further strengthened by the braincase morphology of *Sphenodus* and *Synecodus* (MAISEY et al., 2004). Similarly, KLUG (2009) in a phylogenetic analysis also included *Sphenodus* in Synecodontiformes. However, CAPETTA (1987; 2012) makes a strong pleading for the inclusion to Hexanchiformes, based on extra-dental characters. When talking about the species of the genus *Sphenodus* DUFFIN & WARD (1993) present a number of 29 referred nominal species, of which 23 are Jurassic. Most likely some of these species are invalid or synonymous.

Several species of the genus *Sphenodus* are well-known from Europe: *Sphenodus macer* Quenstedt (1851), with mesio-distally wide teeth, low cusps and well-developed cutting edges, *Sphenodus venulosus* Chabakov & Zonov (1935) whose tooth morphology is similar to that of *S. macer* (probably *S. venulosus* is synonymous with *S. macer*) (REES, 2010) and *Sphenodus nitidus* Wagner (1862) whose mesial cutting edge is more developed that the distal one, and has a strong and sigmoidal curvature of the crown (GUINOT, 2013). While *S. longidens* was reported from the late Cretaceous by authors such as YABUMOTO & UYENO (1994) we believe those mentions to be uncertain at best and the material could probably belong to other species. As such, we consider this species to be a probably exclusive Middle

Jurassic distribution (early Bajocian-Oxfordian). Based on the above description and on the tooth morphology, the new tooth (P.21540) can be assigned to the species *Sphenodus longidens*.

Occurrence: in Europe, this species was reported from Switzerland (AGASSIZ, 1843), Germany (DUFFIN, 1993), from Poland (REES, 2010) and from the Ottange-Roumelange quarry, at the border between France and Luxembourg (DELSATE & FELTEN, 2015); in Romania, it was reported from the Bucegi Mts. (Horoaba Valley, Strunga and Tatarului Gorges) in Middle Callovian and Rucăr Basin (Lupului and Purcărețului valleys) in Middle Callovian (*Anceps* Zone) (SIMIONESCU, 1899). Although there are many more reports in literature, we find that only these ones are reliable.

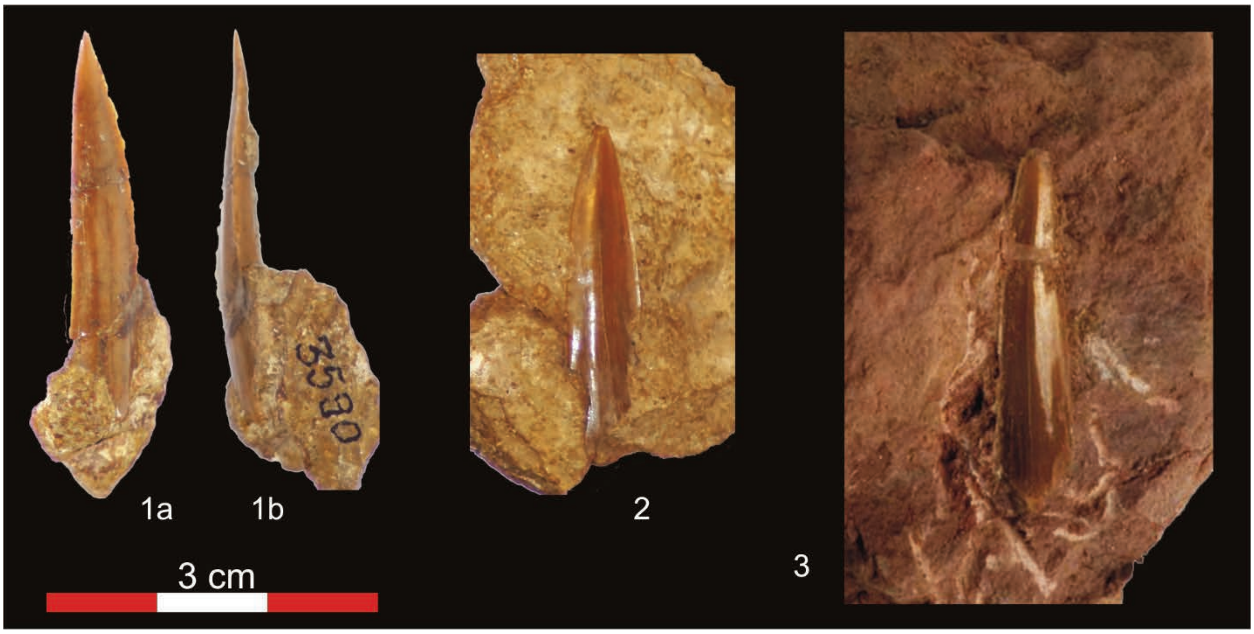

Figure 2. Sphenodus longidens Agassiz (1843) from MNG: 1) Patrulius Collection (inv.no. P.3590a) – Horoaba Valley a) labial and b) lateral view 2) Patrulius Collection (inv.no. P.3590b) – Cheile Tatarului (?) - labial view; both from Bucegi Mts. 3) Grigore Collection (inv. no. P.21540 provisory) – Purcărețului Valley (Rucăr).

CONCLUSIONS

Although the genus *Sphenodus* is rarely encountered in Romania (TRIF & CODREA, 2018) new material belonging to this species can still be found, such as the one presented here. The systematic position at the order level is still uncertain. Future studies are still necessary for understanding the exact systematic position of the genus. Based on the tooth morphology, and comparisons with the different morphologies of the other species of the genus *Sphenodus*, we assign the teeth herein described to the species *Sphenodus longidens*.

Little is known about *S. longidens* diet. The development of the main cusp and the obvious strong cutting edges suggest a predatory life, with pray likely including fish and reptiles. In fact, *Sphenodus* seems to make a transition from the tearing type dentition to a cutting type one (CAPPETTA, 2012), preferring coastal areas where prey was abundant (REES, 2010).

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Torcărescu Bogdan-Alexandru
Geological Institute of Romania
1st Caransebeş Street, 012271 - Bucharest, Romania.
E-mail: torcarescubogdan@yahoo.com

Trif Nicolae
Brukenthal National Museum, Sibiu,
1 Cetăţii Street, Sibiu, RO-550160, Romania.
E-mail: nicolae.trif@gmail.com

Codrea A. Vlad
Babeş-Bolyai University, Faculty of Biology-Geology
1 Kogălniceanu Street, Cluj-Napoca, RO-40-400084, Romania.
E-mail: vlad.codrea@ubbcluj.ro

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THE EFFECT OF DUMRE DIAPIRS ON THE THERMAL MATURITY OF GEOLOGICAL SECTION IN EAST OF BALLAGATI SYNCLINE, ALBANIA

PRIFTI Irakli, GJIKA Aleksander, PIPERI Arqile, LOÇI Rezeart, MINGA Ervin

Abstract. Syncline of Ballagati is one of the most eastern Adriatic Depression units. It is built by Miocene and Pliocene deposits. In the east, is in discordance with flysch deposits and tectonic contact with the evaporate deposits of diapir. Current thermal regimes express a low thermal regimen. The thermal regime during the history of geological development has been high. In the Ballagati syncline, many wells have been drilled in the search for gas and oil spills. The samples were taken from the cuttings of drilled wells in the geological section of the Ballagati syncline. These samples subjected to the pyrolytic determination (rock-eval analysis). During the process of assessing the petroleum potential in the Neogene section of Ballagati syncline, it was observed that the maturation of the organic matter (expressed by Tmax) is lower than the eastern section contacting the diapir. This fact inspired us to prepare this article, evidencing this phenomenon in the geological units in the west of the Dumrea diapir. The maturation of the sedimentary section in the Ballagati syncline is the result of burial history. There is low maturity, while in the eastern side maturation is higher (in contact with diapir). This is due to the thermal effect of the diapir before it is exposed on the surface. This effect is most evident in the southwest of the diapir (where the wells Gajda-1 and Kosova-2 / s have been drilled).

Keywords: Drilled wells, Tmax, thermal conductivity, calculated vitrinite reflectivity.

Rezumat. Efectul diapirelor din Dumre asupra maturității termice în secțiunea geologică de la estul Sinclinalului Ballagati, Albania. Sinclina din Ballagati este una dintre cele mai estice unități de depresie adriatică. Este construită de depozite Miocene și Pliocene. În est, este în dezacord cu depozitele de flyș și contactul tectonic cu depozitele evaporate ale diapirului. Regimurile termice actuale exprimă un regim termic scăzut. În timp ce regimul termic în istoria dezvoltării geologice a fost ridicat în Sinclinalul Ballagati, multe puțuri au fost forate în căutarea scurgerii de gaze și petrol. Probele au fost prelevate din butașii puțurilor forate în secțiunea geologică a sticlinei Ballagati. Aceste probe au fost supuse determinării pirolitice (analiza rock-eval). În timpul procesului de evaluare a potențialului petrolier în secțiunea neogenă din Sinclinalul Ballagati, s-a observat că maturarea materiei organice (exprimată prin Tmax) este mai mică decât secțiunea estică care intră în contact cu diapirul. Acest fapt ne-a inspirat să pregătim acest articol, evidențiind acest fenomen în unitățile geologice din vestul diapirului Dumărean. Maturarea secțiunii sedimentare din sinclina Ballagati este rezultatul istoriei îngropării. Există maturitate scăzută, în timp ce în partea de est maturarea este mai mare (în contact cu diapirul). Acest lucru se datorează efectului termic al diapirului înainte ca acesta să fie expus pe suprafață. Acest efect este cel mai evident în sud-vestul diapirului (unde s-au forat puțurile Gajda-1 și Kosova-2 / s).

Cuvinte cheie: Fântâni grosiere, Tmax, conductivitate termică, reflexivitate calcinată a vitrinitului.

INTRODUCTION

There is no study of the thermal effect of Dumre's diapir. In general, general considerations are given. In an article quoted as “a memo” in the Kuçova anticline (Ionian zone) is more mature than in other sectors (PRIFTI et al., 2014). Kuçova anticline is located in the southeast of the region under study.

Also, the presence of caprocks on the surface is interpreted as the thermal effect of the diapir during its outbreak.

The drilled wells in the diapir and in the sedimentary section around it have allow thermal regime. This is interpreted for the negative effect of diapir when exposed to the surface (PRIFTI et al., 2017). But the higher temperatures of sedimentary rocks has passed (before the diapir was exposed to the surface) are "fossilized" at the highest maturity level. This is the thermal effect of the diapir, which was evaluated by thermal parameters, such as Tmax, Productivity Index, and Calculated Vitrinite reflectance. Current temperatures measured in drilled wells are low, where it is noticed that drilled wells in diapir have lower temperature gradients.

The eastern side of Ballagati syncline is placed trangressively on the Oligocene flysch deposits (Ionian zone) and affected by hydrocarbon migration. The wells drilled in this direction are included in the Rase-Pekisht oilfield. Also, the wells in the Murrizi region (the eastern side of the Ballagati syncline) have met bituminous sandstones in Messinian deposits. These wells are not included in the study. Only the Pekisht-30 and Pekisht-51 wells were interpreted.

The highest values of maturity indicators at the east of the Ballagati syncline are related to the thermal effect of Dumre diapir.

GEOLOGICAL SETTING

The region we had chosen for the study is built by two geological units: the Ionian Zone and the Adriatic Depression. In the Ionian zone, are included the Dumre diapir, the Murrizi anticline and the syncline of Pekisht, while in the Adriatic Depression there is the syncline of the Ballagat and the Karbunare-Lushnje-Konjat anticline (Fig. 1).

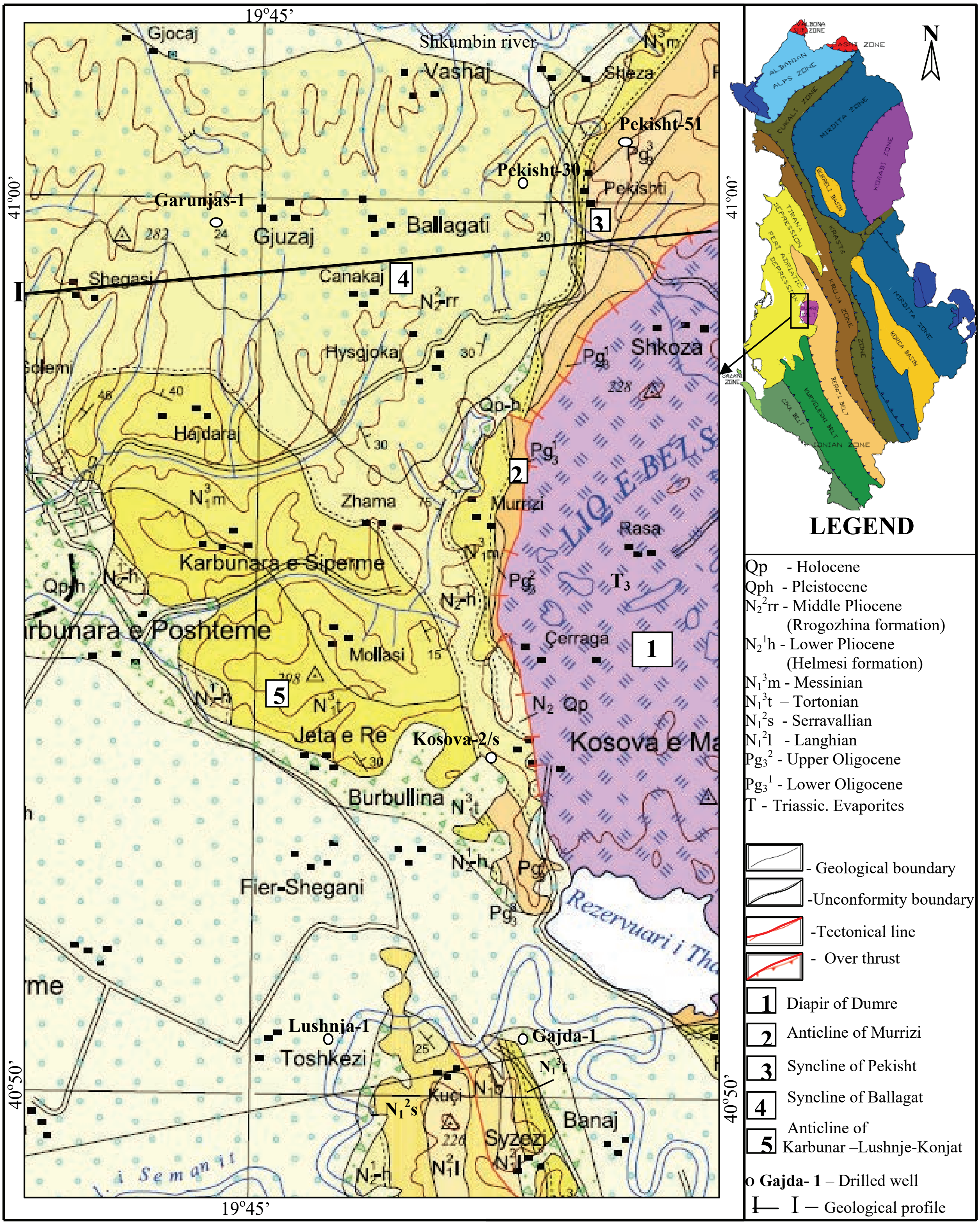


Figure 1. Geological map of Ballagati’s syncline (after VRANAJ et al., 2002, modified by Prifti).

The **Dumrea diapir** is considered an important geological link and is represented by the evaporate rocks of the Upper Triassic age. The diapir has the shape of a wedge, has broken the carbonate and flysch rocks. The Dumrea diapir is surrounded by Oligocene flysch deposits, while on the surface it is covered by caprocks. The body of the diapir is represented by anhydrite, gypsum and salts. The lakes and sinkholes are created by the dissolution of salts.

The high thermal conductivity of minerals has contributed to the increase of the sedimentary rock thermal regime (Table 1) which surrounds the diapir until it is exposed to the surface. After this time, the diapir affects the reduction of the thermal regime.

Table 1. Thermal conductivity of some minerals (MIDDTOMME & ROALDSET, 1999).

Minerals	Thermal conductivity ($Wm^{-1}K^{-1}$)
Quartz	7.8
Calcite	3.4
Dolomite	**5.1**
Anhydrite	**6.4**
Pyrite	19.2
Siderite	3.0
K-feldspar	2.3
Albite	2.3
Mica	2.3
Halite	**6.5**
Kaolinite	2.8
Illite	1.8
Mixede layer I/S	1.9
Oil	0.21
Gas	0.21

The Murrizi anticline is located in the western part of the diapir contact. It is constructed from the thick layers of sandstones with turbidite layers (Pg_3^1) and onwards with the thin flysch layers. In the western part, it is depicted by the transgressive placement of Messinian deposits (QIRKO, 2008).

The Pekishti syncline is located in the northern part of the flysch belt, which exposes only the eastern side, the western side is disguised by Messinian deposits which are transgressively placed on the flysch deposits. The center of syncline is constructed by a thin layer of flysch deposits (Pg_3^2). The eastern side of this syncline is tectonically complicated by Dumrea diapir. In this unit the Pekisht-51 well was drilled.

These two units represent the eastern extremity of the Ionian Zone.

The Ballagati syncline (Fig. 2) extends the west of the Dumrea diapir. The southern starts somewhere in the Kosova village (Kosova-2/s well is drilled). In this sector, oldest deposits of Langhian-Serravalian are exposed, while the north side continues to the Shkumbini River. The syncline is constructed from the sandstone and claystone sedimentary rock of Miocene-Pliocene.

The newest deposits that fill the center of this syncline are the Pliocene ones. The western side runs to the anticline of Karbunare - Lushnje-Konjat. The eastern side is in contact with flysch and salt deposits of Dumrea diapir. In this regard it meets the oil traps (PRIFTI et al, 2017).

The Karbunar-Lushnje-Konjat anticline stretches to the west of the Ballagati syncline, from Karbunar village to Hajdaraj, north of Lushnja town. It is constructed from the same deposits. In the southern part, Messinian-Pliocene deposits are missing, while in the north they begin to appear gradually. The region is exposed only in the eastern side.

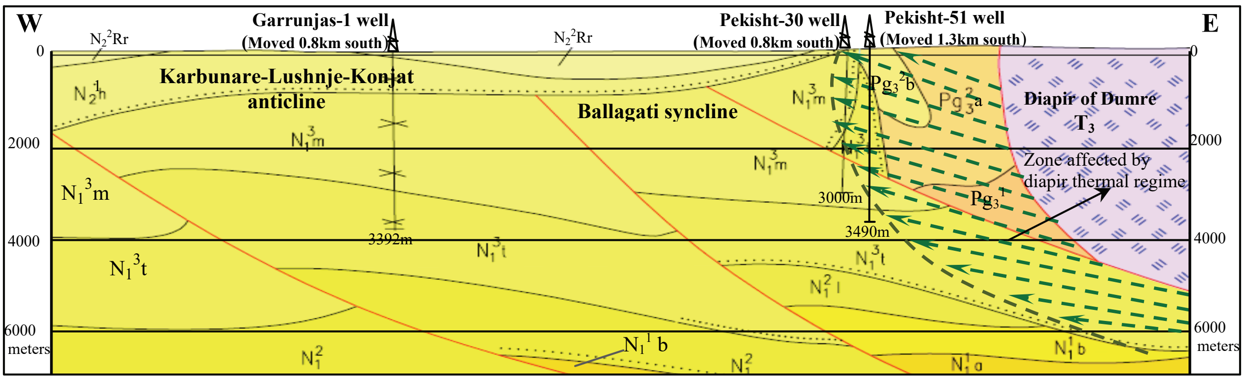


Figure 2. Geological profile in west side of diapir (VRANAJ et al., 2002, modifed by Prifti).

MATERIAL AND METHOD

Current geothermal studies have been conducted by various authors where the most prominent are the studies of prof. Alfred Frasheri (FRASHERI & FRASHERI, 2005). Current geothermal estimations are carried out in drilled wells. The temperature in the wells was recorded at regular intervals. It was measured by means of resistance and hermistor thermometers. The measurements were carried out in a steady-state regime of the wells filled with mud or water (FRASHERI & FRASHERI, 2005).

We have separated 3 wells: the Garunjas-1 well in the Ballagatan Syncline (Miocen-Pliocene section of Adriatic depression); Paper-1 in flysch deposits coverings the diapir (north of diapir body); the Grekan-4 well drilled in the body of diapir (east of the region under study). Their geothermal gradients are different, indicating by diapir and burial history (Figs. 3, 4).

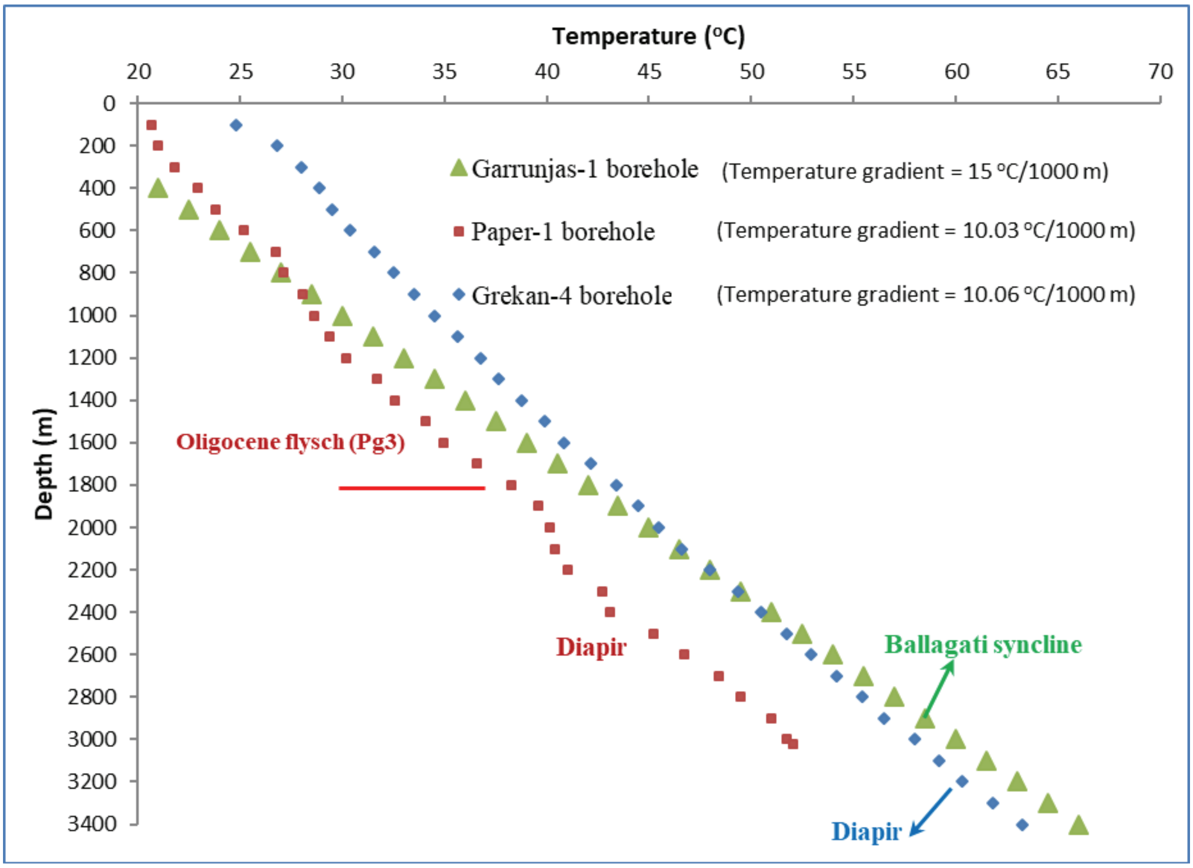


Figure 3. Measured temperatures and geothermal gradient in drilled boreholes in region.

Based on the field observations it was observed that the flysch blocks on the diapir have been reddish, as a result of the thermal influence of the diapir.

The thermal effect of diapir is the result of the high thermal conductivity of minerals, such as dolomite, anhydrite, halite and various salts. This feature has been studied by various authors given in Table 1. Also in the geophysical logs of drilled wells in the diapir, the high content of these minerals are identified (SOTA et al., 2002).

The diapir thermal effect is sensitive to the sedimentary rock surrounding the diapir. This effect is "fossilized" at the maturity level of the organic matter of sedimentary rocks. Exposure to the surface of the diapir ends up the thermal effect, or otherwise affects the cooling of the geological section.

Salts of diapir have been modeled as having a large effect on the thermal maturity of surrounding sediments as a result of the high thermal conductivity contrast between halite and other lithologies (DOWNS, 2012).

The study did not take into account the wells drilled in the Rase-Pekisht oilfield. The pyrolytic indicators are masked by the presence of oil and lead to wrong conclusions. For this reason, 6 wells were studied. Four wells were drilled in the eastern side of the Ballagati syncline (Pekisht-30, Pekisht-51, Kosova-2/s and Gajda-1), while Garunjas-1 was drilled on the western side. The Lushnja-1 well was drilled to the west of the Gajda-1 well. Samples of wells (which are stored) were subjected to pyrolytic determination by means of the "Oil Show Analyzer". The samples were taken only in the clay faction in the Messinian-Tortonian deposits. In the Middle Miocene deposits, the samples were taken from the claystone and marlstone fractions (MILE, 2017).

Geochemical estimation was performed on sedimentary section penetrated by wells. We will not interpret all the "rockeval" indicators, but only those who evaluate the maturity of the organic matter as Tmax (Table 2).

Table 2. Geochemical parameters of Tmax, PI and calculated vitrinite reflectivity.

Wells	Depth (m)	Tmax (^oC)	RoCalc (%)	PI	Wells	Depth (m)	Tmax (^oC)	RoCalc. (%)	PI
Garunjas-1	3000	415	0,31	0	Garunjas-1	3265	422	0,436	0
Garunjas-1	3003	416	0,328	0	Garunjas-1	3266	426	0,508	0
Garunjas-1	3006	419	0,382	0	Garunjas-1	3270	417	0,346	0
Garunjas-1	3009	417	0,346	0	Garunjas-1	3273	421	0,418	0
Garunjas-1	3010	421	0,418	0	Garunjas-1	3277	418	0,364	0
Garunjas-1	3012	416	0,328	0	Garunjas-1	3280	421	0,418	0
Garunjas-1	3018	420	0,4	0	Garunjas-1	3283	422	0,436	0
Garunjas-1	3021	419	0,382	0	Garunjas-1	3286	419	0,382	0
Garunjas-1	3024	416	0,328	0	Garunjas-1	3288	416	0,328	0
Garunjas-1	3027	420	0,4	0	Garunjas-1	3293	418	0,364	0
Garunjas-1	3034	418	0,364	0	Garunjas-1	3296	413	0,274	0
Garunjas-1	3036	413	0,274	0	Garunjas-1	3299	419	0,382	0
Garunjas-1	3042	413	0,274	0	Garunjas-1	3302	426	0,508	0
Garunjas-1	3045	416	0,328	0	Garunjas-1	3305	422	0,436	0
Garunjas-1	3047	425	0,49	0	Garunjas-1	3308	425	0,49	0
Garunjas-1	3051	413	0,274	0	Garunjas-1	3311	420	0,4	0
Garunjas-1	3059	417	0,346	0	Garunjas-1	3314	421	0,418	0
Garunjas-1	3061	416	0,328	0	Garunjas-1	3318	421	0,418	0
Garunjas-1	3064	416	0,328	0	Garunjas-1	3321	423	0,454	0
Garunjas-1	3069	416	0,328	0	Garunjas-1	3327	425	0,49	0
Garunjas-1	3072	414	0,292	0	Garunjas-1	3330	427	0,526	0
Garunjas-1	3075	414	0,292	0	Garunjas-1	3333	417	0,346	0
Garunjas-1	3101	414	0,292	0	Garunjas-1	3336	423	0,454	0
Garunjas-1	3105	418	0,364	0	Garunjas-1	3339	420	0,4	0
Garunjas-1	3107	418	0,364	0	Garunjas-1	3342	421	0,418	0
Garunjas-1	3110	413	0,274	0,03	Garunjas-1	3342	428	0,544	0
Garunjas-1	3112	418	0,364	0	Garunjas-1	3345	414	0,292	0
Garunjas-1	3114	418	0,364	0	Garunjas-1	3349	419	0,382	0
Garunjas-1	3119	415	0,31	0	Garunjas-1	3352	419	0,382	0
Garunjas-1	3122	422	0,436	0	Garunjas-1	3355	427	0,526	0
Garunjas-1	3125	420	0,4	0	Gajda-1	1279	425	0,49	0
Garunjas-1	3128	414	0,292	0	Gajda-1	1353	429	0,562	0
Garunjas-1	3131	415	0,31	0	Gajda-1	1512	428	0,544	0
Garunjas-1	3134	423	0,454	0	Gajda-1	1640	430	0,58	0
Garunjas-1	3137	423	0,454	0	Gajda-1	1723	429	0,562	0
Garunjas-1	3144	419	0,382	0	Gajda-1	1802	429	0,562	0
Garunjas-1	3149	417	0,346	0	Gajda-1	1876	425	0,49	0
Garunjas-1	3166	413	0,274	0	Gajda-1	1971	430	0,58	0
Garunjas-1	3169	416	0,328	0	Gajda-1	1997	431	0,598	0,063
Garunjas-1	3172	420	0,4	0	Gajda-1	2090	427	0,526	0
Garunjas-1	3175	423	0,454	0	Gajda-1	2225	428	0,544	0,026
Garunjas-1	3178	424	0,472	0	Gajda-1	2268	424	0,472	0,045
Garunjas-1	3181	422	0,436	0	Gajda-1	2268	428	0,544	0,063
Garunjas-1	3184	416	0,328	0	Kosova-2/s	648	428	0,544	0
Garunjas-1	3187	415	0,31	0	Kosova-2/s	803	424	0,472	0
Garunjas-1	3190	417	0,346	0	Kosova-2/s	955	429	0,562	0
Garunjas-1	3195	414	0,292	0	Kosova-2/s	1006	430	0,58	0
Garunjas-1	3198	417	0,346	0	Kosova-2/s	1796	427	0,526	0
Garunjas-1	3201	417	0,346	0	Kosova-2/s	1996	432	0,616	0
Garunjas-1	3205	422	0,436	0	Kosova-2/s	2247	435	0,67	0,049
Garunjas-1	3208	419	0,382	0	Kosova-2/s	2383	431	0,598	0
Garunjas-1	3211	417	0,346	0,07	Kosova-2/s	2745	426	0,508	0
Garunjas-1	3216	419	0,382	0	Lushnja-1	1020	430	0,58	0
Garunjas-1	3220	424	0,472	0	Lushnja-1	1143	428	0,544	0,036
Garunjas-1	3224	422	0,436	0	Lushnja-1	1260	424	0,472	0,053
Garunjas-1	3228	419	0,382	0	Lushnja-1	1669	430	0,58	0,166
Garunjas-1	3229	420	0,4	0,56	Pekisht-30	2005	427	0,526	0,375
Garunjas-1	3232	422	0,436	0	Pekisht-30	2629	414	0,292	0,1
Garunjas-1	3235	423	0,454	0	Pekisht-30	2921	412	0,256	0,333
Garunjas-1	3240	417	0,346	0	Pekisht-51	3439	426	0,508	0,47
Garunjas-1	3250	415	0,31	0	Pekisht-51	346	429	0,562	0,118
Garunjas-1	3255	416	0,328	0	Pekisht-51	3473	418	0,364	0,04
Garunjas-1	3263	418	0,364	0	Pekisht-51	3473	424	0,472	0,063

Based on the conducted studies, it is estimated that the organic matter in the Miocene-Pliocene deposits is of the third type.

Another indicator for the maturity assessment is the productivity index, which is calculated from the equation, $PI = S_1 / (S_1 + S_2)$ ratio, where S_1 is the presence of free rock oil, S_2 the presence of oil, which is generated during the increase of temperature.

By means of Tmax, the reflectance of the vitrinite for the values of Tmax <430°C was calculated, by equation:

Ro(%) = (0.018 x Tmax) -7.16 where Tmax is reported in °C (JARVIE, 2001).

The values of the used indicators (Tmax, PI) and the calculated reflectance are given in Table 2.

The relationship between vitrinite reflectance and time-temperature history of the sedimentary rocks (GURI et al., 2002; LOPATIN, 1976; PRIFTI, 1995; 2011) was applied to calculate the paleotemperatures. This method utilizes a modified Lopatin method, which presents the relationship between Vitrinite Reflectance and the time-temperature history of the sedimentary rocks (LOPATIN, 1976; PRIFTI, 1995; PRIFTI & PRENJASI 2011), as follows:

$\mathbf{Ro^a = R^a_{init} + bt\ exp(cT)}$, where:

Ro = vitrinite reflectance

$\mathbf{R_{init}}$ = initial reflectance of vitrinites (0.20 or 0.15%),

a = 5.5, b= 2.8 $*10^6$, c = 0.065,

t = time (Ma), T = temperature (°C).

The paleotemperatures are about 18°C higher than current temperatures, while the paleogeothermal gradient is 20.6ºC/1000m for Miocene-Pliocene deposits. Actual geothermal gradient is 15ºC/1000m. While in diapir, actual geothermal gradient is 10ºC/1000m.

RESULTS AND DISCUSSION

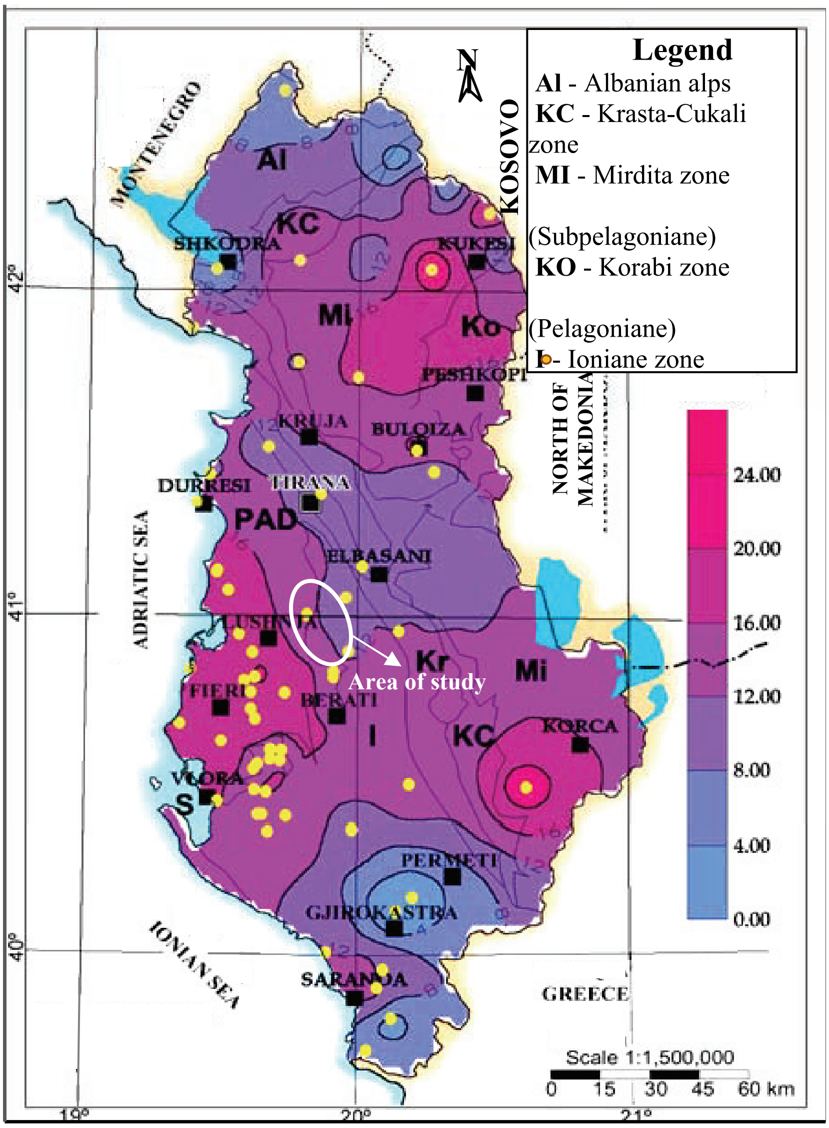


Figure 4. Geothermal gradient map of Albania (based on FRASHERI & FRASHERI, 2005, modified by Prifti and Gjika).

Current geothermal gradient estimates. As noted above, we will discuss the trend of thermal gradients in the three wells: Garrunjas-1; Papri-1 (in the northeast of the region) Grekan-4 (in the east of the region, on top of diapir body). Temperature measurements are obtained from wells files. By comparing the geothermal gradients, these changes are observed:

a. The current geothermal gradient in the Garrunjas-1 well is 15°C / 1000m.

b. The geothermal gradient in the Grekan-4 well, is 10.06°C1000m. It has higher values of temperatures, but low geothermal gradients. These phenomena are related to the high thermal permeability of evaporate rocks.

c. Papri-1borehole presents an interesting curve of the geothermal gradient. After the flysch block (in contact with the diapir) there is a very low temperature rise. We think it should be related to the presence of "cuprock". After the 2100m depth the same tendency of the geothermal gradient of diapir continues. The geothermal gradient is 10.03°C1000m (Figs. 3, 4).

Evaluation of the Maturity of Garunjas-1well. Garunjas-1well is the most studied well. This is also related to the search for biogenic gas traps in the Messinian-Tortonian section. The maximum temperature (Tmax) as described above fluctuates in the range of 410 °C ÷ 425 °C in the Messinian deposits (Fig. 5). These values show a low level of maturity of organic matter (is immatured).

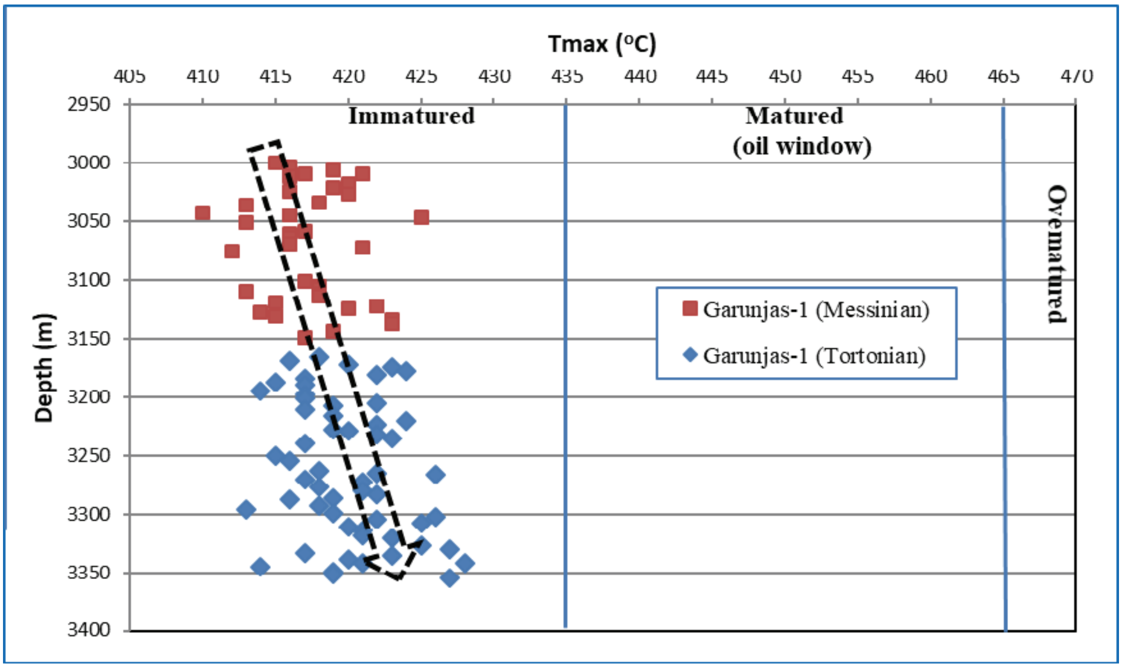


Figure 5. Maturation of organic matter (Tmax) in the geological section of the Garunjas-1 well.

Interpretation of this indicator is given in Fig. 5, where up to 435°C is the immatured stage, 435°C ÷ 465°C organic matter is matured and is included in the "oil window", whereas when exceeded the value of 465°C is included in the overmatured stage.

The maximum temperature (Tmax) varies in the range of 413 °C ÷428 °C in the Tortonian deposits; therefore it is more mature than those of Messinian. In Fig. 5 it is noticed that maturation of organic matter increases with the depth as a result of the burial history of the Ballagati's syncline.

The same tendency is observed with the calculated reflectance of vitrinitite (Fig. 5). This indicator fluctuates in the range of 0.22%÷0.49% for the deposits of Messinian and 0.274%÷0.544% for the Tortonian deposits.

Evaluation of the Maturity of others wells (Pekisht-30, Pekisht-51, Kosova-2/s, Gajda-1, Lushnja-1). The maximum temperature (Tmax) fluctuates in the range of 424 °C ÷ 435 °C in the upper block of Messinian deposits (Fig. 6). These values show a maturity level somewhat higher than of Garunjas-1 well. This phenomenon is the result of Diapir's thermal impact.

Current geothermal studies show low values of geothermal gradients (Figs. 3; 4). The current geothermal gradients of geological section rise from the diapir to the geological section surrounding the diapir.

Calculated values of the vitrinite reflection in the Messinian-Tortonian section of Garunjas-1 well (Fig. 7), were faced with the measured values of vitrinite reflection in drilled wells (PRIFTI, 2007) in the Adriatic Depression. It is noted that they are almost the same values that express the maturation of sedimentary section as a result of the burial history of the Adriatic Depression.

Maturity is also valued with the productivity index. There are few calculated PI values as there is no free oil on the sedimentary rocks (organic matter is of the third type that does not generate oil). Based on this indicator the section did not enter the "oil window" and its tendency to increase with depth is noticed (Table 2).

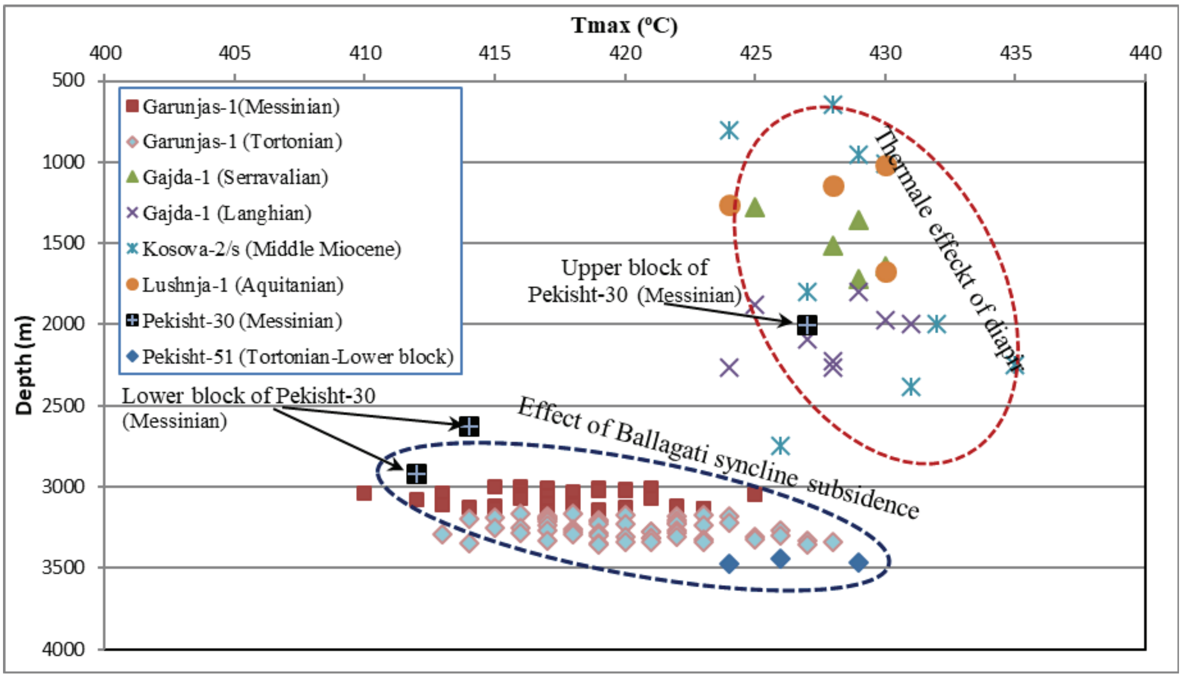


Figure 6. Maturity of Organic matter (Tmax) in geological section of wells drilled in the Ballagati region.

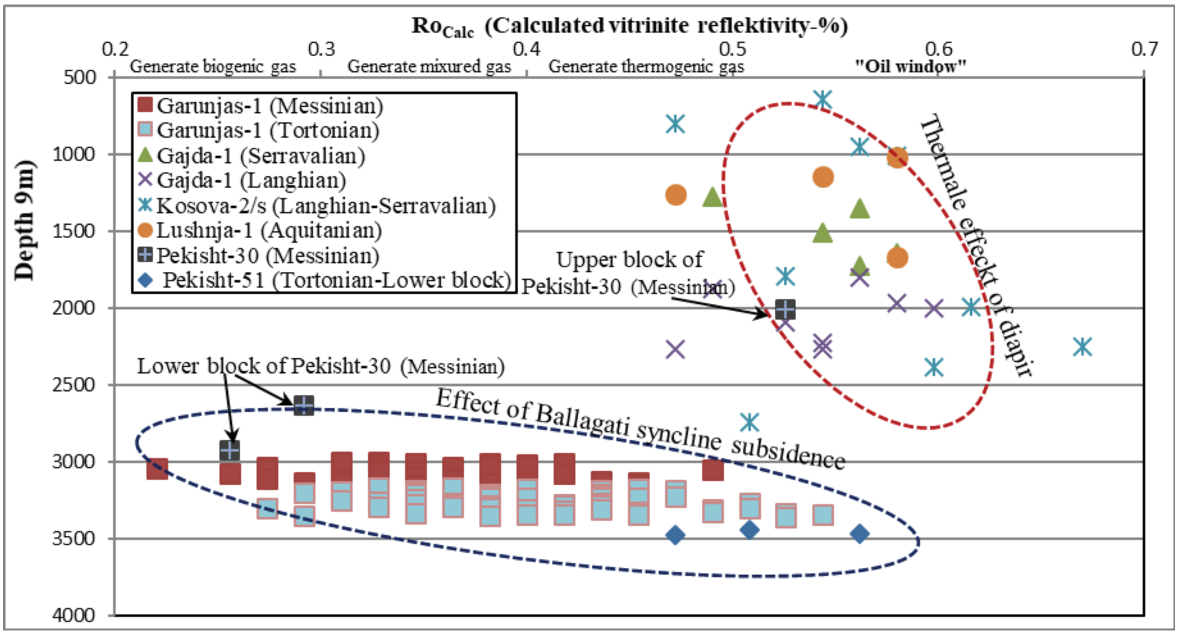


Figure 7. Maturity of Organic matter by Calculated vitrinite reflection (Ro_{calc}) in geological of drilled wells in the Ballagati region.

At this level of maturity that has the geological section penetrated by Garunjas-1 well. The lower block penetrated by the Pekisht-30 and Pekisht-51 wells is at the same level of maturity. This block represents one of the deeper sectors of the Ballagati's syncline. This maturity level is not influenced by the thermal effect of the diapir but by the burial history of the Ballagati syncline. Thus, the Tmax in the Tortonian deposits in the Pekisht-51 well fluctuates in the range of 424 °C to 429°C, which represents the most mature level of Ballagati syncline.

Evaluation of the maturity of wells in the eastern part of Ballagati syncline. Drilled wells near the western periphery of the diapir are: Pekisht-30 (upper block); Pekisht-51 (upper block); Kosovo-1/s; Gajda-1 and Lushnja-1.

The maximum temperature (Tmax) fluctuates at 424°C÷ 435°C, therefore it is higher than that in the Ballagati's syncline (mostly Garunjas-1). This change appears clearly in the two blocks penetrated by the Pekisht-30 well, where the upper block (Messinian deposits) has Tmax higher than the lower block (Messinian deposits).This result is interpreted only with the diapir thermal effect.

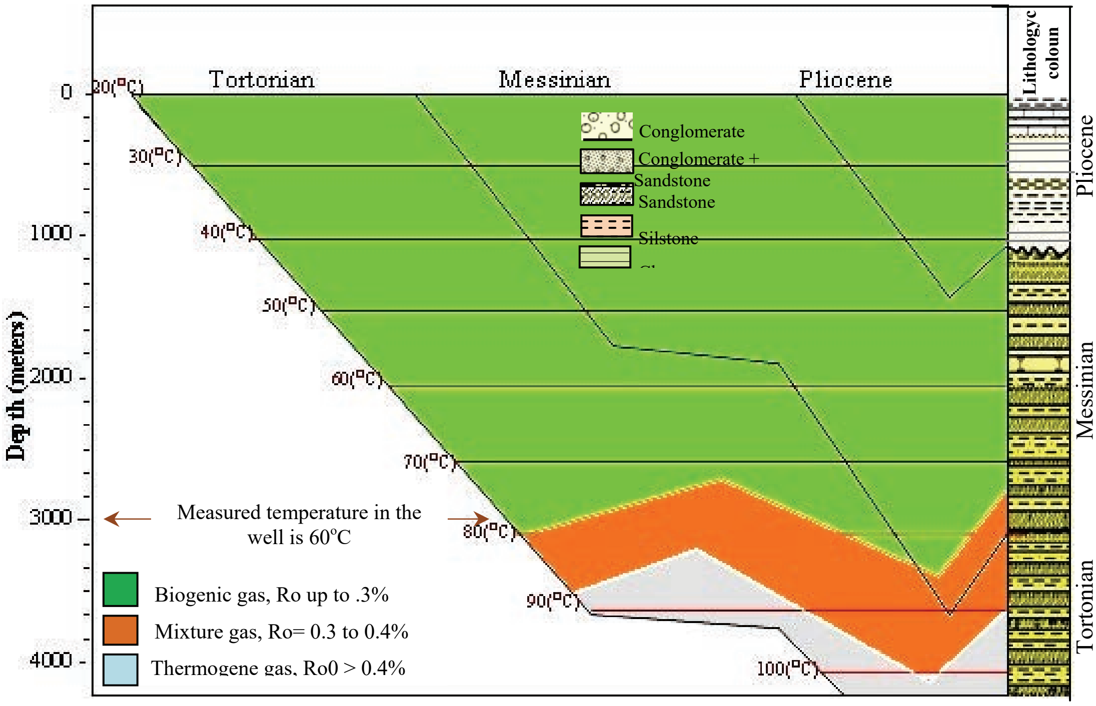
The highest values of Tmax are most clearly reflected in the geological section of the Gajda-1 and Kosovo2 / s wells (wells near the diapir).

The high values of Tmax reflect the thermal effect of the Dumrea diapir in increasing the maturation of the sedimentary rocks surrounding the diapir.

The same tendency to increase maturity is also represented by the values of calculated reflectance vitrinite and productivity index.

Burial history of Ballagati syncline. Preparation of the burial history requires several conditions: recognition of the real thickness of the geological section (Pliocene and Miocene); there should be no tectonic breakdown and geothermal gradient estimation. These conditions are met by the geological section of the Garrunjas-1 well Proper paleotemperatures and paleogradients data help determine burial history (PRIFTI & PRRENJASI, 2011) of the Ballagati syncline (Fig. 8).

Geothermal paleogradient is estimated 20°C/1000m (in position of Garrunjas-1 borehole).



Burial history can't be prepared on the eastern side of the Ballagati syncline. In this side, the thickness of Miocene-Pliocene deposits is reduced. This sector has an active tectonic as a result of tectonic activity of the diapir. This phenomenon is clearly expressed in the geological section of Kosovo-2 / s well.

Based on the interpretations in Figs. 7 and 8, Pliocene section has generated biogenic gas. Messinian section has generated mixed hydrocarbon gas (generated by early biochemical and thermal factor) and early thermal gas. Tortonian section has entered the "oil window" and has generated thermal hydrocarbon gas.

The geological section of Kosovo-2 / s well has entered the "oil window" and has generated hydrocarbon thermo-gas. The highest level of maturity is influenced by the diapir's thermal effect.

CONCLUSIONS

The current geothermal gradient decreases in the direction of the diapir towards the west from 10°C/1000m to 16 °C / 1000m.

Geothermal paleogradients have been higher than the current one and go up to 20°C/1000m.

The region has undergone two thermal regimens:

The thermal regime as a result of the burial history of the Ballagati syncline. ;

The thermal regime influenced by the Dumrea diapir in sedimentary rock surrounding the diapir.

The level of maturity at Ballagat's syncline goes up to the entrance of the “oil window”.

The level of maturity on the eastern side of the Ballagatan syncline is included in the “oil window”.

The region where the diapir's thermal effect is most evident extends to the Kosovo-1 / s and Gajda-1 wells. This should be the result of the southwest direction of the explosion of the Dumrea diapir.

The sedimentary section that has been on the cup’s diapir (before it is exposed to the surface) should be more mature than the other large distance of diapir.

The thermally influenced section by the diapir is tectonised.

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Prifti Irakli
Polytechnic University of Albania
Faculty of Geology and Mining, Department of Earth Sciences
Rruga e Elbasanit, Tiranë, Republic of Albania
E-mail: irakliprifti@yahoo.com

Gjika Aleksander
Albpetrol Sh. a. Petroleum Company
Patos, Republic of Albania
E-mail: Aleksander.Gjika@albpetrol.al

Piperi Arqile
Albpetrol Sh. a. Petroleum Company
Patos, Republic of Albania
E-mail: Arqile.Piperi@albpetrol.al

Loçi Rezeart
Albpetrol Sh. a. Petroleum Company
Patos, Republic of Albania
E-mail: Rezart.Loci@albpetrol.al

Minga Ervin
NOA CONTROL ltd, Tiranë, Republic of Albania
E-mail**:** ervin-minga@hotmail.com

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PETROGRAPHY AND PROVENANCE OF THE FRĂTEŞTI BEDS GRAVELS (SOUTHERN DACIAN BASIN)

GHENCIU Monica, CULESCU Flori

Abstract. Pebbles of quartzo-feldspathic gneisses, quartzites, cherts, sandstones, andesites, andesitic tuffs, and hornblende gneisses have been identified in the Frăteşti Beds gravels (Lower Pleistocene) from the southern Dacian Basin, Giurgiu Town area. As rare petrographic types we mention the pebbles of spessartite gneisses, andesitic tuffs, and sandstones with lithoclasts of jasper. All these rocks are also present in the coarse gravels of the contemporary Cândeşti Beds (Lower Pleistocene) in the Getic Piedmont east of the Olt River, with certain Carpathian provenance. The paper argues in favor of the Carpathian origin of the Frăteşti Beds gravels.

Keywords: Frăteşti Beds, gravels, provenance.

Rezumat. Petrografia şi provenienţa pietrişurilor din Stratele de Frăteşti (sudul Bazinului Dacic). În pietrişurile Stratelor de Frăteşti (Pleistocen inferior) din sudul Bazinului Dacic, zona Giurgiu, au fost identificate gnaise cuarţo-feldspatice, cuarţite, cherturi, gresii, roci andezitice şi gnaise cu hornblendă. Ca tipuri petrografice rare, menţionăm galeţii de gnaise cu spessartin, tufuri andezitice şi gresii cu litoclaste de jaspuri. Toate aceste roci apar şi în pietrişurile grosiere ale Stratelor de Cândeşti (Pleistocen inferior) din Piemontul Getic de la est de Olt, cu certă provenienţă carpatică. Lucrarea aduce argumente în favoarea originii carpatice a pietrişurilor din Stratele de Frăteşti.

Cuvinte cheie: Strate de Frăteşti, pietrişuri, provenienţă.

INTRODUCTION

Stratigraphic data. The Frăteşti Beds or Gravels (LITEANU, 1952; 1953) represent the Lower Pleistocene fluvial deposits of sands with gravels in the southern Dacian Basin. The stratotype is near the Frăteşti Village, Giurgiu County (LITEANU, 1953). These deposits occupy much of the Wallachian Depression, starting from the lower basins of the Siret and Prut rivers and continuing along the Danube till the west of the Olt River. The sands and gravels horizon extends to the north in the lower basins of the Ialomiţa, Argeş and Vedea rivers (GHENEA et al., 1969). In the investigated region, the Frăteşti Beds outcrop on the southern margin of the Burnas Plain and the valleys that drain this plain (BANDRABUR et al., 1966). The thickness of the sands level with gravels is of 10-13 m in the drillings from the Giurgiu Town area.

Over the Frăteşti Beds lies a horizon of sandy marls and clays of 3-4 m thick representing the southern extension of the marly complex intercepted in the drillings from Bucharest (LITEANU, 1952). The marly complex in the Burnas Plain is largely eroded and covered by loessoid deposits with limestone concretions, of Late Mid-Pleistocene and Upper Pleistocene age (BANDRABUR et al., 1966). North of Giurgiu, on the southern margin of the Burnas Plain between the villages of Daia and Frateşti, the Lower Pleistocene sandbanks with gravels lie over the Romanian gray clayey marls (LITEANU, 1953). Older deposits, of Dacian and Cretacic age, are known from the drillings performed along the Danube.

Petrographic data. The first information on the petrographic composition of sands and gravels in the Dacian Basin were provided by MRAZEC (1899) who studied the samples from the drilling near the Mărculeşti Village, Ialomiţa County. Granites, ortophyres (orthoclase trahites), leptynites (quartzo-feldspathic gneisses in this case), Liassic quartzitic sandstones, micaceous sandstones, cherts, garnet-bearing micaschists, and Mesozoic white limestones were identified in the gravel. The sand contain quartz, muscovite, feldspar, garnet, rutile, magnetite, sphene, zircon, apatite, corundum, and kyanite granules. Based on petrographic observations, the author concludes that the studied detritic material is of Carpathian origin.

LITEANU (1952) has identified quartzites, granitic gneisses, micaschists, conglomerates, sandstones, jaspers, and cherts in the Frăteşti Gravels crossed by the drillings from Bucharest. In the Frăteşti Beds outcropping in the Burnas Plain, LITEANU (1953) found pebbles of rhyolites and cherts. In his opinion, these rocks could come from the Bulgarian Plateau (Pre-Balkans). Remarking the absence of Cretaceous limestone outcroping south of the Danube, the author admits that most of the detritic material in the Frăteşti Beds is of Carpathian origin. The petrographic types considered of Balkan origin (rhyolites, cherts) would be specific for the gravels in the Burnas Plain.

In this paper we present new data on the petrographic composition of the gravels in the Frăteşti Beds. For this were sampled the gravels on the southern margin of the Burnas Plain outcropping in the Onceşti Quarry and near the Daia Village, north of the Giurgiu Town. We have not found gravels outcrops on the valleys in the plain. For the samples to be representative it was taken into account the frequency of the petrographic types encountered on the field and their relevance to identify the provenance area. Forty-eight samples of pebbles were fully collected representing the following petrographic types, in order of frequency estimated on the field: quartz (4 samples, irrelevant to the source area), quartzo-feldspathic gneisses (14 samples), quartzites (2 samples), cherts (17 samples), sandstones (4 samples), volcanic rocks (6 samples), and hornblende gneisses (one sample). The pebbles dimensions are small, rarely exceeding 10 cm.

MICROSCOPIC STUDY

Quartzo-feldspathic gneisses. Are fine to coarse grained leucocratic rocks with oriented to massive (granitic) texture. Their mineral association contains two metamorphic parageneses. The first paragenesis, well represented in the massive gneisses, consists of quartz, plagioclase feldspar (oligoclase), reddish-brown (ferric) biotite, greenish-brown (ferroan) biotite, rare green hornblende, and apatite as accessory mineral. The second paragenesis, especially present in the gneisses with oriented texture, is mainly composed of K-feldspar (microcline) and muscovite formed on the expense of plagioclase, respectively biotite, in medium grade metamorphic conditions. The manganiferous garnet (spessartite) is also present in one sample (Fig. 1). Magnetite, ilmenite, sphene, and minerals from the epidote group are by-products of the two substitution reactions. In post-metamorphic alteration processes, chlorite and sericite are formed on the expense of biotite, respectively oligoclase.

Cherts. Are fine-grained sedimentary rocks with massive or layered textures and various colors of ocher, reddish-brown, red and gray, given by the content of organic matter and iron oxides and hydroxides (hematite, goethite). They consist of a fine-grained chalcedony mass with varying proportions of organic remains (Fig. 2a), frequent silicified radiolarians tests and spicules, organic matter, and quartz microclasts. The radiolarians tests are undeformed in the massive cherts and flattened in the layered ones (Fig. 2b). According to texture and organic content, our samples can be grouped as cherts rich in radiolarians tests, cherts rich in silicified shells and organic matter, and micritic cherts poor in organic remains.

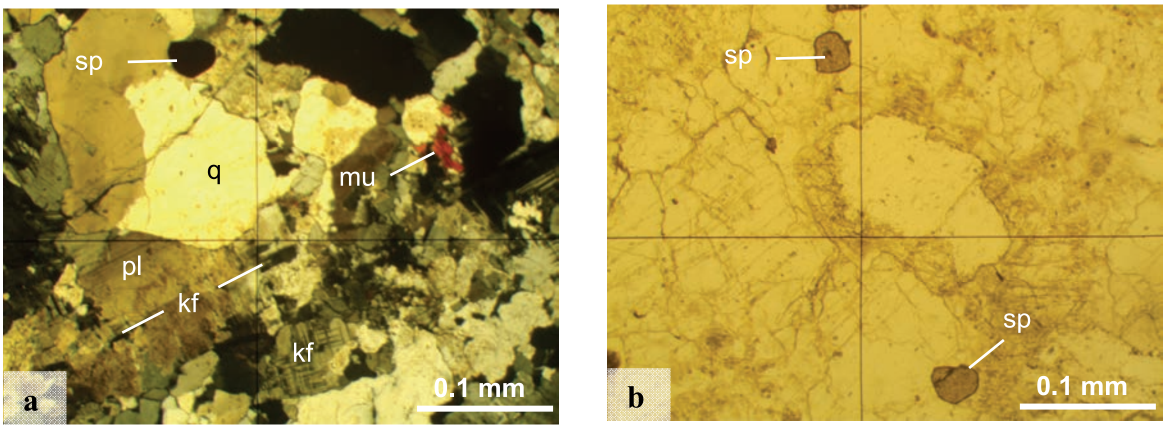

Figure 1. Thin sections in a pebble of quartzo-feldspathic gneiss with microcline (kf) formed on the expense of plagioclase (pl), muscovite (mu), quartz (q) and spessartite (sp). Cross-polarized (a) and plane-polarized light (b).

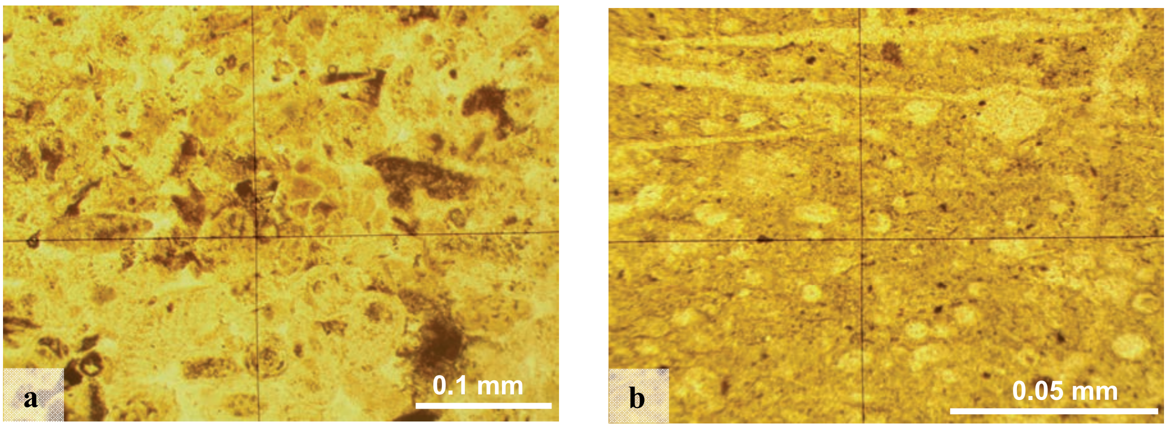

Figure 2. Thin sections in pebbles of cherts with silicified shells (a) and tests of radiolarians (b). Plane-polarized light.

Volcanic rocks. Are represented by andesites (4 samples) rhyodacites (one sample), and andesite tuffs (one sample). The andesites contain phenocrysts of zoned plagioclase, single or grouped in polycrystalline aggregates, phenocrysts and microlites of biotite and hornblende in various stages of decomposition (Fig. 3), and rare phenocrysts of quartz (5-10 percent) corroded by the melt from which the matrix crystallized. Fibrous aggregates of devitrified glass sometimes appear in the matrix. The andesitic tuff consists of a microcrystalline matrix of plagioclase and minor quartz, plagioclase phenocrysts with diffuse contours, and lithoclasts of altered andesite. The rhyodacite sample contains plagioclase phenocrysts with albite borders, corroded phenocrysts of quartz and opacified microlites of biotite. The proportions of plagioclase and quartz are approximately equal.

Sandstones. Are fine-grained quartzitic sandstones of light gray to reddish-gray color, with varying degrees of rounding and sorting. In addition to quartz, these also contain feldspar (albite and K-feldspar), micaceous minerals (sericite, muscovite, chlorite) and lithoclasts of gray quartzites. In a well-rounded and relatively well-sorted sample of reddish-gray sandstone there are also jasper lithoclasts (Fig. 4a).

Quartzites. Are rocks predominantly consisting of quartz, often with mylonitic textures. One of the two samples actually is a quartzitic mylonite with post-kinematically recrystallized matrix, coarse-grained aggregates of post-kinematically recrystallized quartz with intergranular magnetite associated with calcite and siderite (Fig. 4b), and microclasts of deformed relict quartz. A particularity of the quartzitic mylonite is the presence in the matrix of discrete alignments of Fe-Ti oxides (hematite, magnetite, ilmenite).

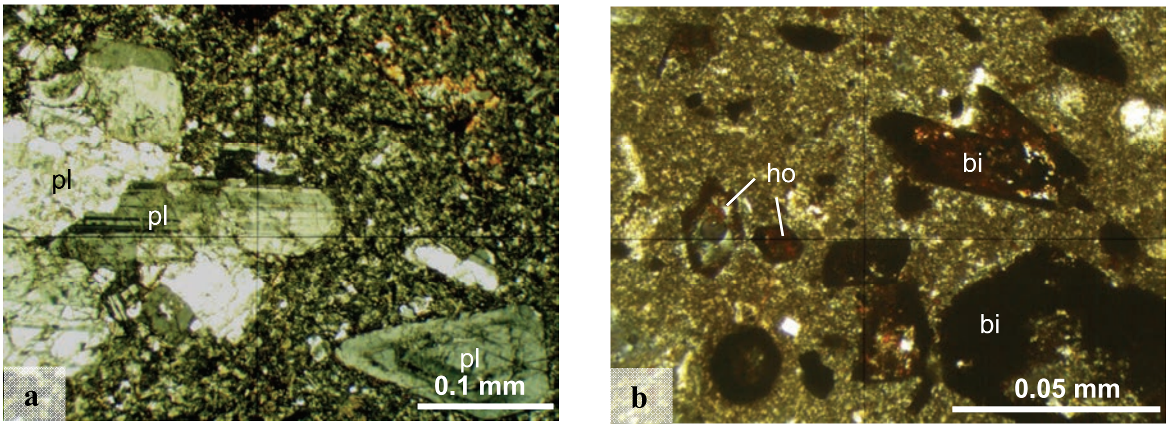

Figure 3. Thin sections in pebbles of andesites: a) euhedral and subhedral phenocrysts of plagioclase (pl); b) opacified phenocrysts of biotite (bi) and hornblende (ho). Cross-polarized light.

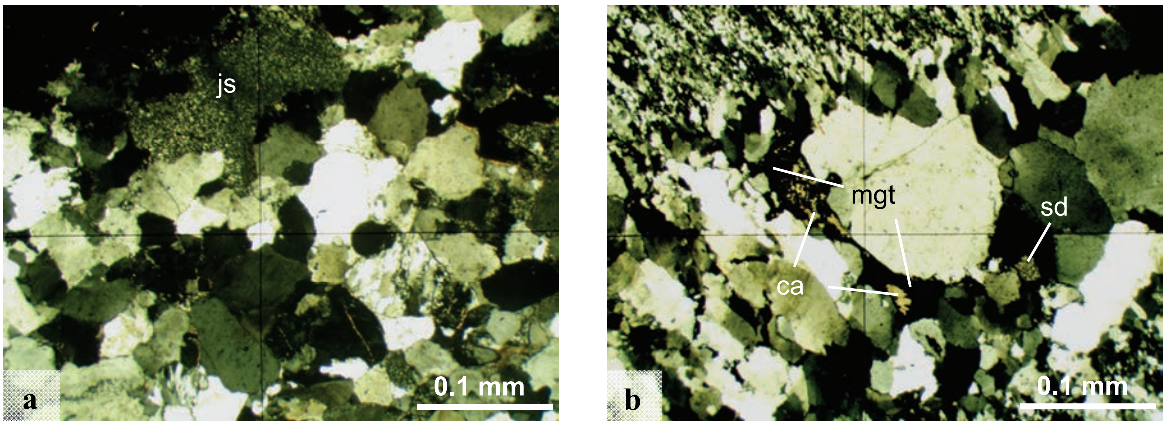

Figure 4. Thin sections in pebbles of sandstones (a) and quartzites (b). **a**) Reddish quartzitic sandstone with lithoclasts of jasper (js). **b**) Quartzite with magnetite associate with calcite (ca) and siderite (sd). Cross-polarized light.

DISCUSSIONS AND CONCLUSIONS

At the end of Pliocene (Romanian), the Dacian Basin has evolved as fluvial-lacustrine sedimentation area, bounded to the north by the Carpathian orogen and to the south by the Balkan orogen and the raised Pre-Balkans and Dobrogea adjacent areas (JIPA, 2006). Theoretically speaking, in the gravels and sands deposits of the Dacian Basin there should be detritic material of both Carpathian and Balkan origin, especially in its southern part. The source areas reconstitution based on the sediments thickness (e.g. JIPA, 1997) shows that the most active source of sediments was the Carpathian area throughout the evolution of the Dacian Basin (Sarmatian-Quaternary). The Balkan and Dobrogea areas had minor contributions in the southwest, respectively southeast of the basin.

Even minor, an influx of clastic material specific to the Dobrogea area, such as greenschists or basalts, is not found in the Frăteşti Gravels from the Giurgiu area. Regarding the possible Balkan origin of volcanic rocks and cherts evoked by LITEANU (1953), we specify that these rocks, like the reddish sandstones with jasper lithoclasts, are characteristic for the Cândeşti Gravels in the Cotmeana Piedmont, where the pebbles are large in relation to those in the southern part of the Dacian Basin. We must mention here that the petrography of the gravels from this piedmont is subject of the doctoral thesis of the coauthor of this paper.

Like in the Frăteşti Beds, the quartzo-feldspathic gneisses and the quartzites are the most common petrographic types of pebbles in the Cândeşti Gravels from the Getic Piedmont east of the Olt River (e.g. GHENCIU & STELEA, 2016).

The gneisses outcrop on large areas in the crystalline basement of the South Carpathians, but the spessartite-bearing quartzo-feldspathic gneisses only outcrop in the Getic Crystalline of the Sebeş-Cibin Mountains. Although outcrop as lenses, the quartzites frequently occur in the gravel deposits of the piedmont due to their resistance to weathering and transport. The magnetite-hematite quartzitic mylonites, which are rarer, outcrop inside the Infragetic Complex from The Parâng Mountains (e.g. STRUSIEVICZ & STRUTINSKI, 1988), structural equivalent of the Severin Nappe.

Likewise, the andesitic volcanic rocks are frequent in the Cândeşti Gravels of the Cotmeana Piedmont. As small pebbles, the andesites, among which an andesitic tuff, also appear in the Frăteşti Beds. The presence of tuffs at the exterior of the Carpathian arch is known. A lens of andesitic tuff is mentioned by GHENEA (1967) in the lower Pleistocene deposits of the Olteţ Piedmont, south of the Drăgăşani Town. The cineritic material origin, aeolian transported, is attributed to the Quaternary volcanism from the interior of the Carpathian arch. But the pebble of andesitic tuff identified in the gravels from Giurgiu was fluvial transported. We do not exclude the possibility of it coming from the levels of andesitic tuffs and agglomerates which were deposited in the Baraolt Basin during the Lower Pleistocene (LITEANU et al., 1962). The transport was probably provided by a river that crossed the South Carpathians at the beginning of Quaternary.

In conclusion, almost all the petrographic types of pebbles identified in the Frăteşti Gravels from the Burnas Plain also appear in the gravels from the Getic Piedmont, of the same Lower Pleistocene age. Are exceptions the spessartite-bearing quartzo-feldspathic gneisses and the andesitic tuffs, which have not been identified so far in the piedmont but which have lithological correspondent in the Carpathian area. From petrographic point of view, the gravels in the Frăteşti Beds are identical with those in the Cândeşti Beds. If the Cândeşti Gravels can not be questioned about the Balkan source area, given their proximity to the Carpathians and their petrographic composition, we do not see why the Balkan source should be invoked for the similar detritic material in the Frăteşti Gravels. In relation to the Carpathian source area, the gravels in the Frăteşti Beds represent the distal correspondent of the coarse gravels in the Cândeşti Beds.

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Ghenciu Monica, Culescu Flori
Geological Institute of Romania, 1st Caransebeș street, 012271 – Bucharest, Romania.
E-mails: monica_ghenciu@yahoo.com; m_flori_m@yahoo.com

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THE THERMO-MINERAL WATERS FROM THE HÂRȘOVA – VADU OII AREA, CONSTANȚA COUNTY

PERȘA Diana, BALTRES Albert

Abstract. The artesian well F1 drilled by the Hârșova City Hall in the northwestern part of the city intercepted on the 80-150 m depth interval the thermal mineral water aquifer in the Hârșova - Vadu Oii area, confirming the historical data related to this aquifer. The chemical and biological analyses of the water in the well attest to the fact that the water is maintaining its chlorosodic and sulfurous character of water, being recommended for curative purposes.

Keywords: thermo-mineral water, Hârșova – Vadu Oii.

Rezumat. Apele termo-minerale din zona Hârşova – Vadu Oii, judeţul Constanța. Puțul artezian F1, forat de Primăria Hârșova în partea de nord-vest a orașului, a interceptat pe adâncimea de 80 – 150 m acviferul de ape termo minerale din zona Hârșova - Vadu Oii, confirmând șirul de date istorice referitoare la acest acvifer. Analizele chimice și biologice ale apei din puț atestă faptul că acesta își menține caracterul de apă clorurată și sulfuroasă, care este recomandată în scop curativ.

Cuvinte cheie: ape termo-minerale, Hârșova - Vadu Oii.

INTRODUCTION

The Hârșova – Vadu Oii thermo mineral waters are located north of Hârșova Town, in the Constanța County, on the right bank of the Danube River, in a flat relief area, with altitudes below 40 m. Access is possible through the Vadu Oii-Constanța road.

The geology in the study area is represented by the basement and Jurassic, Cretaceous and Quaternary sedimentary deposits (Fig. 1). Here **the basement** consists of Green Schists of Upper Proterozoic Age, represented by silty shales, feldspatic grit stones with clay, grit stones and well lithificated, hard, compact, dark green quartz conglomerates. In the study area the Green Schists are folded, tilted to 35 degrees to the W and SW, as in the Hârșova 63 well. The basement does not outcrop anywhere in the area, but it was intercepted by the Hârșova 63 well at a depth of 34.2 m. The Hârșova 5095 well located 140 m west of "Privalul Puturosu" intercepted the Green Schists at a depth of 129 m (VASILESCU & PÂRVU, 1967). Eight km west of Hârșova, on the left bank of the Danube River, at "Piua Petrii", the 403 well intercepted the Green Schists at a depth of 498 m. (CONSTANTINESCU & CROITORU, 1968). Another well, drilled 6 km downstream (NW) of Hârșova, entered the Green Schists at a depth of 203 m (PRICĂJAN, 1985).

The succession of mesozoic sedimentary layers that have been intercepted in the wells of the study area is described below (Fig. 1).

The Jurassic deposits referred to as the Casimcea formation are to be found as follows:

- At the base Lower Oxfordian represented by massive to bedded red breccias of silicified limestone clasts;
- Above, Lower Oxfordian consisting of hard, white limestones with chert nodules;
- On top of it, Upper Oxfordian is represented by white, bedded, ammonite bearing with some chert nodules;
- Covering Oxfordian, Kimmeridgian deposits consist of white fossiliferous bioclastic limestones.

The Cretaceous is represented by Aptian deposits accumulated in the continental environment. Aptian sediments occur as patches with reduced thickness, consisting of boulders, conglomerates, gravels, sands and kaolin, polychrome clays.

In the low area north of Hârșova Town, **Quaternary deposits** are 34.2 m (Hârșova 63 well) and 70 m (Hârșova 5095 well) thick. They are loose, uncemented and consist of alternating gravel and coarse, gray sand. Genetic types of Quaternary deposits covering the entire area from Hârșova to the East are diluvium-proluvium (BANDRABUR et al., 1968). These loess deposits, dusty-sandy in nature, are macro-porous and contain calcareous concretions. Sometimes they have clay, bricky layers, which are paleosols. The loessoid diluvium deposits come from the washing of the primary loess, followed by their deposition at the base of the slopes, while the proluvium deposits are the torrent slurry cones. They date back to the Middle – Upper Pleistocene. In the Danube meadow, the Upper Holocene alluviums consist of sands and clay sands, 10-15 m thick (Fig. 2).

The Hârșova area is situated in **Central Dobrogea**, North of the Capidava-Ovidiu Fault on a Dobrogea-type basement of the Moesian Platform, consisting of Green Schists (Green Schists Block). To the N-E of the Capidava-Ovidiu Fault, the Proterozoic foundation of Green Schists is affected by two other faults, parallel to this one: Hârșova – Tașaul Fault and Horia-Pantelimonu de Sus Fault. The Hârșova – Tașaul Fault is situated 8 km N-E from the Capidava-Ovidiu Fault, passing through the Danube meadow, south-west from Hârșova, near the town and to the west of Ghindărești. The geological area on which Hârșova is situated is higher than the southern one, which is delineated by the Capidava-Ovidiu Fault. Horia-Pantelimonu de Sus Fault is located 5 km northwest from the Hârșova-Tașaul Fault and its north-eastern section is lower compared to that on which Hârșova is situated (Fig. 1).

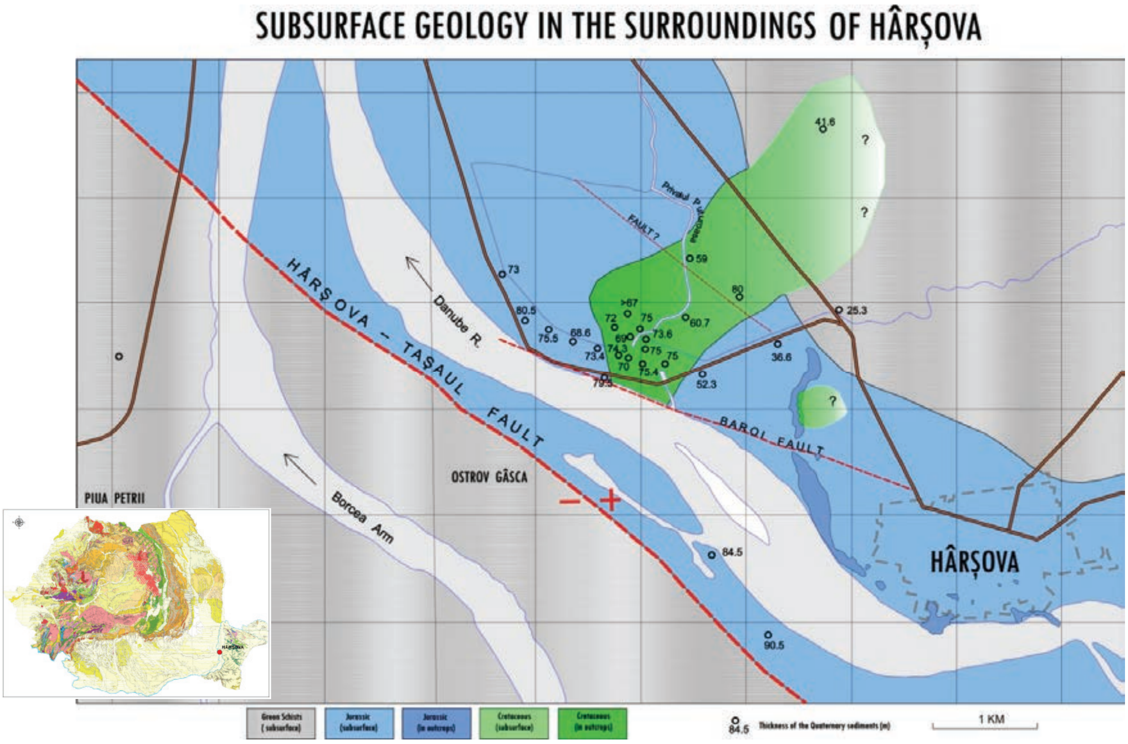

Figure1. Map with wells that intercepted the aquifer area Vadu Oii - Hârșova and thickness of Quaternary sediments intercepted (original; BALTRES, 2014). The map from the left corner is the geological map of Romania with the Hârșova location (source - Geological Institute of Romania).

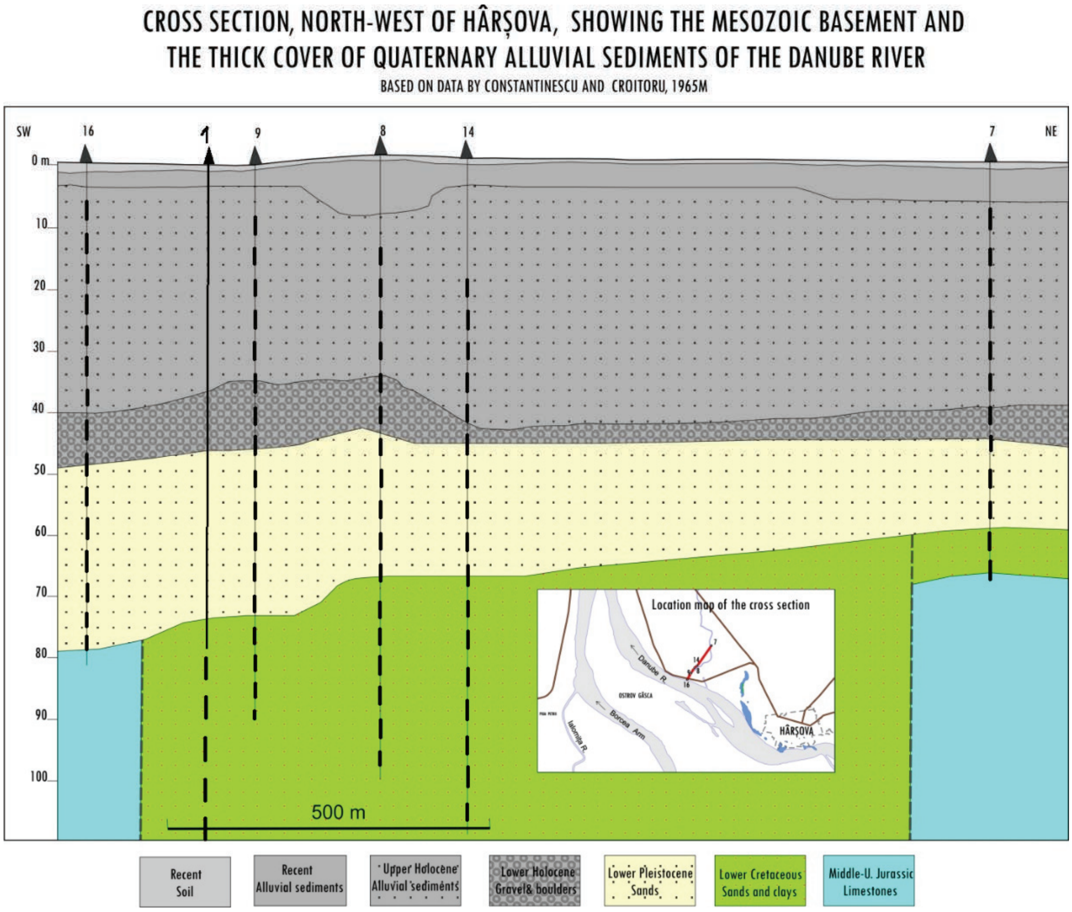

Figure 2. Geological section in the north-west of Hârșova, indicating the depth at which Mesozoic deposits were intercepted, over which were deposited the Quaternary alluvial deposits of the Danube River (BALTRES & PERȘA, 2014);
F1 was drilled in 2013, it is artesian.

The thermo mineral waters from Hârşova have been studied since the 1970s. During the period 1961–1966 numerous boreholes were drilled by I.P.G.G. (Enterprise of Geological and Geophysical Prospections) to the West of the Puturosu canal and in the Danube meadow between Hârşova and Vadu Oii, and by I.S.P.H. at Ostrovul (Islet) Gâsca. Based on these data, CONSTANTINESCU & CROITORU elaborated a report in 1965, and FERU (1971). During the period 1978 – 1983 five other hydrogeological wells were drilled outside Hârşova – Vadu Oii, on the left bank of the Danube River. Their depth was between 163 m and 270 m. The depth of productive layers is in some cases between 60 and 140 m, and in other cases between 160 m and 236 m. The flow rate registered for these wells varied between 5.5 l/s and 8.4 l/s. The registered temperatures range between 18 and 42ºC. Based on total mineralization and H2S content, water was diagnosed as chlorosodic and sulphurous, with a total mineralization up to 2700 mg/l and dissolved H2S up to 57 mg/l.

In 1979, based on data from the well F1 ISLGC by Conclusion 52-89 / 15 June 1979, the substance "chlorine, sulfurous thermal waters with temperatures of 23 - 420C" was approved as an exploitable resource. The flow rate corresponding to the C1 reserve is 432 cubic meters/day, and the extracted reserve is 432 cubic meters/day. The available reserve can be used as spa, for cure and recreation purposes.

MATERIAL AND METHODS

In 2013, the Hârşova Town Hall drilled a new water supply well for the town, but it turned out that the water extracted from this well is geothermal (Fig. 3). On this occasion BALTRES & PERŞA (2014) prepared a hydrogeological report regarding the thermal mineral waters in the Hârşova - Vadu Oii area, whose results are presented in this article. The report includes, besides new detailed maps and cross-sections in the Hârşova - Vadu Oii area, the integration of new data acquired from the well with historical hydrogeological data.

Figure 3. Artesian well F1 Hârșova drilled in 2013 (original).

In 2013, the Hârşova Town Hall, through S.C. Fluid Service performed a new drilling (F1 Hârşova), which is artesian and confirms the existence of the geothermal resources highlighted since the seventies. The depth of the well is 150 m, and the aquifer was intercepted from 80 m to 150 m deep. The filter diameter is 250 mm. In order to determine the hydrogeological parameters of the aquifer, experimental tests through pumping were carried out by S.C. Fluid Service, obtaining the results given in Table 1.

Table 1. Hydrogeological parameters of F1 Hârșova well.

Drilling	Flow rate (l/s)	Drop-down level S (m)	Height of discharge (m)
F1 Hârșova well – aquifer layer interception	3.0	Artesian well	+ 7 m
F1 Hârșova well – stage I	11.4	4.5	-

In June 2014 a water sample was taken from the F1 Hârșova well, and chemical analyses were performed in the laboratory of S.C. Prospectiuni S.A. Spectroscopy's of atomic absorption, potentiometry, volumetry were used as assay techniques. The results of these analyses are given in the Table 2.

Table 2. Chemical analysis of the water sample collected from F1 Hârșova.

Ions	Units	Detection limit	Value
pH		0.1	7.19
Conductivity	μS/cm	0.5	4170.0
Chloride (Cl^-)	mg/l	0.5	1078.0
Sulfate (SO_4^{--})	mg/l	2	160.1
Bicarbonate (HCO_3^-)	mg/l	3	381.3
Sodium (Na^+)	mg/l	0.01	599
Potassium (K^+)	mg/l	0.01	29.85
Calcium (Ca^{++})	mg/l	0.01	153.0
Magnesium (Mg^{++})	mg/l	0.01	61.0
Carbon dioxide (CO_2)	mg/l	3	31.68
Dry residue 180ºC	mg/l	0.1	2420.0
Soluble dry residue (calculation)	mg/l	3	2610.65
Total dissolved salts	mg/l	0.1	3169.0

The bacteriological indicators from the water sample taken from F1 Hârșova well have been analyzed by the National Institute for Research and Development for Industrial Ecology (ECO-IND) Bucharest. The result is that no bacteria have been found in the water, confirming the previous recommendations that thermo-mineral water can be used for balneological purposes. As a result, the Hârșova Town hall intends to submit for funding a project proposal for a spa complex that is about to use these waters.

RESULTS AND DISSCUTIONS

The aquifer of thermo mineral waters is a confined aquifer, which is ascending or artesian in some places. In the Hârșova – Vadu Oii area, which is located to the north-west of Hârșova, about 2 km from the town, more than 22 wells intercepted two types of deposits: on top alluvial complex of the Danube River, and below karstified Jurassic, (or Cretaceous) limestones. Thus, nine of the wells only intercepted the upper layers, and the rest had filters both for Quaternary and Jurassic deposits.

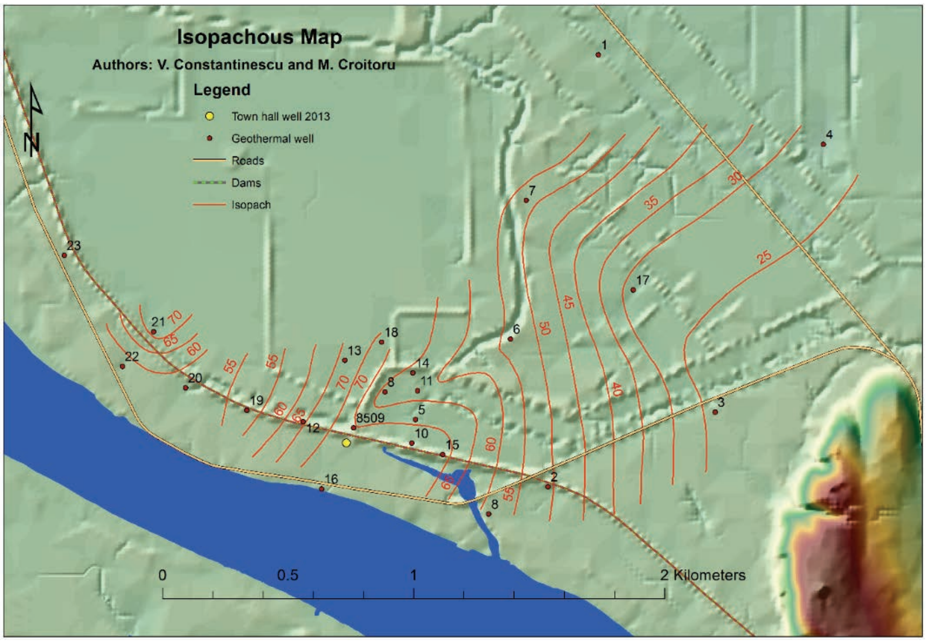

Figure 4. Isopachous Map of Alluvial deposits of the Danube in Hârșova – Vadu Oii area, redrawn by Perșa;
With yellow is F1 Hârșova artesian well that was drilled in 2013.

The thickness of the Danube alluvial deposits that host geothermal waters varies from 70-75 m towards the Danube and gradually decreases to 20-25 m eastward (Fig. 4). Between the aquifer and the river there is a direct connection and the existence of impermeable or poorly permeable layers in the alluvial complex determines the ascending nature of the aquifer. The thickness of impermeable layers, which consist of dusty, fine sands, fine clay sands and sandy clay, varies between 2 and 22 m. Based on data from the wells drilled in the seventies, an isopach map

(CONSTANTINESCU & CROITORU, 1968) was elaborated, indicating the spatial extent of the aquifer. The thickness of the aquifer layers increases proportionally while getting closer to the Danube and decreases eastward, as the distance from the river increases.

The hydrostatic levels identified through drilling are found at depths ranging between 0.50 m and 5.80 m, which are lower in areas where clay, dusty, silty sediments are thicker. Three of the wells drilled in the seventies and the one drilled in 2013 are of artesian nature. The wells that intercepted only the alluvial complex have an ascending character, and the artesian character is observed in the wells which undergo the influence of Danube's raised level and flooding surrounding areas, so it is more prominent in the wells located near or even in the thalweg of the river. The data obtained through pumping indicate good permeability and a great discharge capacity of the alluvial complex. Filtration coefficients for the well F8 are around 48 m/24 h. The artesian character is reported mainly in the wells which intercept karstified Jurassic limestones. An example is well F22, which was of an ascending nature when intercepting alluvial deposits. When the well intercepted the Jurassic layer, at depth of 80.5 m, it became artesian.

The high water temperatures of the aquifer from Hârșova - Vadu Oii area are due to their mixture with hyperthermal waters from the depth, which circulate through the cracks and karstic voids belonging to Cretaceous and Jurassic limestone as well as on lines of fracture.

Regarding the origin of hot waters coming from the depth, it is considered that they are of vadose origin. Infiltrating into limestone, they reach the depth where their temperature rises according to the geothermal gradient, and when they come into contact with dislocation lines, they head to the surface where they take the form of hidden artesian waters in the alluvial deposits.

The geothermal gradient at Hârșova has values of 3.5-4 degrees at 100 m (GHENEA et al., 1980) and, according to BUTAC & OPRAN (1985), even higher values of 4-5 degrees at 100 m. To some extent these high values can explain the water temperatures corresponding to the Hârşova - Vadu Oii aquifer. In the boreholes located in the east, values between 11.30^0C and 16^0C were recorded, while in the wells to the west, in areas bordering the Danube, temperatures range between 36^0C and 42^0C. High water temperatures were recorded in the wells from "Ostrovul Gâsca", which intercepted the limestones. There, the measured temperatures were 45^0C (well 12) and 39^0C (well 33).

The results of the chemical analysis performed in 2014 confirms the historical values and show that one characteristic of the geothermal waters from Hârşova -Vadu Oii area is represented by the high values of total dissolved salts (3169.0 mg/l), predominantly sodium and chloride ions. To a lower degree, one can find bicarbonate ions (HCO_3^-), calcium (Ca^{++}), magnesium (Mg^{++}) and sulphate ($SO4^{--}$) plus ions of bromine (Br^-), iodine (I^-) and free gases, such as carbon dioxide (CO_2) and hydrogen sulfide (H_2S). The presence of Cl^- and Na^+ in large quantities in the groundwater is due to their mixture with hot mineral waters that come from depth (CONSTANTINESCU & CROITORU, 1968).

The hydrogen sulfide comes from the water flowing through the upper layer of green schist. Pyrites, which are commonly found in a dispersed form in the green schists, are oxidized according to the following reaction, resulting into hydrogen sulfide and limonite:

$2FeS_2 + 4\ H_2O = 4H_2S + Fe_2O_3 + O$

Considering the temperatures and chemical composition of groundwater in the Hârșova-Vadu Oii area, waters are characterized as chlorine, sulfurous thermo-mineral waters, with low salt concentration.

In terms of temperature, they are categorized as mesothermal waters.

CONCLUSIONS

The drillings that have intercepted the aquifer in the Hârșova - Vadu-Oii area have been carried out over the years in several stages and have provided information on the succession of the strata hosting the aquifer, on the hydrostatic level of the soil, the hydraulic characteristics of the aquifer, temperature and chemical composition of thermal mineral water, etc.

In 2013 with the occasion of drilling a new well by the Hârșova town hall, IGR representatives had the opportunity to reconsider and confirm the historical data. The following were observed, *inter alia*:

- The F1 Hârșova well, drilled by the Danube right bank, is artesian.
- The water temperature of the new well has a value of 40 ° C.
- Water has a chlorosodic and sulfurous character, as it has been characterized in the past.
- The thickness of the permeable deposits intercepted in F1 Hârșova corresponds with the thickness of the aquifer as resulting from the Isopach map. Thus, the older data based on which the map was elaborated are validated.

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Perşa Diana
Geological Institute of Romania
1st Caransebeş Street, 012271 – Bucharest, Romania.
E-mail: persa.diana@yahoo.ro

Baltres Albert
Geological Institute of Romania
1st Caransebeş Street, 012271 – Bucharest, Romania.
E-mail: alxbal@yahoo.com

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THE DEVELOPMENT OF DATA PROCESSING TOOLS ALLOWING TO EXTRACT MORE INFORMATION ABOUT GEOMAGNETIC STORMS

ASIMOPOLOS Laurențiu, ASIMOPOLOS Adrian-Aristide, ASIMOPOLOS Natalia-Silvia

Abstract. In this paper, we show the Fourier and wavelet analysis of geomagnetic data recorded at the Surlari Geomagnetic Observatory (about 30 km north of Bucharest-Romania) concerning the geomagnetic storm of 28 August 2015. The Fourier analysis highlights predominant frequencies of magnetic field components. Waveles analysis gives complete information (time, frequencies, and amplitude) of magnetic field components through variable frequency windows, that contains longer time intervals for low-frequency information, middle time intervals for medium frequency information, and short time intervals for highlight the high frequencies or details of the analysed signals. Also, the wavelet analysis allows us to decompose a geomagnetic signal into different waves. The presented analyses are only the significant ones for the geomagnetic storm period. The data for the next three days after the storm showed a mitigation of the perturbations and a transition to a quiet period from a geomagnetic point of view.

Keywords: Geomagnetic Storm, INTERMAGNET Network, Continuous Wavelet Transform, Discrete Wavelet Transform, 1D Fourier Transform.

Rezumat. Dezvoltarea de instrumente de prelucrare a datelor care permit extragerea mai multor informații privind furtunile geomagnetice. În lucrarea noastră, prezentăm analiza Fourier și wavelet a datelor geomagnetice înregistrate la Observatorul Surlari Geomagnetic (cca 30 km nord de București-România) în timpul furtunii geomagnetice din 28 august 2015. Analiza Fourier evidențiază frecvențele predominante ale componentelor câmpului magnetic. Analiza wavelet aduce informații complete (timp, frecvență, amplitudine) ale componentelor câmpului magnetic prin ferestre cu frecvență variabilă care conțin intervale de timp mai lungi pentru informații cu frecvență redusă, intervale de timp medii pentru informații de frecvență medie și intervale scurte de timp pentru evidențierea frecvențelor înalte sau a detaliilor semnalelor analizate. De asemenea, analiza wavelet permite descompunerea semnalelor geomagnetice în valuri diferite. Analizele prezentate sunt doar cele semnificative pentru perioada furtunii geomagnetice. Datele pentru urmatoarele trei zile de după furtună au arătat atenuarea perturbațiilor și trecerea la o perioadă calmă din punct de vedere geomagnetic.

Cuvinte cheie: Furtuna geomagnetică, rețeaua INTERMAGNET, Transformata Wavelet Continua, Transformata Wavelet Discreta, Transformata Fourier 1D.

INTRODUCTION

A geomagnetic storm is a temporary disturbance of the Earth's magnetosphere caused by a disturbance in space weather. Associated with solar coronal mass ejections, coronal holes, or solar flares, a geomagnetic storm is caused by a solar wind shock wave which typically strikes the Earth's magnetic field 24 to 36 hours after the event.

This only happens if the shock wave travels in a direction toward Earth. The solar wind pressure on the magnetosphere will increase or decrease depending on the Sun's activity. These solar wind pressure changes modify the electric currents in the ionosphere. Magnetic storms usually last 12 to 48 hours, but some may last for many days. The data used in this paper are acquired within the Surlari Observatory, and additional information to characterize the analysed geomagnetic storm was obtained from the sites: http://www.intermagnet.org, http://www.noaa.gov, https://www.spaceweatherlive.com/en/archive/2015/08/28/kp.

The analysis of geomagnetic storms is dealt with in many works from which we can recall the following: BENOIT (2012), GEBBINS & HERRERO-BERVERA (2007), ASIMOPOLOS &. ASIMOPOLOS (2018), ASIMOPOLOS L. et al. (2011, 2012).

The wavelet analysis allows us to decompose a signal in different waves, called wavelets. In the case of this paper, we refer to the magnetic field components. The wavelet methodology is described in detail in the signal processing documentation, such as: CHATFIELD (1989), DAUBECHIES (1990), TORRENCE & COMPO (1998) and site: https://www.mathworks.com/products/signal.html. In this paper, we refer to the magnetic field components.

DATA PROCESSING TOOLS

Wavelets allow the local analysis of magnetic field components through variable frequency windows. Windows that contain longer time intervals allow us to extract low-frequency information, average ranges of different sizes lead to extraction of medium frequency information, and very narrow windows highlight the high frequencies or details of the analysed signals. The wavelet functions describe the orthogonal bases in the L2 (R) space, with signal approximation properties, while the orthonormal bases in the Fourier analysis are made up of sinusoidal waves.

The estimation of geomagnetic field disturbances is similar to the standard problem of estimating a signal disturbed by signal theory.

The term noise refers to any modification that changes the periodic or quasi-periodic characteristics of the original signal.

The model of the disturbed geomagnetic field is composed of periodic oscillations plus non-periodic oscillations given by the impact of solar wind on the terrestrial magnetosphere.

The purpose of wavelet analysis is to build orthonormal bases composed of wavelets that can reconstruct the geomagnetic signals recorded in the observatories.

The wavelet algorithm was originally formulated by Goupillaud, Grossmann and Morlet in 1984 (www.mathworks.com) as a constant κ_σ subtracted from a plane wave and then localized by a Gaussian window:

$$\Psi_\sigma(t) = C_\sigma \pi^{-\frac{1}{4}} e^{-\frac{1}{2}t^2} (e^{i\sigma t} - k_\sigma),$$

where: $k_\sigma = e^{-\frac{1}{2}\sigma^2}$ is defined by the admissibility criterion and the normalization constant C_σ is:

$$C_\sigma = (e^{-\sigma^2} - 2e^{-\frac{3}{4}\sigma^2})^{-\frac{1}{2}}$$

Multiple resolution analysis is the core of wavelet analysis. This involves the decomposition of a signal in the subscripts at different levels of resolution.

The wavelet analysis is based on the decomposition of an approximate, constant portion, of a function f from the space L_2 (R) in a rough approximation and a detail function.

At each level j, the approximate f_j of the given function f can be written as a sum of a gross approximation f_{j-1} located at the next approximation level and the detail function g_{j-1}, i.e. $f_j = f_{j-1} + g_{j-1}$. Each detail function can be written as a linear combination of mother wavelet functions:

$$\psi_{j,k}(x) = 2^{\frac{j}{2}} \psi(2^j x - k),$$

where j is the index of dilatation and k is the index of translation, j, k € Z. When the index j gets higher, the approximate approximations become finer. For each level of resolution we have a basic function area $(\psi_{j,k})$, j,k € Z. Therefore, we will work with multiple areas at different resolutions (multiresolution). In Fig. 1 are division of time-frequency plan (time on x-axis and frequency on y-axis) for wavelet analysis, Fourier transform and Fourier transform in the short term (LIU, 2010, www.mathworks.com):

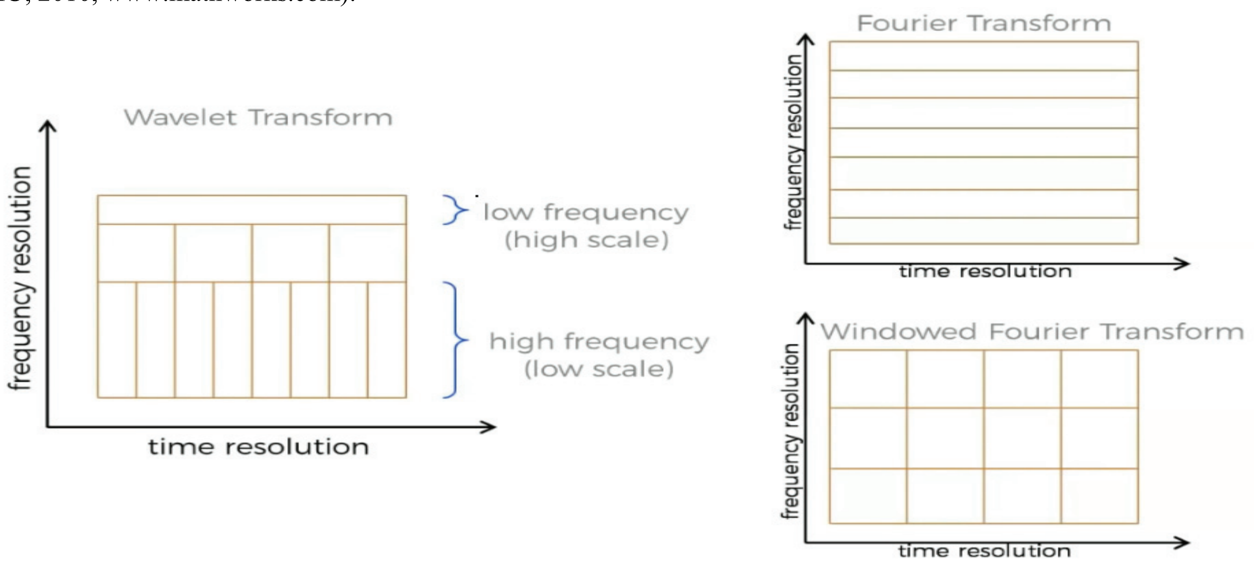

Figure 1. Different time-frequency tile allocation of the three transforms: wavelet transform, Fourier transform, Windowed Fourier Transform (STFT).

The wavelet function is designed to strike a balance between the time domain (finite length) and the frequency domain (finite bandwidth). As we dilate and translate the mother wavelet, we can see very low frequency components at the large s while very high frequency component can be located precisely at the small s.

The transition from STFT to wavelet was done by replacing a fixed-length analysis window, regardless of the frequency of the studied signal, with a set of variable duration analysis windows, so that at low frequencies we use long duration, and at high frequencies we use small durations.

To make the Wavelet Continue Transform (CWT), a real or complex signal must satisfy the following two conditions:

$$\int_{-\infty}^{\infty} \psi(t)dt = 0 \quad , \quad \int_{-\infty}^{\infty} |\psi(t)|^2 dt < \infty$$

The first property, according to which the signal has a mean null value, suggests a possible oscillating aspect, while the second property, referring to the finite energy value, indicates that the signal concentrates most of the energy within a finite range of time.

The two conditions, together with a so-called admissibility condition (required to define the transformed wavelet inverse), are sufficient for a signal to "qualify" as a wavelet signal. In the literature, numerous such signals have been proposed, some of them with finite (thus compact support) and others with infinite duration, but with concentrated energy within a finite timeframe. Fig. 2 shows examples of wavelet signals (www.mathworks.com) and Fig. 3 shows the different bases for transforms.

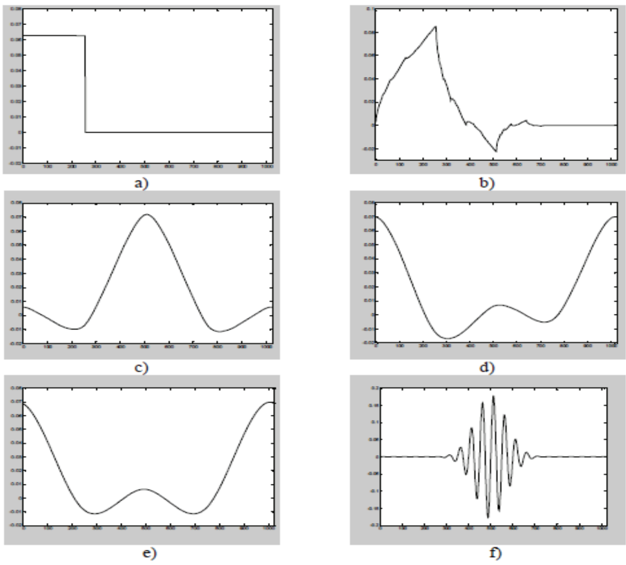

Figure 2. Examples of wavelet signals. a) Haar; b) Daubechies; c) Coiflet; d) Symmlet; e) Battle-Lemarie; f) Morlet (www.mathworks.com).

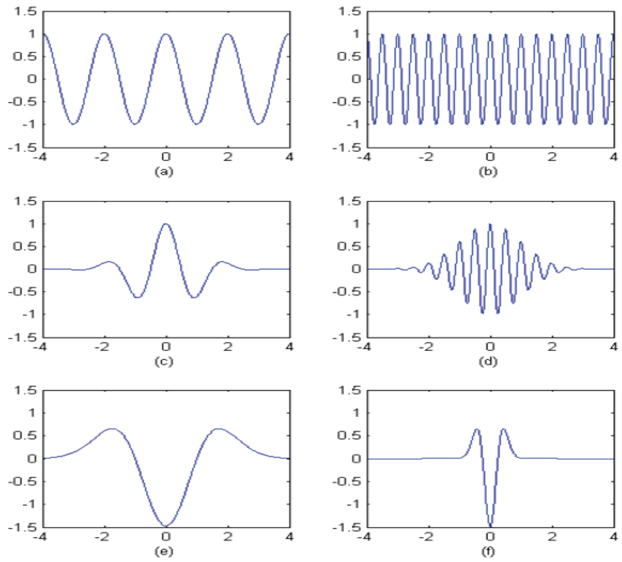

Figure 3. Different bases for transforms. (a) Real part of the basis for Fourier transform, exp(jπt). (b) Basis for different frequency, exp(j4πt). (c) Basis for STFT, using Gaussian window of σ = 1. It is: exp(−t^2/2) exp(jπt). (d) Basis for different frequency, exp(−t^2/2) exp(j4πt). (e) Mexican-hat mother wavelet function and (f) s = 4. (www.mathworks.com).

In both the Fourier Transform and the Wavelet Transformation, the transformation evaluation involves the calculation of a scalar product between the analysed signal and a set of signals that form a particular base in the vector space of the finite energy signals. The Fourier representation uses an orthogonal vector basis, whereas in the case of wavelet there is the possibility to use also bases consisting of independent linear non-orthogonal vectors. Unlike the Fourier transform, which depends only on a single parameter, wavelet transform type depends on 2 parameters (a and b). As a result, the graphical representation of the spectrum is different. Examples in this regard are illustrated, from www.mathworks.com, in Figs. 4-5.

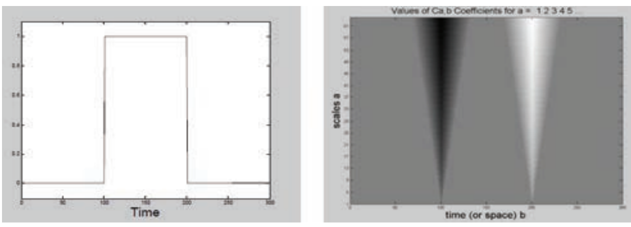

Figure 4. Graphical representation of the CWT transformation corresponding to elementary signals (www.mathworks.com).

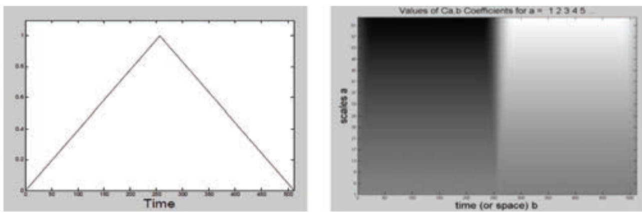

Figure 5. Graphical representation of the CWT transformation (www.mathworks.com).

EXPERIMENTAL RESULTS OF WAVELET ANALYSIS

In our example, we used the data recorded at the Surlari Geomagnetic Observatory at a frequency of 2Hz to identify correlations occurring between the high frequency oscillations of the geomagnetic field components over day, 2015, August 28, 00:00:00 to 24:00:00). We used in the Fourier and wavelet analysis 172800 samples at 2 Hz sampling rates, where we can view the predominant frequencies for each point and can be distinguished range of frequencies.

We used for the Fourier analysis the MATLAB with the code presented in ANNEX. Also, for the wavelet analysis we used function Daubechies db1, at level 5, the same wavelet as Haar, with the code presented in ANNEX.

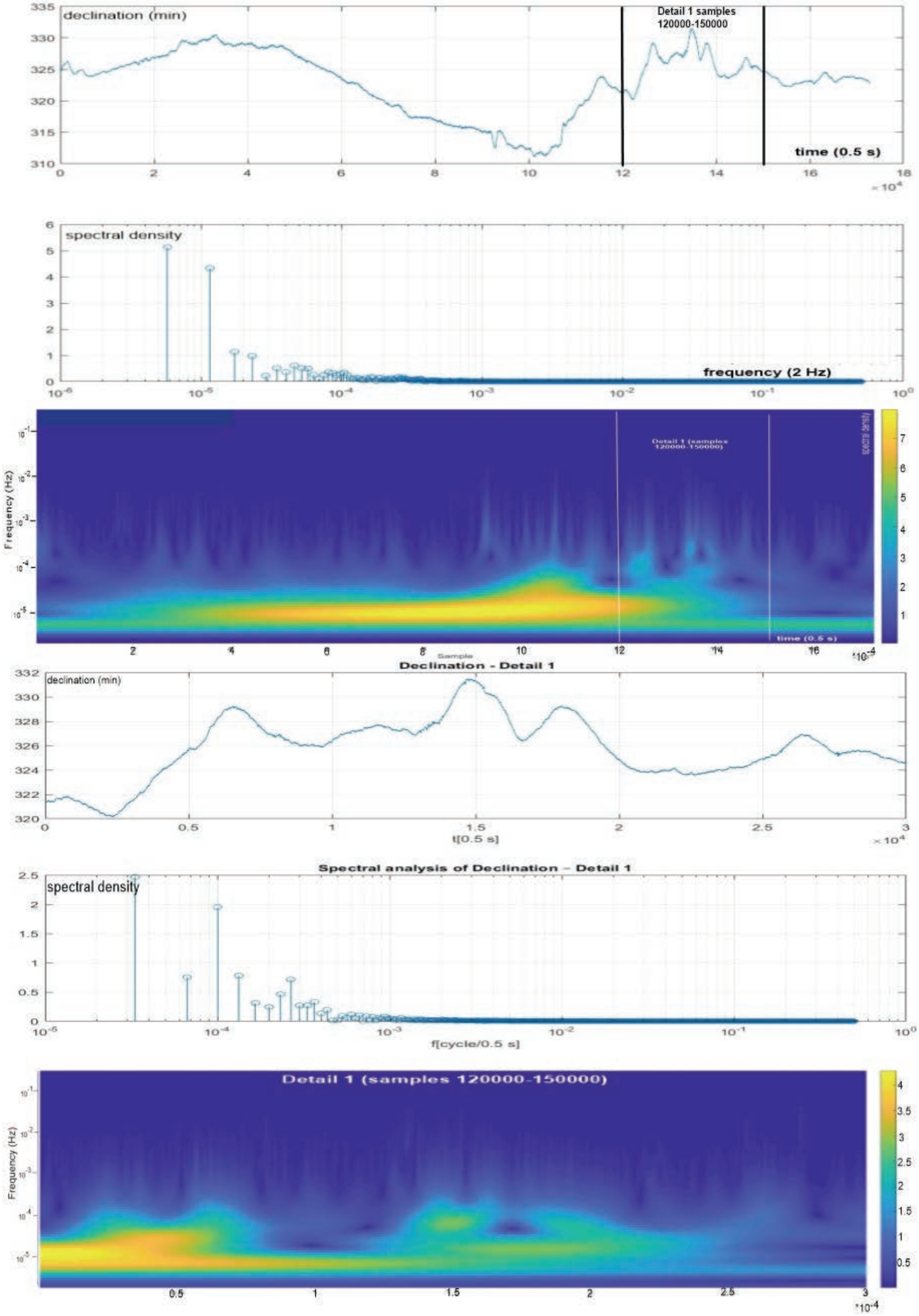

Figure 6. Time series, spectral analysis and wavelet analysis of declination. From top to bottom the images have the following meaning: In the first three images we have the time series, Fourier analysis and wavelet analysis for all days of 2015, August 28, 00:00:00 to 24:00:00. In the last three images we have the time series, Fourier analysis and wavelet analysis for Detail 1 – interval 120000-150000 samples - a range of 4 hours and 10 minutes.

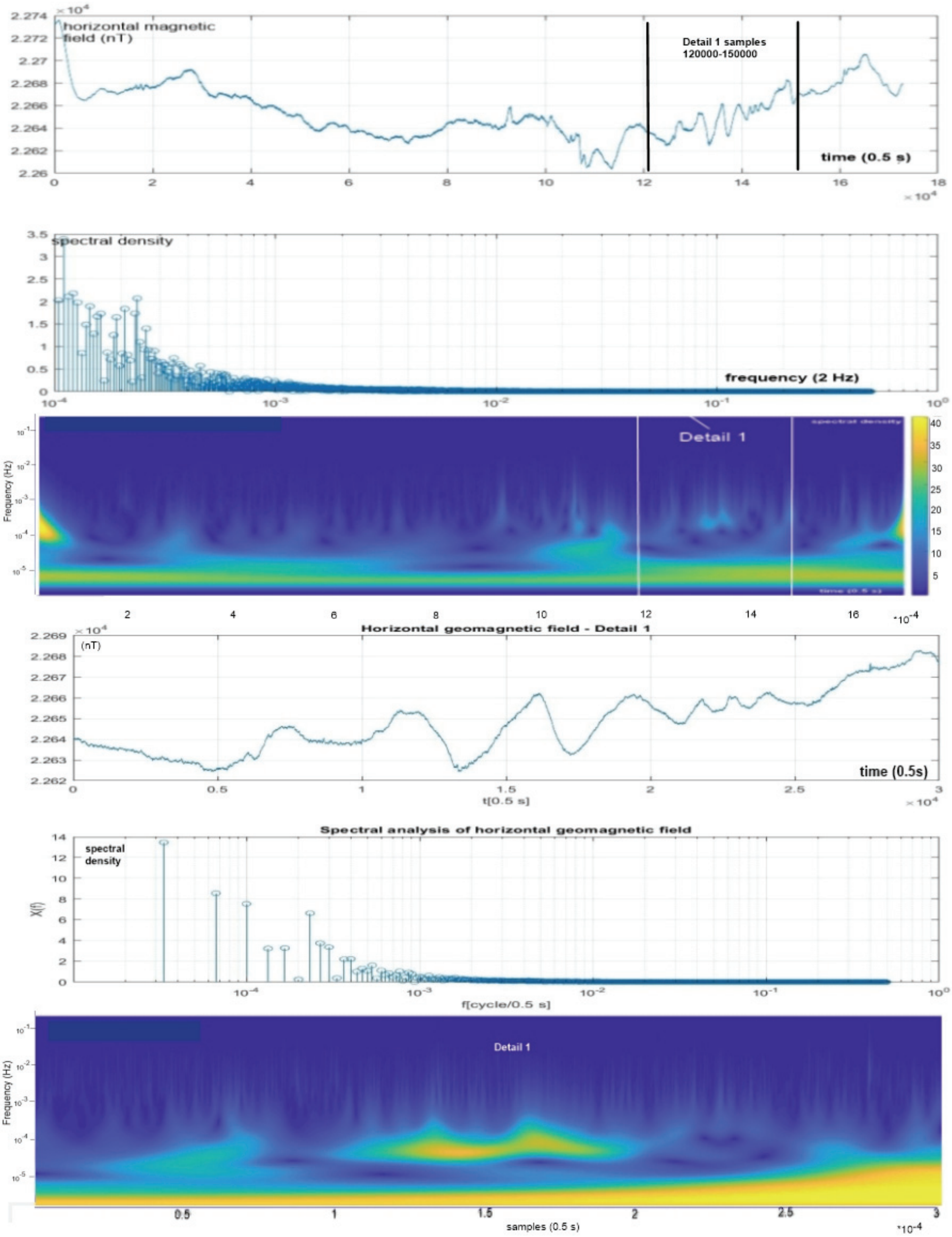

Figure 7. Time series, spectral analysis and wavelet analysis of horizontal geomagnetic field. From top to bottom the images have the following meaning: In the first three images we have the time series, Fourier analysis and wavelet analysis for all days of 2015, August 28, 00:00:00 to 24:00:00. In the last three images we have the time series, Fourier analysis and wavelet analysis for Detail 1 - interval 120000-150000 samples - a range of 4 hours and 10 minutes.

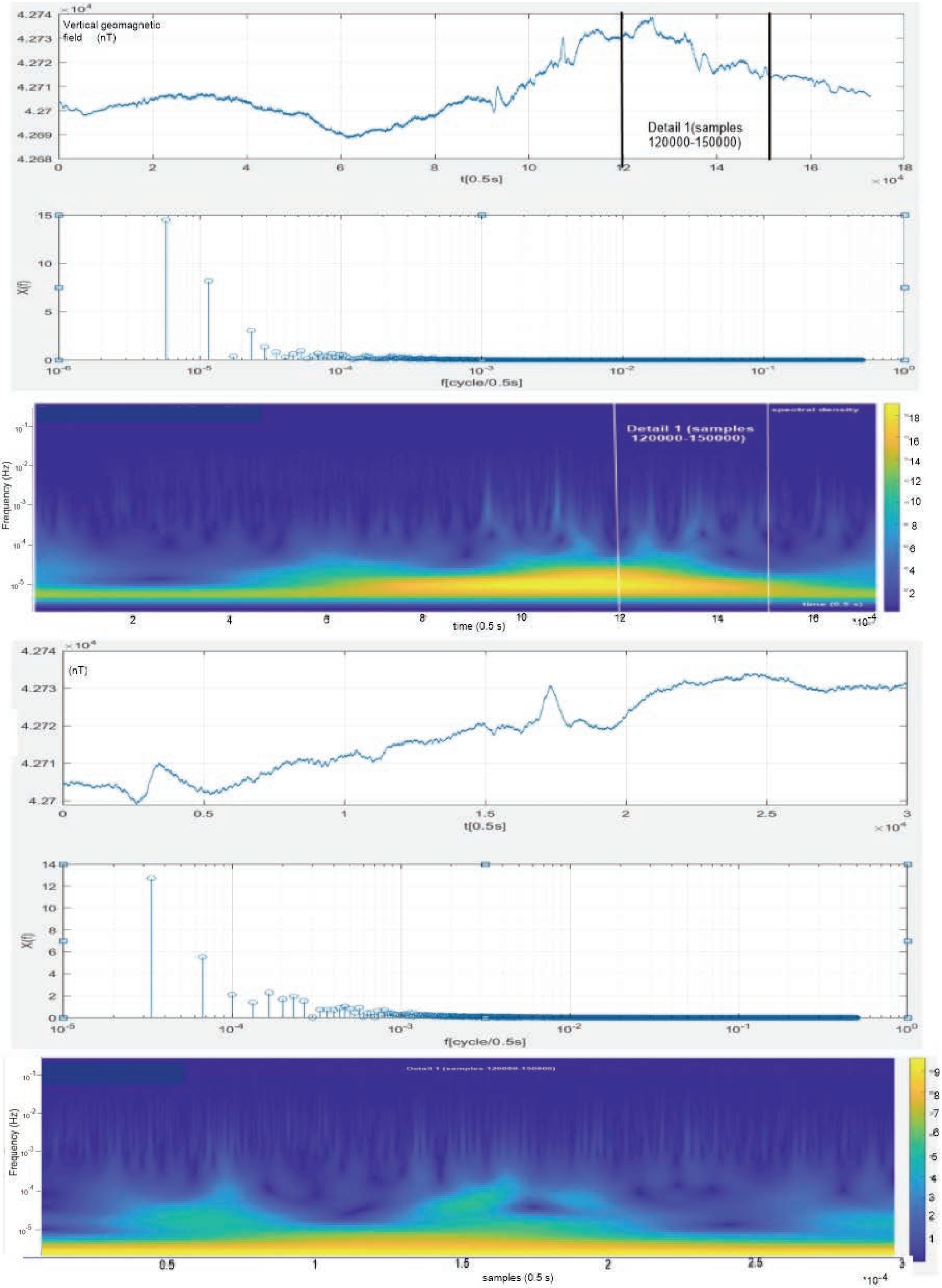

Figure 8. Time series, spectral analysis and wavelet analysis of vertical geomagnetic field. From top to bottom the images have the following meaning: In the first three images we have the time series, Fourier analysis and wavelet analysis for all days of 2015, August 28, 00:00:00 to 24:00:00. In the last three images we have the time series, Fourier analysis and wavelet analysis for Detail 1 - interval 120000-150000 samples - a range of 4 hours and 10 minutes.

In the Figs. 6, 7 and 8, there are similarities between the detail 1 and the corresponding portion of the full 24-hour signal. On the right sides of DWT images are the frequency scales found in the signal analysis.

The amplitude in the horizontal component (North magnetic direction) had variations of up to 120 nT, in the declination up to 25 minutes and in the vertical direction up to 50 nT. There is an increase in the number of frequencies between 1/500 Hz and 1/5000 Hz on all components, which corresponds to periods ranging from eight minutes to over one hour, belonging to the pulses of the categories pc5 (continuous pulses) and pi3 (irregular pulses). Associated with these pulses, we notice the overlapping of other higher frequencies with lower amplitude (from categories pc3, pc4 and pi2). These types of events reflect the geomagnetic activity specific to geomagnetic storms.

CONCLUSIONS

A simple but effective way to highlight a geomagnetic storm is the calculation of gradients of geomagnetic components. Sudden geomagnetic variations (SSC, SI, SFE, geomagnetic storms) are relevant through Kp index (only for geomagnetic storms calculated for INTERMAGNET observatories).

The Kp indexes (6,4,4,3,5,5,6,4) from the site https://www.spaceweatherlive.com/en/archive/2015/08/28/kp, qualify the perturbations from August 28, 2015 in the category of M2 events, moderate storms and two sunspot regions on the disk. Solar wind speed, as measured by the ACE spacecraft, reached a peak speed of 440 km/s at August 28, 2015 and the maximum southward vertical component of magnetic field Bz reached 16 nT. Electrons greater than 2 MeV at geosynchronous orbit reached a peak level of 256 pfu. The statistical and spectral analysis of the geomagnetic field variation from geomagnetic observatories provides information on the geomagnetic pattern. In the wavelet charts, the frequencies are marked with colours between blue and yellow representing the weight of each frequency in the analysed signal. According with this, we can find the predominant frequency for each component at each time. The STFT tries to solve the problem in Fourier transform by introducing a sliding window w(t-u). The detailed windows are designed to extract a small portions of the signal f(t) and then take Fourier transform. The transformed coefficient has two independent parameters. The wavelet functions are designed to strike a balance between time domain (finite length) and frequency domain (finite bandwidth).

As we dilate and translate the mother wavelet, we can see very low frequency components at large scale, while a very high frequency component can be located precisely at small scale.

ACKNOWLEDGEMENT

We gratefully acknowledge the many and significant contributions and comments provided by our colleagues from geomagnetic observatories. The manual about observatories' methodologies is based on the original document (INTERMAGNET Technical Reference).

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ANNEX

The code used for Fourier analysis in MATLAB:

```
load table.txt; X1= table (:,1); X2= table (:,2); X3= table (:,3); N=length(X1); t=1:1:N; fe=1/N; x=X1'; Xt=fft(x); Xm=abs(Xt); X=Xm(1,1:N/2+1)/(N/2); f=[0:N/2]*fe; subplot(211); plot(t,x); grid; xlabel('t[min]'); ylabel('x(t)[ ]'); title(' '); subplot(212); stem(f,X); xlabel('f[o.5Hz]'); ylabel('X(f)'); grid; title(‘')
```

The code used for wavelet analysis with function Daubechies db1, at level 5, in MATLAB:

```
load table.txt; SX=table(:,1); signal = SX; lev = 5; wname = 'db1'; nbcol = 64; [c,l] =wavedec(signal,lev,wname);len = length(signal); cfd = zeros(lev,len); for k = 1:lev; d = detcoef(c,l,k); d = d(:)'; d = d(ones(1,2^k),:); cfd(k,:) = wkeep1(d(:)',len); end
cfd = cfd(:); I = find(abs(cfd)<sqrt(eps)); cfd(I) = zeros(size(I)); cfd = reshape(cfd,lev,len); cfd = wcodemat(cfd,nbcol,'row'); h211 = subplot(2,1,1); h211.XTick = []; plot(signal,'r'); title('Analyzed signal.'); ax = gca; ax.XLim = [1 length(signal)]; subplot(2,1,2); colormap(cool(128)); image(cfd); tics = 1:lev; labs = int2str(tics'); ax = gca; ax.YTickLabelMode = 'manual'; ax.YDir = 'normal'; ax.Box = 'On'; ax.YTick = tics; ax.YTickLabel = labs; title('Discrete Transform, absolute coefficients.'); ylabel('Level'); figure;[cfs,f] = cwt(signal,1,'waveletparameters',[3 3.1]); hp = pcolor(1:length(signal),f,abs(cfs)); hp.EdgeColor = 'none'; set(gca,'YScale','log'); xlabel('Sample'); ylabel('log10(f)').
```

Asimopolos Laurențiu
Geological Institute of Romania
1st Caransebeş Street, 012271 - Bucharest, Romania.
E-mails: laurentiu.asimopolos@igr.ro, asimopolos@gmail.com

Asimopolos Adrian Aristide
University POLITEHNICA of Bucharest
Faculty of Transports, 313 Splaiul Independentei, 060042 - Bucharest, Romania.
E-mail: adrian.asimopolos@gmail.com

Asimopolos Natalia-Silvia
Geological Institute of Romania
1st Caransebeş Street, 012271 - Bucharest, Romania.
E-mails: natalia.asimopolos@igr.ro, asi_nata@yahoo.com

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THE ACTUAL STATE OF THE PSAMOPHILIC FLORA AND VEGETATION IN THE OLTENIA REGION (ROMANIA)

SIMEANU Cătălin George, MĂCEȘEANU Daniela Mihaela, RĂDUŢOIU Daniel

Abstract. The psamophilic flora and vegetation in Oltenia has a good representation in the southern part of the region. Significant areas are occupied by plants characteristic for these places. Few data can be found starting with the beginning of the 20th century (PRODAN, 1925), but a thorough study of psamophilic flora and vegetation in Oltenia started after 1930s. The flora and vegetation diversity of these places is reflected by the numerous specialty works published over time by various botanists from the University of Craiova. The influence of the anthropogenic factor in the last years has led to a change in flora and vegetation composition. In some areas some taxa, with high sozological value, have dissapeared: *Cyperus hamulosus* BIEB, 1808, *Fimbristylis bisumbellata* (FORSSK) BUBANI, 1850; *Rindera umbellata* (WALDST et KIT) BUNGE, 1851; *Jasione montana* LINNAEUS 1753 etc. or phytocoenoses of some associations edified by rare species: *Achilleo ochroleucae-Secalietum sylvestris* Mititelu et al. 1973; *Violo hymettiae-Cynodontetum* CÂRȚU, 1973; *Digitario sanguinalis – Molluginetum cervianae* (BORZA, 1963; PUȘCARU SOROCEANU et al., 1963; *Bassio laniflorae - Brometum tectorum* (SOÓ, 1929; BORHIDI, 1996). The conservation of these places is strictly necessary if we take into account the disappearance or change of the area of plants characteristic for sandy lands. If we add the zoo-anthropogenic influence that has been manifested more and more in recent years, we can see the need to protect these.

Keywords: flora, sandy soils, Oltenia, vegetation.

Rezumat. Stadiul actual al florei și vegetației psamofile din regiunea Oltenia (România). Flora și vegetația psamofilă a Olteniei are o bună reprezentare în partea de sud a acesteia. Suprafețe apreciabile sunt ocupate de plante caracteristice acestor locuri. Date sporadice găsim încă de la începutul secolului 20 (PRODAN, 1925), însă studiul amănunțit al florei și vegetației psamofile din Oltenia a început după anii 1930. Diversitatea floristică și de vegetație a acestor locuri este reflectată în numeroasele lucrări de specialitate publicate de-a lungul timpului de diverși botaniști de la centrul universitar craiovean. Influența factorului antropic din ultimii ani a condus la schimbarea compoziției floristice și de vegetație. Din unele suprafețe au dispărut taxoni cu valoare sozologică ridicată: *Cyperus hamulosus*, *Fimbristylis bisumbellata*, *Rindera umbellata*, *Jasione montana* etc. sau fitocenoze ale unor asociații edificate de specii rare: *Achilleo ochroleucae - Secalietum sylvestris* Mititelu et al. 1973; *Violo hymettiae-Cynodontetum* CÂRȚU, 1973; *Digitario sanguinalis – Molluginetum cervianae* (BORZA, 1963; PUȘCARU SOROCEANU et al. 1963; *Bassio laniflorae - Brometum tectorum* (SOÓ, 1929; BORHIDI, 1996). Conservarea acestor locuri este de strictă necesitate dacă ținem cont de dispariția sau schimbarea arealului plantelor caracteristice terenurilor nisipoase. Dacă la acestea se mai adaugă și influența zoo-antropogenă manifestată din ce în ce mai pregnant în ultimii ani, ne putem da seama de necesitatea protejării acestor suprafețe.

Cuvinte cheie: floră, locuri nisipoase, Oltenia, vegetație.

INTRODUCTION

The sands and sandy soils in Romania occupy an appreciable area of about 500.000 ha, meaning over 2% of the country`s territory (Fig. 1). Almost 1/3 of this area is occupied by mobile and semi-mobile sands, undeveloped or weakly developed, poor in nutrients and with low water retention capacity.

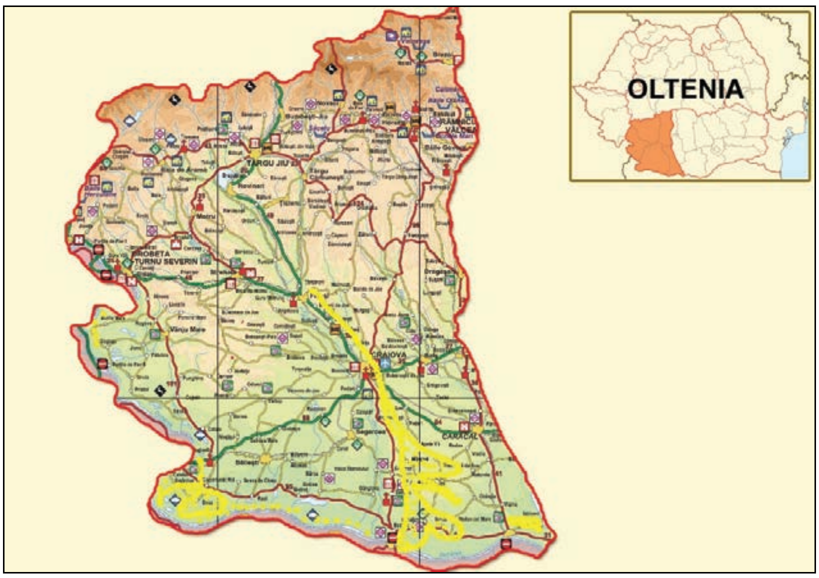

Figure 1. Map of Oltenia with the marking of the areas occupied by the sandy lands (processing from the Internet).

The largest sandy areas are found in the west and southwest part of Romanian Plain, being known as the sands in southern Oltenia (about 200,000 ha).

PRODAN (1939) places these sands according to their position on the Danube sands.

Among the first works that treat psamophilic species in Romania are "The Sands Flora in Romania", elaborated by the illustrious professor Iuliu Prodan (1925). This paper also lists 548 vascular species, some of these being characterized. The first agricultural researches on the sands in Romania were carried out between 1932-1935, by Gh. Ionescu-Sisești, N. Hulpoi and C. Coculescu at the School of Agriculture from Poiana Mare – Dolj County.

After about 20 years, the teachers from the Agronomic Institute of Craiova, in Tâmbuşti village – Dolj County, resumed the studies.

Since 1970, research has been carried out to improve the sands at SCCCPN Dăbuleni.

With regard to these lands, there is data from Oltenia in the monumental paper work named Flora R.P.R.-R.S.R. (SĂVULESCU et al. 1952-1976). BUIA et PĂUN (1958) have published the paper work named Spontaneous plants on the sands from the left part of Jiu River. The same authors published in 1964 the paper named Flora and vegetation of the sands from the left side of Jiu River and M. Păun published in 1967 the paper named Materials for sands flora from Danube Elbow, Oltenia Region.

In 1972, PAUN and POPESCU published the paper named La végétation de sables de la courbure du Danube (Olténie).

In 1985 PĂUN & POPESCU presented data regarding the psamophilic flora and vegetation in Oltenia.

MATERIAL AND METHODS

The material was collected only in the case of specimens whose identification was not possible in the field or were missing from the herbarium of the University of Craiova (CRA).

The taxa identification was made on dry preserved material or on living material using taxonomic sources BELDIE Al. 1977, 1979; CIOCÂRLAN V. 2000, 2009; SĂVULESCU T. & al., 1952 -1976; TUTIN et al., 1964-1980; SÂRBU et al. 2013).

Most of the botanical plants and sites were iconographed. For rare species, GPS coordinates have been taken.

RESULTS AND DISCUSSIONS

As a result of our research in the 15 years since we have been following these psamophilic species, we can say that there are some differences from what is known in literature.

The differences consist of:

- the disappearance of some rare taxa;
- new contributions are added to the chorology of some rare species;
- the disappearance of some species from some localities mentioned in some specialty work papers is noted;
- some discussions are made about associations with typical psamophilic species;
- conservation measures are proposed for the areas occupied by rare species or by the associations with reduced area.

Disappeared taxa from the mentioned places in Oltenia, in scientific literature

Cyperus hamulosus: was mentioned in the interdunes from Fântâna Obedeanu. It was not identified again.

Fimbristylis bisumbellata: was mentioned in the interdunes from Obedeanu Fountain. It was not identified again.

Viola hymettia BOISS. et HELDR. 1855: Obedeanu Interdunes, Malu Mare, Ciurumela Forest. It was not identified in any of these localities.

Rindera umbellata – mentioned at the SW border of Craiova. It was not identified in any location.

Jasione dentata (DC.) HAL. 1902 (*J. janke* NEILR. 1870) – between Balta Craioviței, Cernele, Troaca and Afumați; between Malu Mare and Secui, Apele Vii, Marotin, Tâmburești.

Alyssum montanum LINNAEUS 1753 subsp. *gmelinii* (JORDAN) HEGI et E. SCHMID 1919 – is mentioned in the specialty literature from Fântâna Obedeanu, Craiova. It was not identified again.

Asperula orientalis BOISS. et HOHEN. 1843 – mentioned in Tâmburești and Balta Craioviței. It was not identified again in any of these station. There is no herbarium material.

Tragopogon floccosus WALDST. et KIT. 1805 – mentioned only in Apele Vii. It was not identified again.

Disappeared species from the Obedeanu Dunes:

Equisetum arvense LINNAEUS 1753, *E. palustre* LINNAEUS 1753, *Dryopteris thelypteris* (LINNAEUS 1753) A. GRAY 1848, *Salvinia natans* (LINNAEUS 1753) ALL. 1785, *Kochia laniflora* (GMEL.1774) BORB. 1900, *Salsola ruthenica* ILJIN 1934, *Mollugo cerviana* (LINNAEUS 1753) SER. in DC. 1824, *Cerastium semidecandrum* LINNAEUS 1753, *C. pumilum* CURT. 1777, *Holosteum umbellatum* LINNAEUS 1753, *Arenaria serpyllifolia* LINNAEUS 1753, *Herniaria incana* LAM. 1789, *H. glabra* LINNAEUS 1753, *Silene conica* LINNAEUS 1753, *S. otites* (LINNAEUS 1753) WIB. 1799 var. *effusa* OTTH 1824, *S. o.* supsp. *parviflora* (EHRH.) HAY. 1927, *Gypsophila* *muralis* LINNAEUS 1753, *Tunica prolifera* (LINNAEUS 1753) SCOP. 1772, *Euphorbia seguieriana* NECK. 1770, *E. virgata* WALDST. et KIT. 1805, *Descurainia sophia* WEBB et BERTHEL. 1836, *Alysum montanum* subsp. *gmelini*, *A. alysoides* LINNAEUS 1753, *A. desertorum* STAPF 1886, *Erophila verna* A. MEY. 1839, *Lepidium ruderale* LINNAEUS 1753, *Nasturtium officinale* R. BR. 1939, *Viola kitaibeliana* ROEM. et SCHULT. 1819, *V. hymettia*, *Potentilla arenaria*, *Trigonella monspeliaca*, *Medicago lupulina*, *M. falcata*, *M. sativa*, *M. minima*, *M. rigidula*, *Trifolium campestre* SCHREB. 1804, *T. repens* LINNAEUS 1753, *T. arvense* LINNAEUS 1753, *Vicia striata* M. BIEB. 1808, *V. lathyroides* LINNAEUS 1753, *Lythrum hyssopifolia* LINNAEUS 1753, *Malva neglecta* WALLR. 1824, *Tribulus terrestris* LINNAEUS 1753, *Eryngium campestre* LINNAEUS 1753, *Hottonia palustris* LINNAEUS 1753, *Heliotropium europaeum* LINNAEUS 1753, *Myosotis micrantha* PALL. 1817, *Datura stramonium* LINNAEUS 1753, *Gratiola officinalis* LINNAEUS 1753, *Veronica beccabunga* LINNAEUS 1753, *Prunella vulgaris* LINNAEUS 1753, *Lamium purpureum* LINNAEUS 1753, *Mentha pulegium* LINNAEUS 1753, *Plantago indica* LINNAEUS 1753, *Menyanthes trifoliata* LINNAEUS 1753, *Scabiosa argentea* LINNAEUS 1753, *Filago arvnesis* LINNAEUS 1753, *Gnaphalium luteo-album* LINNAEUS 1753, *Xanthium spinosum* LINNAEUS 1753, *Anthemis ruthenica* M. BIEB. 1808, *A. arvensis* LINNAEUS 1753, *Achillea ochroleuca*, *A. setacea* WALDST. et KIT. 1802, *Matricaria recutita* LINNAEUS 1753, *Senecio vernalis* WALDST. et KIT. 1800, *Xeranthemum cylindraceum* SIBTH. et SM. 1813, *Centaurea calcitrapa* LINNAEUS 1753, *Centaurea arenaria* M. BIEB. 1803 subsp. *borystenica* (GRUNER) DOSTÁL 1868, *Carthamus lanatus* LINNAEUS 1753, *Chondrilla juncea* LINNAEUS 1753, *Lactuca serriola* TORNER 1756, *Hieracium hoppeanum* SCHULT. 1814, *Gagea pusilla* (SCHMIDT 1794) J. A. et J. H. SCHULT 1829, *Ornithogalum refractum* KIT. 1813, *Muscari racemosum* (LINNAEUS 1753) MILL. 1768, *Juncus bufonius* LINNAEUS 1753, *Cyperus flavescens* LINNAEUS 1753, *C. hamulosus*, *C. fuscus* LINNAEUS 1753, *Scirpoides holoschoenus* (LINNAEUS 1753) SOJÁK 1972, *Fimbristylis bisumbellata*, *Carex hirta* LINNAEUS 1753, *Bromus commutatus* SCHRAD. 1806, *B. squarrosus* LINNAEUS 1753, *B. tectorum* LINNAEUS 1753, *Vulpia myuros* (LINNAEUS 1753) GMEL. 1806, *Sclerochloa dura* (LINNAEUS 1753) P. BEAUV. 1812, *Poa annuua* LINNAEUS 1753, *P. compressa* LINNAEUS 1753, *Catabrosa aquatica* (LINNAEUS 1753) P. BEAUV. 1812, *Elymus repens* (LINNAEUS 1753) GOULD. 1947, *Dasypyrum villosum* (LINNAEUS 1753) P. CANDARGY 1901, *Hordeum murinum* LINNAEUS 1753, *H. hystrix* ROTH 1797, *Agrostis stolonifera* LINNAEUS 1753, *Tragus racemosus* (LINNAEUS 1753) ALL. 1785.

Chorology data for the rare taxa in Romanian psamophilous flora

Achillea ochroleuca Ehrh.

Is known from: Ghindeni, Dunele Obedeanu, Apele Vii, Celaru, Dăbuleni, Ogrin, Ciupercenii Vechi.

New locality: Sadova – Dolj (Fig. 2).

Jasione montana L.

Is quoted from: Ghindeni and Celaru.

New location: Adunații de Geormane, next to the Victoria Lake (Fig. 3).

Alkanna tinctoria Tausch

It is known from: Dăbuleni, Ciupercenii Noi-Desa (Fig. 4), Nebuna, Tunarii Vechi.

Following the investigation made in these points we can say that the presence of this plant is only certain in the protected area Ciupercenii Noi-Desa. In the rest of the mentioned points in the literature, this plant species has not been found again.

Figure 2. *Achillea ochroleuca* from Sadova (original).

Figure 3. *Jasione montana* from Victoria Lake – Dolj county (original).

Figure 4. *Alkanna tinctoria* from Ciupercenii Noi-Desa (original).

Bassia laniflora (S.G: Gmelin) A.J. Scott

It is known from Malu Mare, Secui, Ghindeni, Apele Vii localities and from Obedeanu Dunes.

It has been identified on the sands from the west part of Craiova, on the outskirts of Sadova (Fig. 5) and in the protected area Ciupercenii Noi-Desa.

Mollugo cerviana (L.) Ser.

It is mentioned in the Oltenia psamophilous flora starting with1925 by I. Prodan. Further, Buia Al. & Păun (1958, 1964), Păun M. & Popescu Gh. 1985 mentioned its presence on the sands from the left side of the Jiu River: Cernele, Malu Mare, Ghindeni, Secui, Teasc, Bratovoești, Daneți, Mârșani, Apele Vii, Tâmburești, Rojiște, Ogrin, Dăbuleni, Ianca. It missed on the sands from the Danube Elbow and more recently from Dunes.

Although scientific literature stipulates that this plant species forms phytocoenosis framed by the specialists to *Digitario sanguinalis – Molluginetum cervianae* (Borza 1963) Pușcaru Soroceanu et al. 1963 (*Molluginetum cervianae oltenicum* Borza 1961), today it seems that these surfaces have been replaced in most of the cases by the phytocoenosis of *Plantaginetum arenariae* associations (Buia et al. 1960) Păun et Popescu 1972 (*Plantaginetum indicae* (Păun 1964)).

Figure 5. *Bassia laniflora* on the outskirts of Sadova (original).

The species has been found only as isolated specimens.

Silene borystenica (Gruner) Walters

It is known from sandy places at the west part of Craiova. It has been identified on the outskirts of Sadova (Fig. 6) and in the protected area Ciupercenii Noi-Desa.

Figure 6. *Silene borystenica* from sandy places in Sadova (original).

Erodium hoefftianum C.A. Meyer subsp. ***neilreichii*** (Janka) Soó

It is mentioned by Buia and Păun on the sands around Craiova. It has been identified by us in the western part of Craiova and on the sands from Dăbuleni.

Herniaria hirsuta L.

It is known from: Calafat, Vârciorova, Gura Văii, Svinița – Tricule, Dubova.

It has been identified on the sands from the outskirts of Ciupercenii Vechi.

Secale sylvestre Host – Ciupercenii Vechi, near Calafat.

In different specialty papers floristic lists of these sandy soils are mentioned (405 species on the sands from the left side of Jiu River and 355 species on the sands form the Danube Elbow or 560 species with 55 typical psamophilous (Păun & Popescu, 1985)) with numerous rare taxa (20). Their number has been reduced either by their disappearance from certain areas or by the change in their conservation status (ex. *Polygonum arenarium* (Fig. 7), *Euphorbia seguieriana, Syrenia cana, Viola kitaibeliana, Helicrysum arenarium, Crepis foetida* subsp. *rhoeadifolia, Potentilla arenaria, Scirpoides holoschoenus* etc.).

On the sands from Oltenia, forests occupy insignificant areas. Scientific literature mentions the remains of forest near Amărăștii de Jos. This has *Quercus pedunculiflora* in the floral composition, as a wood species (Fig. 8). Besides this, there are many shrubs and herbaceous species.

Figure 7. *Polygonum arenarium* on the outskirts of Sadova (original).

Figure 8. The physiognomy of the woods *Quercus pedunculiflora* from Ciupercenii Vechi – Dolj county (original).

As rare shrubs, the greyish oak has been identified in Mârșani, Daneți, Tâmburești and Ogrin.

A good representation of these silvosteppe forests is found at the outskirts of Ciupercenii Vechi Otherwise the tree vegetation is represented today by some rests of acacia plantations or black pin, areas that have escaped from people cutting.

Psamophilic herbaceous vegetation in Oltenia is classified in various associations by different authors: Buia & Păun (1964) mentions 51 associations; Cîrțu (1973) 14 associations; Păun & Popescu (1985) – 13 associations. Some of these have rare species in compositions who often give the name of association: *Achillea ochroleuca* (*Achilleo ochroleucae-Secalietum sylvestris*); *Viola hymettia* (*Violo hymettiae-Cynodontetum*), *Mollugo cerviana* (*Digitario sanguinalis-Molluginetum cervianae*), *Bassia laniflora* (*Bassio laniflorae-Brometum tectorum*).

As a result of the researches carried out in the last 15 years, we can say that the vegetation of the grassy layer has undergone some changes, i.e. the disappearance of the phytocenosis of some associations by replacing them with others.

The associated phytocoenosis edified by *Mollugo cerviana* has disappeared from some points mentioned in scientific literature (ex. Obedeanu Dunes, Craioviţa). Otherwise, this species is found as isolated specimens.

Violo hymettiae-Cynodontetum is mentioned from the interfluvial Jiu-Desnăţui (Obedeanu, Gângiova, Jiu Meadow, Radovan) or on the sands from the left side of Jiu River as *Viola kitaibeliana* with *Viola hymettia* Association.

No phytocoenoses of this association have been identified in any of these sites. They have been replaced with those edified by *Plantago arenaria* (Fig. 9).

Figure 9. Areas dominated by *Plantago arenaria* from Oltenia (original).

Phytocoenoses of the *Tribulo - Tragetum* association were identified in large areas Soo et Timar 1954.

Findings in the floral composition of the *Mollugo cerviana* and *Cynodon dactylon* species enable us to say that this vegetation has replaced the one edified by *Mollugo cerviana* and evolves towards the one dominated by *Cynodon dactylon.*

CONCLUSIONS

The sands in Southern Oltenia are made up of two distinct areas, one located on the left of the Jiu River, and the second on the western terraces of the Danube.

The flora and vegetation of these landscapes shelters many rare elements in Romania: *Cyperus hamulosus, Fimbristylis bisumbellata, Rindera umbellata, Jasione montana* etc. or phytocoenosis of some associations edified by rare species: *Achilleo ochroleucae-Secalietum sylvestris*; *Violo hymettiae-Cynodontetum*, *Digitario sanguinalis-Molluginetum cervianae*, *Bassio laniflorae-Brometum tectorum*.

After consulting the specialized literature, numerous modifications have been found regarding the reduction of the area or the disappearance of some species or vegetal associations, the identification of some new places for some rare psamophilous taxa in Romania's flora (ex. *Silene borystenica*, *Achillea ochroleuca*) or by disappearance of some plant association (ex. *Violo hymettiae-Cynodontetum*).

Human activity has also materialized in the establishment of acacia plantations and trees curtains for protection (*Robinia pseudacacia*), greyish oak (*Quercus pedunculiflora*), to control deflation in all the sandy areas of the country.

The cuts of protection curtains made from acacia plantations have caused, at some times, true sand storms.

To avoid these unpleasant situations and to limit the spread of the anthropic factor, the extension of the anthropic factor should be limited and this area should be monitored by the Environmental Protection Inspectorate by means of periodic inspections.

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Simeanu Cătălin George
University of Craiova, Faculty of Horticulture, Biology Department, Libertăţii Street 15, Craiova, 200585, Romania.
E-mail: simeanucg@yahoo.com

Măceșeanu Daniela Mihaela
Museum of Oltenia, Craiova,Popa Șapcă Street, No. 8, Craiova, 200410, Romania.
E-mail: daniela.maceseanu@yahoo.com

Răduţoiu Daniel
University of Craiova, Faculty of Horticulture, Biology Department, Libertăţii Street 15, Craiova, 200585, Romania.
E-mail: radutoiu02daniel@gmail.com

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MEDICINAL AND AROMATIC PLANT VARIETIES RESISTANT TO DROUGHT

GONCEARIUC Maria, COTELEA Ludmila, BALMUS Zinaida, BUTNARAS Violeta, MASCOVTEVA Svetlana, BOTNARENCO Pantelimon

Abstract. The climate change in recent decades imposes the cultivation and use of plant varieties that are adapted to drought conditions, high critical temperatures and ensure high productivity. It has been shown that the consequences of drought can be substantially diminished by cultivating drought-resistant varieties of the aromatic and medicinal species such as *Salvia sclarea, Lavandula angustifolia* and *Salvia officinalis*. The early-, mid- and late-ripening *Salvia sclarea* varieties Ambra Plus, Balsam, Parfum Perfect, Ambriela, Dacia 99; Victor; Nataly Clary are very resistant to drought; they accumulate in dry years high content (0.916-1.202%) of essential oils, provide a production of 15.1-22.4 t/ha of inflorescences in two years of plantation exploitation and guarantee yields of 41.1-77.4 kg/ha of essential oil depending on the variety. The efficiency of *Salvia sclarea* varieties ranges between 2.8 and 3.6 kg per ton. The essential oil content of *Lavandula angustifolia* varieties is higher (5.103-6.164%) in dry years than in those with common atmospheric depositions (4,318-5,915%). The productivity of the lavender varieties Moldoveanca 4, Vis Magic 10, Alba 7, Aroma Unica etc. is higher and makes 7-12 t/ha of inflorescences with high content of essential oil (4.575-6.164%) and 121.1-182.6 kg/ha of essential oil. The efficiency varies from 16.8 to 21.5 kg of essential oil per ton of inflorescences. Variety Miracol of *Salvia officinalis* drought-resistant ensures a production of 850-989 kg / ha of dried leaves in the dry years and 960-1070 kg / ha of ordinary habitat. The production of essential oil of the variety in the dry years is higher (18.7-18.9 kg/ha) than in the years with common atmospheric depositions (17.2-17.6 kg/ha).

Keywords: Medicinal plant, *Salvia sclarea*, *Lavandula angustifolia, Salvia officinalis*, variety, drought resistance, productivity.

Rezumat. Soiuri de plante medicinale şi aromatice rezistente la secetă. Schimbările climatice din ultimele decenii impun cultivarea și utilizarea soiurilor de plante care sunt adaptate condițiilor de secetă, temperaturilor critice ridicate și care asigură o productivitate ridicată. S-a demonstrat că consecințele secetei pot fi diminuate în mod substanțial prin cultivarea soiurilor rezistente la secetă din speciile aromatice și medicinale, cum ar fi *Salvia sclarea, Lavandula angustifolia, Salvia officinalis*. Soiurile de *Salvia sclarea* timpurii, medii şi tardive Ambra Plus, Balsam, Parfum Perfect, Ambriela, Dacia 99; Victor; Nataly Clary sunt foarte rezistente la secetă. Acestea acumulează în anii secetoși un conținut înalt (0.916-1.202%) de ulei esențial, asigură o producție de 15,1-22,4 t/ha de inflorescențe în doi ani de exploatare a plantațiilor și garantează o producţie de ulei esențial de 41.1-77.4 kg / ha în funcţie de soi. Eficiența, randamentul soiurilor de *Salvia sclarea* variază între 2,8 și 3,6 kg per tona de materie primă. Conținutul de ulei esențial al soiurilor de *Lavandula angustifolia* este mai mare (5.103-6.164%) în anii secetoși decât în cazul celor cu depuneri atmosferice obișnuite (4,318-5,915%). Productivitatea soiurilor de lavandă este înaltă: 7-12 t/ha de inflorescențe cu conținut ridicat de ulei esențial (4.575-6.164%) și 121.1-182.6 kg/ha de ulei esențial. Eficiența variază de la 16.8 până la 21.5 kg de ulei esențial pe tonă de inflorescențe în funcţie de soi. Soiul miracol de *Salvia officinalis* rezistent la secetă asigură o producție de 850-989 kg/ha de frunze uscate în anii uscați și 960-1070 kg/ha în anii obișnuiți. Producția de ulei esențial al soiului în anii uscați este mai mare (18,7-18,9 kg / ha) decât în anii cu depuneri atmosferice obișnuite (17,2-17,6 kg / ha).

Cuvinte cheie: Plante medicinale, *Salvia sclarea*, *Lavandula angustifolia, Salvia officinalis,* soiuri, rezistenţă la secetă, productivitate.

INTRODUCTION

The importance of medicinal and aromatic plants is indisputable in view of the revival of phyto-pharmacy and herbal treatments. Thus, the share of drug products from medicinal and aromatic plants and their derivatives has been constantly growing. More than 50% of the prescribed drugs are chemical derivatives identified for the first time in medicinal plants. Around 50 -70 thousand plant species are used in medicines throughout the world (ROSE, 1981). The use of these plants for medicinal, perfumery, cosmetics reasons is due to the essential oil and its components separated from inflorescences. Given the fact that about 3500 tons of essential oils, 10,000 tons of food additives, 10,000 tons of perfumery additives are produced in the international cultivation of varieties of the medicinal and aromatic plants are strictly necessary, thus guaranteeing the steadfast production of high quality pharmaceutical, perfumes, and food raw materials, with a much more enhanced content of active principles in comparison with the types collected in wild flora. On the other hand, they provide an important source of income in rural areas. All of these have influenced constantly the studies on the chemical composition, qualities and benefits of using flowers, leaves, essential oils and other derivatives of medicinal an aromatic plant, including, *Lavandula angustifolia* Mill., *Salvia sclarea* L., *Salvia officinalis* L. etc. well as the diversity of essential oil use depending on its qualitative and quantitative composition.

A particular research area includes the studies carried out to develop new hybrids and varieties that are resistant to abiotic factors that would ensure an enhanced production of inflorescences with a higher content of essential oil and a quality that corresponds to the envisaged purpose. Such studies have obviously intensified during the last decades as a consequence of the climatic changes, slow but steady processes of global warming, transformation of some zones into a desert including in south-eastern Europe where farm crops are affected by drought and scorching heat more and more frequently. Simultaneously, our researches show that the cultivars of medicinal and aromatic plants

(*Lavandula angustifolia*, *Salvia sclarea*, *Salvia officinalis*, *Anethum graveolens*, *Origanum vulgare* etc.) provide an enhanced production of raw material and high-quality essential oil in dry years. Some of these cultivars such as lavender accumulate a content of essential oil that is even higher in dry years than in the years with common atmospheric depositions.

MATERIAL AND METHODS

The biological material comprises *Salvia sclarea* L.*, Salvia officinalis* L., *and Lavandula angustifolia* Mill varieties of different hybrid origins. Thus, *Salvia sclarea* cultivars are hybrids with fixed, constant heterosis (GONCEARIUC et al., 2016) of different complexity: simple (Dacia-50, Dacia-99, V. Junior, Victor), triple (Nataly-Clary, Parfum Perfect), backcross (Ambra Plus) and stepwise (Balsam, Ambriela) hybrids. The *Lavandula angustifolia* varieties Moldoveanca 4, Vis magic 10, Alba 7 and Aroma Unica as well as new varieties in the testing process (Fr.8-5-15V; VM-18V; Fr.5S8-24) are first-generation hybrids with a high heterosis effect on a number of quantitative traits including essential oil content (GONCEARIUC, 2018; GONCEARIUC et al., 2018). The validation of the quantitative traits and productivity of all varieties was carried under legal methods. The essential oil content was assessed in fresh inflorescences at the stage of industrial maturity through hydrodistillation in the Ginsberg apparatus and recalculated for dry matter.

The weather conditions in the years of conducting the studies were as follows:

The agricultural years 2012, 2015 and 2018 were dry according to the reports of the State Hydro meteorological Service of the Republic of Moldova. The summer of 2012 was recorded as the hottest, the average temperature of the air exceeding the norm by 3-4ºC per season. Rainfall in the spring-summer period was 238.9 mm, compared to the multiannual average of 308 mm; the amount of annual precipitation being 378.3mm or 69.1 mm lower than the multiannual average (526 mm). In 2015, the annual precipitation amounted to 480.5 mm, by 45.5 mm lower than the multiannual average. During the spring-summer period, 205.2 mm of rainfall were recorded, the multiannual average being 308.0 mm. The largest humidity deficit was attested in June-August: the precipitation amount was only 85.1 mm, or 100.9 mm lower than the multiannual average of 186 mm. 2018 is a special year characterized by an abnormally hot spring, when the average monthly air temperature in April exceeded the norm by 4.5-5.5ºC, a fact reported for the first time in the entire observation period. The temperature of the soil during May - August ranged between 58.7 and 64º C. Precipitations were only 3.7 mm in April, and reached 17.5 mm in May, by 35.3 and 34.5 mm lower, respectively, than the multiannual norm. August was also very dry with 0.6 mm of atmospheric deposits. Drought periods alternated with heavy rainfall, which provided a total annual rainfall that did not differ much from the multiannual average, or both the periods of acute drought and those with heavy rainfall were accompanied by very high temperatures.

The agricultural years 2013, 2014, 2016, 2017 are characterized by an amount of precipitations in the spring - summer period ranging from 316 mm in 2013 to 380.2 mm in 2017; the amount of annual rainfall was 608 mm in 2013, 86 mm higher than the multiannual average; 524.6 mm in 2014, 1.4 mm lower than the multiannual average; 567.6 mm in 2016, by 41.6 mm exceeding the multiannual average; 641.4 mm in 2017, or 115.4 higher than the multiannual average.

RESULTS AND DISCUSSIONS

Previous research has shown that intraspecific hybridization is an efficient method to develop valuable genotypes through pronounced variability of the indices of bio morphological character values including the content and components of essential oil in *L.angustifolia, S. sclarea* and *S. officinalis* (GONCEARIUC, 2014, GONCEARIUC et al., 2016; GONCEARIUC, 2018). Importantly, our hybrid varieties are strongly resistant to drought (GONCEARIUC et al., 2016; 2018). In contrast to other *S. sclarea* cultivars, the ones we have developed begin flowering in the first year of vegetation providing both production of 3-5 t/ha of inflorescences and 12-20 kg/ha of essential oil. So, the cultivar Ambra Plus is distinguished by abundant flowering and the yields of inflorescences make up to 11 t/ha and 40.9 kg/ha of essential oils in the first year (Table 1.). The production of raw material of all *Salvia sclarea* varieties in drought condition of the 2015 year constituted between 3 and 8 t/ha, in dependence on the variety. The content of essential oil was higher in the cultivar Balsam (1.286%). The production of essential oil varied between 5.7 kg/ha in the cultivar Nataly Clary and 11.6 and 12.5 kg/ha in the cultivars Ambra Plus and Balsam, respectively. Also, in the dry year 2015, the second year of vegetation, all the varieties produced high quantities of raw material (12.1- 18.7 t/ha) and essential oil (32.5-58.8 kg/ha) (GONCEARIUC et al., 2018).

The inflorescence yields, the content and production of essential oil are supported by a number of quantitative traits. The indices of their values were remarkable in the dry 2015 year: the plants formed a great number of floral stems per m^2 and the plant's height of 117.7-125.1 cm, long inflorescences (56.7-64.3 cm) with a large number of ramifications, high content of essential oil, which shows excellent development under drought conditions.

In the two years of exploitation (2014-2015), the yields of raw material were 15.1 t/ha – 22.4 t/ha, and essential oil production varies between 41.1 n 77.4 kg/ ha depending on the variety (Fig. 1).

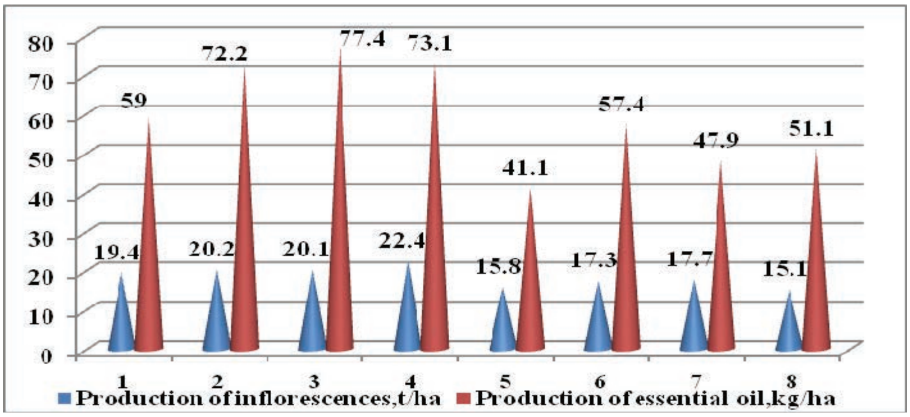

Figure 1. The producing capacity of the *Salvia sclarea* varieties in two years of plantation exploitation, 2014-2015: 1. Dacia-50,st.; 2. Ambra Plus; 3. Balsam; 4. Parfum perfect; 5. Dacia 99; 6. V. Junior; 7. Victor; 8. Nataly Clary.

The 2018 year in the Republic of Moldova was also dry. Under these conditions, the varieties of *S.sclarea* in the second year of vegetation formed high yields (10.7-13.9 t/ha) of inflorescences with high content of essential oil (0.859-1.202%) (Table 1). Essential oil production in the second year of vegetation consisted of 27.6 to the standard variety up to 43.1 kg/ha at variety Ambriela.

In two years of operation of the plantation, the yield of the raw material ranged from 14.4 t/ha for the standard variety to 23.2 t/ha for the Ambra Plus variety and essential oil production ranged from 51.8 kg/ha attested for Dacia 99 to 73.6 kg/ha for the Ambra Plus variety. The efficiency of all varieties is very high: 3.3-3.6 kg/t in the first year of vegetation and 2.7-3.6 kg/t in the second year that was dry (Table 1).

The high productivity of these varieties is sustained, influenced by the values of the quantitative characters of plants. In drought conditions (2018), the tested varieties formed a large number of floral stems (44.4-69.1/m^2), long inflorescences (52.7-70.0 cm) with large number of branches, which shows an excellent plant development. All of this has resulted in a high content (0.858-1.202%) of essential oil (Table 2.) and high productivity (Table 1).

Table 1. The productivity of *Salvia sclarea* L. varieties, first & second years of vegetation, 2017-2018*.

Variety, hybrids	Row material yield, t/ha		Essential oil content, %		Essential oil production kg/ha		Efficiency, kg /t	
	2017 Ist year	2018* IInd year	2017 Ist year	2018* IInd year	2017 Ist year	2018* IIndyear	2017 Ist year	2018* IIndyear
early varieties								
Dacia-50, st.	3.7	10.7	1.120	0.858	12.5	27.6	3.3	2.7
Ambra Plus	11.7	11.8	1.163	0.916	40.9	32.6	3.5	2.9
Balsam	8.9	12.8	1.131	1.015	30.1	39.4	3.4	3.1
Ambriela	8.3	11.9	1.215	1.202	30.3	43.1	3.6	3.6
Parfum Perfect	7.8	12.2	1.132	1.086	26.5	39.9	3.4	3.3
middle variety								
Dacia 99	3.8	12.2	1.097	1.070	12.6	39.2	3.3	3.2
late varieties								
Nataly Clary	3.8	13.9	1.187	1.036	13.7	43.3	3.6	3.1

* dry year DL, 0,5 1.1 1.2
P, % 2.0 2.1

Table 2. The values of some productivity indices in *Salvia sclarea* varieties in competitive crops, 2018.

Variety	Floral stems/ m^2	Plant height, -cm- X ± Sx	Inflorescence length, -cm- X ±Sx	Inflorescence branches, number Grade I X ± Sx	Grade II X ± Sx	Essential oil content, % (dry matter)
early varieties						
Dacia-50 st.	46.5	138.6±7.4	66.9±7,9	16.0±2.1	25.4±6.2	0.858
Ambra Plus	54.7	137.1±8.0	67.9±6,7	15.8±1.7	25.9±8.0	0,916
Balsam	46.4	138.2±7.2	66.4±6.4	15.4±1.8	21.7±4.8	1,015
Parfum Perfect	60.0	143.2±8.8	69.2±6.7	15.0±1.9	23.0±6.4	1.086
Ambriela	54.6	141.0±7.8	70.0±7.9	16.1±2.7	22.6±5.7	1.202
middle variety						
Dacia-99	55.7	135.7±9.9	63.4±8.3	15.5±2.3	24.3±8.2	1.070
late varieties						
Victor	69.1	138.8±9.5	64.4±7.9	15.6±2.1	25.0±6.8	0.815
Nataly Clary	58.6	120.9±6.0	52.7±5.3	14.4±1.9	20.1±4.4	1.036

The productivity of other varieties of *Salvia sclarea*, such as the Ukrainian variety Krymsci ranii, and the Russian variety Voznesenskii 24, cultivated in the Republic of Moldova until 1992-1994 did not bloom in the first year of vegetation. In the second year of vegetation, the productivity of these varieties was10-13 t / ha of the raw material and 8-12 kg / ha of essential oil with an efficiency about 2 kg / t of essential oil.

The hybrid varieties of lavender accumulate enhanced content of essential oil in drought conditions than in the years that are not affected by drought (GONCEARIUC, 2018; GONCEARIUC et al., 2018) (Table 3). In 2015, this important trait ranged from 4.575-6.164% in the cultivar Vis Magic 10 to 6.164% in the cultivar FR.5S8-24.

It is well known that severe drought has a negative effect on perennial species both in the year of major humidity deficiency and in the years that follow. The consequences of the 2015 drought were different in the case of the lavender cultivars. The F_1 hybrids recorded a higher content of essential oil in the 2015 than in the 2014, 2016, 2017 and 2018 exceeding the maternal form of origin (GONCEARIUC et al., 2018). Similar results were recorded in the years of severe drought 2007 and 2012.

Table 3. The content of essential oil in the varieties (hybrids) of *Lavandula angustifolia*.

Varieties (hybrids F_1)	**Essential oil content, % (dry matter)**				
	2014	**2015, dry year**	**2016**	**2017**	**2018, dry year**
early varieties					
Moldoveanca 4 st.	4,893	5.404	4,318	4,981	4.611
Fr.8-5-15V	4,545	5.803	4,691	5,454	5.624
middle variety					
Vis Magic 10 st.	4,423	4.575	4,597	4,518	4.741
VM-18V	4,710	5.103	4,924	4,829	4.872
late varieties					
Alba 7st.	5,298	5.762	5,915	5,256	5.624
Fr.5S8-24	5,087	6.164	5,786	5,915	5.656
Aroma Unica	4.901	5.496	4.899	4.961	5.476

The average producing capacity of the lavender varieties in drought conditions with different vegetation periods ranges between 6.9 t/ha of raw material (inflorescences) in the cultivar VM-18V and 8.9-10.8 t/ha in the cultivars Aroma Unica and Moldoveanca 10 (Table 4). The production of essential oil makes 121.1-182.6 kg/ha depending on the cultivar.

In the years with common atmospheric deposition, the productivity of lavender varieties is 7.4-12.4 t/ha and 132.8-250 kg/ha essential oil depended on the variety (GONCEARIUC, 2014; 2018; GONCEARIUC et al., 2018). These cultivars are also distinguished by high efficiency – one ton of raw material ensures obtaining from 16.8 to 21.5 kg/t of essential oil with content of linalyl acetate making 28 to 39%. This index is 44% in the new cultivars Aroma Unica etc. It should be mentioned that all developed cultivars and hybrids have a low concentration (0.21-0.27%) of camphor in the essential oil (GONCEARIUC, 2014; GONCEARIUC et al., 2018), this component being important as it diminishes the quality and perfumery value of essential oil in high concentrations (more than 2%). In the essential oil Bulgarian lavender varieties, the concentration of camphor is much higher 6.6-9.2% (ZHELJAZKOV et al., 2013). The productivity of Bulgarian lavender varieties is as follows: 6.3-6.9 t/ha fresh raw materials; 1.9-2.0% essential oil in fresh inflorescence; 49.2-180 l / ha production of essential oil (YANCHEV, 2017).

Table 4. Productivity of *Lavandula angustifolia* varieties in drought conditions, 2018.

Variety	**Row material yield, t/ha**	**Essential oil content, %**	**Essential oil production, kg/ha**	**Efficiency, kg /t**
Early varieties				
Moldoveanca 4, st.	10.8	4.611	181.7	16.8
Fr.8-5-15V	8.5	5.656	161.9	19.0
Middle varieties				
Vis Magic 10, st.	8.3	4.741	143.3	17.3
VM-18V	6.9	4.872	121.1	17.6
Cr.13S-6-7	7.9	4.012	136.4	17.3
Late varieties				
Alba 7, st.	7.6	5.624	134.7	17.7
FR.8-5-15V	8.5	5.624	182.6	21.5
Aroma Unica	8.9	5.476	166.8	19.9

The early ripening variety of *S. officinalis* named Miracol as well as varieties of *L .angustifolia* and *S. sclarea* is resistant to drought, frost and wintering. The variety can be used to produce pharmaceutical raw material of *Folium Salviae*, *Herba Salviae* and essential oil – *Oleum Salviae* (GONCEARIUC, 2014).

The producing capacity of the variety Miracol is 850-989 kg/ha of dry leaves (13% of humidity) in drought conditions (2012, 2015, 2018) and 960- 1070 in the years with common atmospheric deposition (Table 5).

A similar content of essential oil as in the Miracol variety was described for the Crimea variety Predgornyi (1.6%). Most of the scientific publications regarding *Salvia officinalis* are about the quantitative and qualitative components of the essential oil, but not the production of raw material, essential oil. The essential oil chemical composition of this species is very variable (BERNOTIENĖ et al., 2006; GONCEARIUC et al., 2012).

Table 5. Yield of *Salvia officinalis* L. variety Miracol.

Years	**Yield of raw material, kg/ha**		**Essential oil content, August 15-20, % (dry matter)**	**Production of essential oil kg/ha**
	Humidity 60%	Humidity 13%		
2012*	2990	850	1.890	18.7
2013	2930	960	1.540	17.4
2014	3055	1029	1.498	17.6
2015*	2989	920	1.835	18.9
2016	3010	980	1.640	17.5
2017	3090	1070	1.596	17.2
2018*	3025	989	1.748	18.9

22 components were identified in the essential oil separated from shoots wits leaves of the variety Miracol. The concentrations of major compounds in the essential oil are: α-thujone, 33.791%; β- thujone, 5.877%; camphor, 24.59%, eucalyptol, 8.416%. In essential oil separated from leaves, the major compounds are: α-thujone, 21.239%; β-thujone, 16.201%; camphor, 19.133%; eucalyptol, 10.372% (GONCEARIUC et al., 2012). In the essential oil separated from the varieties Extracta, Regula, and IPPO the major components are also α- and β-thujone but also 1.8 cineole (GIUSEPPE DE MASTRO, 2006). The chemical composition of *Salvia officinalis* essential oil from Bulgaria are: α-thujone (26.68%), (E)-β-caryophyllene (7.47%), 1,8- cineole (7.19%), α-humulene (6.11%), β-pinene (5.44%), β-thujone (5.35%), camphor (4.84%), allo aromadendrene (4.55%), borneol (3.69%), and α-pinene (3.58%) (DAMYANOVA et al., 2016). In *Salvia officinalis* essential oil from North America was described in different varieties four principal constituents in a concentration of about 10%: camphor, α-thujone, β-thujone, 1.8 cineole which form five chemotypes (TUKER, MACIARELLO, 2011).

The production of essential oil obtained from steam distillation of fresh raw material Miracol variety is about 18.7-18.9 kg/ha in dry years and 17.2-17.6 kg/ha in common years.

Thus, climate changes in recent decades imposed the cultivation and use of medicinal and aromatic plants varieties that support drought, high critical temperatures and ensure high productivity.

CONCLUSIONS

1. The consequences of drought can be substantially diminished by cultivating drought-resistant varieties of aromatic and medicinal species such as *Salvia sclarea*, *Lavandula angustifolia* and *Salvia officinalis*. The results of our research demonstrate: dry years favour the varieties created by us through the synthesis of essential oil, guaranteeing high productivity and quality.
2. The *Salvia sclarea* cultivars Ambra Plus, Balsam, Parfum Perfect, Ambriela, Dacia 99; Victor; Nataly Clary are resistant to drought and, in the dry years, accumulate a high content (0.858-1.202 %) of essential oils, provide a production of 15.1-22.4 t/ha of inflorescences and guarantee yields of 41.1-77.4 kg/ha of essential oil depending on the variety. The efficiency of *Salvia sclarea* varieties ranges between 2.7 and 3.6 kg/t of essential oil per ton of raw material.
3. The essential oil content of *Lavandula angustifolia* cultivars in drought conditions is higher (4.575-6.164%) than in those with common atmospheric depositions (4,318-5,915).
4. The productivity of the lavender cultivars Moldoveanca 4, Vis Magic 10, Alba 7, Aroma Unica, etc. in drought conditions ensures yields of 6.9-10.8 t/ha of inflorescences and 121.1-182.6 kg/ha of essential oil depending on the variety. The efficiency varies from 16.8 to 21.5 kg of essential oil per ton of inflorescences.
5. Variety Miracol of *Salvia officinalis* drought-resistant ensures a production of 850-989 kg/ha of dried leaves in the drought conditions and 960-1070 kg / ha in conditions of normal habitat. The production of essential oil of the variety in the dry years is higher (18.7-18.9 kg / ha) than in the years with normal atmospheric depositions (17.2-17.6 kg/ha).

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Gonceariuc Maria, Cotelea Ludmila, Balmus Zinaida, Butnaras Violeta, Mascovteva Svetlana, Botnarenco Pantelimon
Institute of Genetics, Physiology and Plant Protection Ministry of Education, Culture and Research
20, Pădurii St., Chișinău, MD-2002, Republic of Moldova.
E-mail: gonceariuc.maria@gmail.com

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A BIOMONITORING STUDY ON *Xanthoria parietina* (L.) TH.FR IN ISPARTA, TURKEY

YAVUZ Mustafa, ÇOBANOĞLU Gülşah

Abstract. This study aims at determining air quality and potential pollutant sources in Isparta, as well as Gölcük Nature Park, through lichen biomonitoring. The specimens of cosmopolite epiphytic foliose lichen *Xanthoria parietina* (L.) Th.Fr were sampled from 8 localities in the study area and analysed in an ICP – MS device with reference material, in order to detect Al, As, Cd, Cr, Cu, Fe, Mn, Ni, Pb, V, and Zn elements. The distribution of these airborne elements in the study area was mapped spatially. The results indicate that the elemental sequence of average concentrations measured is Ni > V > Cr > Fe > As > Cu > Al > Zn > Mn > Cd > Pb. Cluster analysis results of the elemental data indicate a strong correlation of the major 3 contaminants in the urban area, which are Ni, V, and Cr. The lichen specimens accumulated maximal concentrations of Cd, Cu, Mn, Ni, Zn within the Nature Park, the rest of the elements in northern and the eastern localities surrounding the city. The elemental pollution in Isparta is higher than expected due to extensive use of coal as fossil fuel in the city, and it seems to be associated with topographic and climatic characteristics of the city.

Keywords: airborne elements, lichen, biomonitoring, Isparta.

Rezumat. Studiu de biomonitorizare al speciei *Xanthoria parietina* (L.) Th.Fr în Isparta, Turcia. Acest studiu are ca scop determinarea calității aerului și posibilele surse poluante în Isparta ca de asemenea și în parcul Natural Gölcük, prin biomonitorizarea lichenilor. Speciile de foliole ale epifitelor cosmopolite *Xanthoria parietina* (L.) Th.Fr au fost luate din 8 localități ale zonei de studiu și au fost analizate cu aparatul ICP – MS pentru a detecta elementele: Al, As, Cd, Cr, Cu, Fe, Mn, Ni, Pb, V și Zn. Distribuirea acestor elemente transmise prin aer în zona de studiu, a fost cartografiată păstrând anumite limite. Rezultatele indică, că există o legătură elementară între concentrațiile măsurate și aceasta este Ni > V> Cr > Fe > As > Cu > Al > Zn> Mn > Cd > Pb. Analizele rezultate indică o strânsă legătură a celor 3 contaminanți majori în zona urbană, aceștia fiind Ni, V și Cr. Speciile de licheni au acumulat o concentrație maxima de Cd, Cu, Mn, Ni, Zn în interiorul Parcului Natural, restul elementelor fiind acumulate în nordul și estul localităților din jurul orașului. Poluarea din Isparta este mai mare decât s-ar fi așteptat datorită folosirii excesive a cărbunelui ca și combustibil și pare a fi asociat cu caracteristicile climatice și topografice ale orașului.

Cuvinte cheie: elemente aeriene, licheni, biomonitorizare, Isparta.

INTRODUCTION

Lichens are symbiotic organisms, consisting of a mycobiont as the fungal partner, and one or more photobionts, like a green alga or cyanobacteria. Lichens are sensitive to environmental changes due to their biological peculiarities and symbiotic lifestyle (HAWKSWORTH & ROSE, 1976), thus lichens are sensitive bioindicators for air pollution, climatic changes, forest structures and dynamics regarding the quality of biodiversity (GIORDANI et al., 2012). Since lichens are slow-growing organisms and have neither roots nor a protective cuticle layer, they absorb air pollutants with moisture mainly through the thallus surface, hence they are open to the effects of any atmospheric contaminants (GARTY, 2001; WOLTERBEEK et al., 2003). Consequently, trace element concentrations in lichen thalli indicate the environmental levels for the elements (BARI et al., 2001). Using lichens as biomonitoring organisms facilitates many aspects such as sampling and cost, and makes them advantageous for the spatial and temporal assessment of pollutant levels in the environment (LOPPI et al., 2003; SCERBO et al., 2003).

The number of lichen biomonitoring studies in Turkey has been increasing during the last two decades (ASLAN et al. 2004; YENISOY-KARAKAŞ & TUNCEL 2004; MENDIL et al. 2005; CAYIR et al. 2007; YILDIZ et al. 2008; İÇEL & ÇOBANOĞLU, 2009; ŞENKARDEŞLER & AYSEL, 2010; ÖLGEN & GÜR, 2012; DOĞRUL-DEMIRAY et al., 2012; BOZKURT, 2017; KURNAZ & ÇOBANOĞLU, 2017). Isparta is a city located in the Mediterranean Region of Turkey and has undergone a dense and uncontrolled increase of population, followed by irregular urbanization at the end of 1990s. This increase in population and urbanization caused environmental problems in the Isparta province. Industrial zones are concentrated in the north-northeast direction of the city. As mentioned in the detailed report by DEMIR (2010), there are various workshops and some factories, focused on sectors of forestry and carpentry (51 facilities), food and beverage (46), metal equipment (34), cement and marble (28), textile and leather (25), petro-chemistry and paint (19), cosmetics (4), and fertilizers (1). For residential heating, wood, coal and fuel oil are widely used in the province, and 102,920,456 kg of coal are consumed between April 2008 – April 2009 in the centre. In addition to the industrial facilities, a major highway between Afyonkarahisar and Antalya pass through Isparta, which is another potential source of airborne pollutants. Air quality assessment done by local authorities in Isparta is based on the monitoring of PM_{10} and SO_2 in air. In such cities with industrial pollution, biological monitoring through lichens is necessary to reach longer-term and broader perspective outcomes. The main objective of this study is assessment of the air quality in Isparta by lichen biomonitoring. In order to achieve this, the degree of metal deposition in Isparta is examined via quantitative analyses and the relationship between potential pollutant sources and levels of airborne metals are investigated. Considering that air pollutants can be transported to very long distances by environmental factors such as wind (ÇOBANOĞLU, 2015), Gölcük Nature Park (GNP) within the provincial borders was also included in this study. This work also aims to establish a baseline for future biomonitoring studies in Isparta.

MATERIALS AND METHODS

Isparta is located in the North-Western Mediterranean Region, Turkey (Fig. 1). The southern part of the city is mountainous while the western part is sporadically hilly and due to these geographical peculiarities, industrial zones are located in eastern and northern parts of the urban area. The northern and eastern parts of the suburban area are surrounded by agricultural fields as well. The Gölcük Nature Park (GNP) is located in the South, South-western part of Isparta city centre. Isparta has a Semi-Arid Mediterranean climate with a mean annual rainfall of 506 mm and a mean annual temperature of 12 °C (Fig. 2). The prevalent winds in the region are from the South-west (9 m/s), South (8.1 m/s), South-east (6 m/s), and West (1.6 m/s) directions (IMIM, 2010).

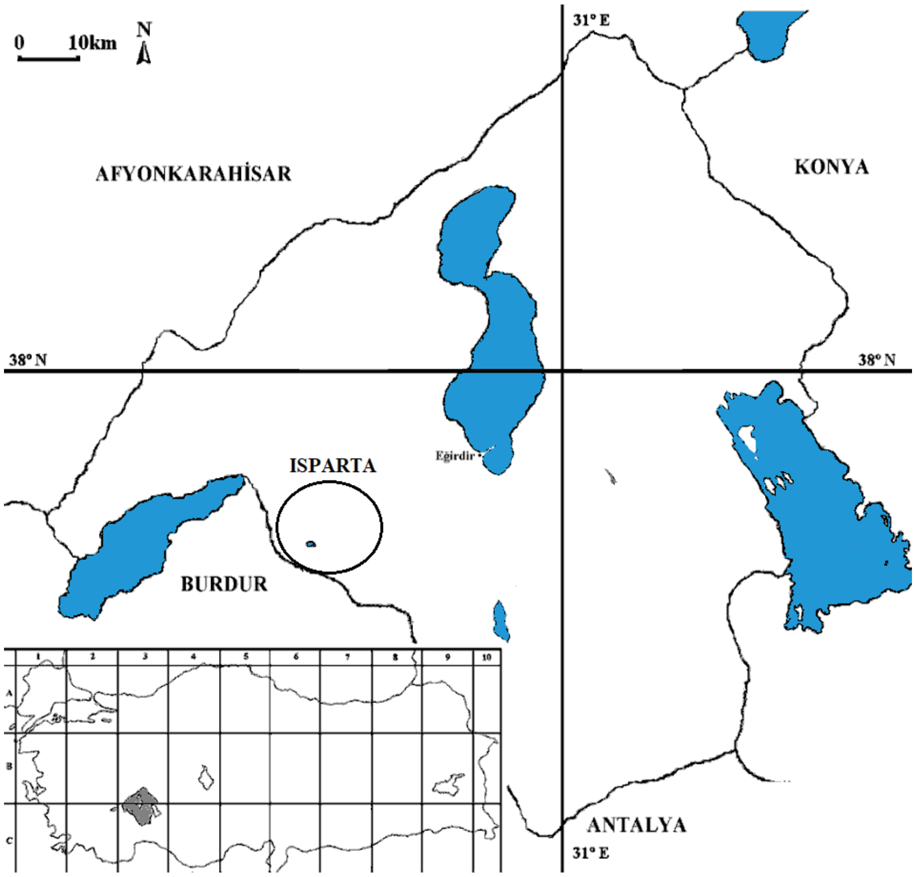
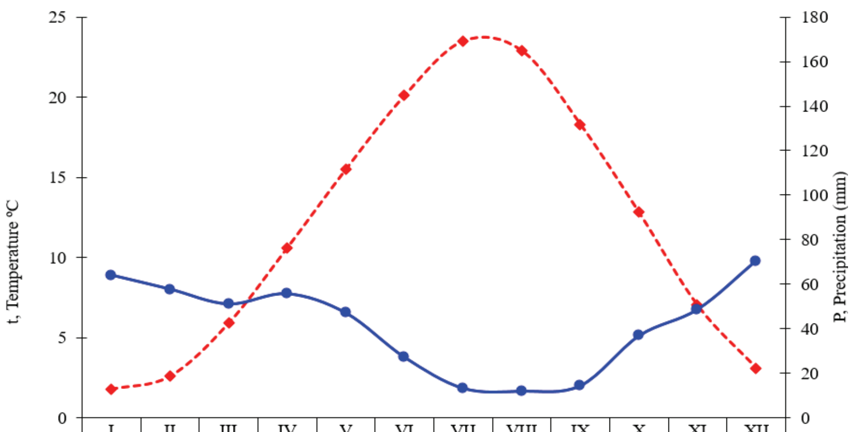


Figure 1. Isparta and the study area (original).



	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Temperature	1,8	2,6	5,9	10,6	15,5	20,1	23,5	22,9	18,3	12,8	7,0	3,1
Precipitation	64,1	57,8	51,1	55,7	47,1	27,2	13,3	12,0	14,5	36,9	48,8	70,7

Figure 2. Ombrothermic diagram of Isparta (original).

The epiphytic foliose lichen *Xanthoria parietina* was selected as biomonitoring organism due to its common presence in the urban regions and GNP, besides high tolerance to atmospheric pollution. Lichen samples were collected from 8 stations distributed around the major industrialized and suburban areas of Isparta as well as GNP between June 2009-July 2010 (Fig. 3).

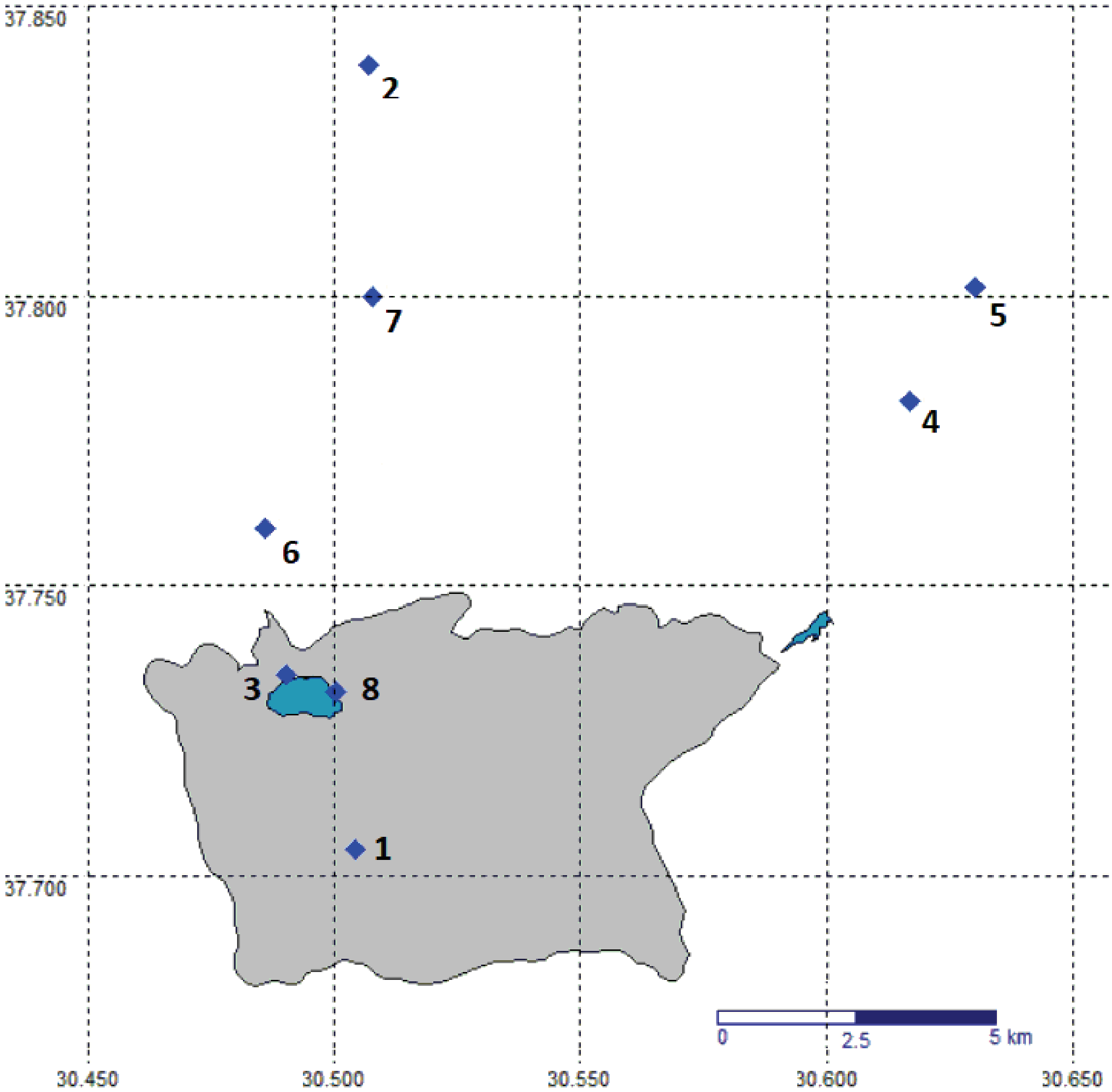


Figure 3. The sampling sites of lichens in the study area.

A composite lichen sample was randomly collected in each station by exploring an area of 50 × 50 m. Lichen rosettes ≥ 2 cm in diameter were selected as samples of biomonitoring and were taken from the bark of *Amygdalus* sp., *Pinus nigra*, *Populus alba*, *Populus nigra*, *Quercus* sp., and *Robinia pseudacacia* at a height of at least 120 cm above the ground in order to avoid terrestrial contamination. Lichen samples were air-dried and stored in polyethylene bags in the laboratory, until chemical analysis. GPS and altitude information of the localities recorded by a *Garmin e-trex summit* device are given in Table 1.

Table 1. Description of the Localities.

No	Locality	GPS Coordinates	Altitude (m)	Date
1	Gölcük Nature Park, Southern Border	37°42'16.00"N - 30°30'15.50"E	**1620**	20.06.2009
2	Behind Campus, Koçtepe Village	37°50'23.00"N - 30°30'26.00"E	1118	04.04.2010
3	Gölcük Nature Park, Picnic Area	37°44'04.70"N - 30°29'25.40"E	1395	01.05.2010
4	Sav Village	37°46'54.40"N - 30°37'02.20"E	980	18.04.2010
5	Küçük Hacılar Village	37°48'05.60"N - 30°37'49.40"E	**972**	18.04.2010
6	Gülbirlik Rose-oil Factory	37°45'34.80"N - 30°29'09.90"E	1215	24.04.2010
7	Kayı Village	37°47'59.70"N - 30°30'28.50"E	1069	24.04.2010
8	Gölcük Nature Park, North-Eastern Part	37°43'53.30"N - 30°30'02.50"E	1390	22.07.2010

Before the analyses, lichen samples were cleaned with plastic tweezers and pieces of bark or extraneous materials were removed. Then samples were stirred in deionized water for thirty seconds to remove the dust over the thalline surface. Cleaned samples were dried at room temperature for 24 h and then at 105 °C of incubation for 18 hours. The dried samples were ground and homogenized with an agate mortar and pestle. 200 mg of dry powdered lichen sample were digested in a mixture of 10 mL 2:8:2 $HCl:HNO_3:H_2O_2$ at 180 psi pressure, between 0-95 °C for 15 minutes, at 95 °C for 1 minute and finally between 95-200 °C for 15 minutes in CEM - Mars Xpress Microwave device. The digestion solution was finally diluted to 20 mL with ultra-pure water and analysed for Al, As, Cd, Cu, Fe, Mn, Ni, Pb, V and Zn with ICP-MS (ACME Analytical Labs., Canada). Analytes were selected mainly based on the potential pollutant sources in Isparta. Efficiency and quality of analytical results were evaluated by analysing a certified reference material, IAEA-336 Lichen (International Atomic Energy Agency, Vienna), with the same procedures adopted for the samples. The precision of analyses was found to be less than 5% for all elements analysed (Table 2).

The Surfer® 15 software package was used to draw a contour map for each analysed element. The Kriging algorithm with gridding method was selected to create the contour maps representing the aerial distribution of metal concentrations in Isparta.

Correlation and cluster analyses were performed on the analytical data to evaluate the relationship between the pollutants and possible pollutant sources. Cluster analyses of all elemental data from the urban and the industrial districts of Isparta were conducted separately using the PAST® 3.18 program package. Complete linkage clustering method and squared Euclidean distance metric were used in the cluster analysis.

RESULTS AND DISCUSSION

The analysis of certified reference material showed that the concentrations of almost all analysed elements were found within the limits of their certified values. The IAEA reference sheet does not include a recommended value for Ni element concentration. The element concentrations detected in *Xanthoria parietina* samples collected from localities in the study area are given in Table 2.

Table 2. Concentrations (µg/g) of elements in lichens collected from 8 localities in the Isparta province.

Locality	Al	As	Cd	Cr	Cu	Fe	Mn	Ni	Pb	V	Zn
1	5,697.53	6.48	0.23	18.29	14.14	5,315.73	279.10	20.74	8.93	27.74	264.42
2	11,294.94	7.76	0.24	33.81	19.16	8,733.10	373.10	32.66	12.99	62.31	212.42
3	5,155.99	5.17	0.46	19.97	65.80	5,013.40	442.70	169.13	8.50	23.23	420.12
4	3,231.03	4.30	0.16	14.44	10.43	3,279.33	124.60	13.27	10.04	15.84	234.82
5	6,275.47	7.54	0.13	20.26	26.10	6,017.91	278.90	42.23	13.48	31.16	219.12
6	993.30	0.84	0.55	3.61	25.96	750.40	47.17	7.01	7.63	2.41	15.35
7	572.81	0.43	0.42	0.89	23.80	436.59	0.20	32.02	6.82	1.32	41.76
8	5,583.76	5.24	0.10	16.92	13.71	4,878.21	146.00	12.49	10.65	24.56	243.72
Mean	4,850.60	4.72	0.29	16.02	24.89	4,303.08	211.47	41.19	9.88	23.57	206.47
IAEA (Certified)	680.00	0.63	0.12	1.06	3.60	430.00	63.00	**	4.90	1.47	30.40
IAEA (Measured)	661.20	0.62	0.11	1.11	3.55	413.44	60.60	2.45	4.75	1.41	28.91
Confidence %	97.24	97.95	95.73	95.22	98.53	96.15	96.19	**	96.89	95.81	95.10
** No certified value											

The order of the average element concentrations in the study area is **Ni > V > Cr > Fe > As > Cu > Al > Zn > Mn > Cd > Pb** according to data of multi-element analysis. The major 3 contaminants in the research area are Ni, V, and Cr respectively probably due to the heavy use of coal in heating facilities and gasoline in vehicles. *X. parietina* specimens tend to maximal degrees of Al and As concentrations in the northern localities while those of As and Pb in eastern localities and interestingly Cd, Cu, Mn, Ni and Zn in the localities of Gölcük Nature Park. The heavy metal pollution in Isparta city is higher than expected due to the extensive use of coal as fossil fuel, and seems to be associated with topographic and climatic characteristics.

In Isparta, **Al** is consumed or used in cars, trucks, doors and windows as a construction material. **As** is consumed or used in dyeing industry, in some agricultural pesticides and it is emitted by coal-fired heating. **Cd** is consumed or used in phosphate-based fertilizers in agriculture and it is emitted by coal-fired heating. **Cr** is consumed in textile and refrigerant industries. **Cu** is consumed or used in dyeing industry, and it is emitted by coal-fired heating. **Fe** is consumed or used in dyeing industry, constructions and metal works, it is emitted from soil and by coal-fired heating. **Mn** is consumed or used in ceramic, tile and brick production as well as dyeing industry. **Ni** is emitted by coal-fired heating and through exhaust gas from cars. **Pb** is emitted by coal-fired heating and through exhaust gas from cars. **V** is consumed or used in dyeing industry, and it is emitted by coal-fired heating and through exhaust gas from cars. **Zn** is consumed or used in dye, textile, plastic industries and cosmetics. It is emitted by coal-fired heating and through exhaust gas from cars.

Localities with the numbers 1, 3 and 8 are inside the borders of the Gölcük Nature Park while the rest of the localities are surrounding the urban area and are closer to possible sources of pollution. Spatial distributions of the element concentrations in the survey area are shown in Fig. 4a-b.

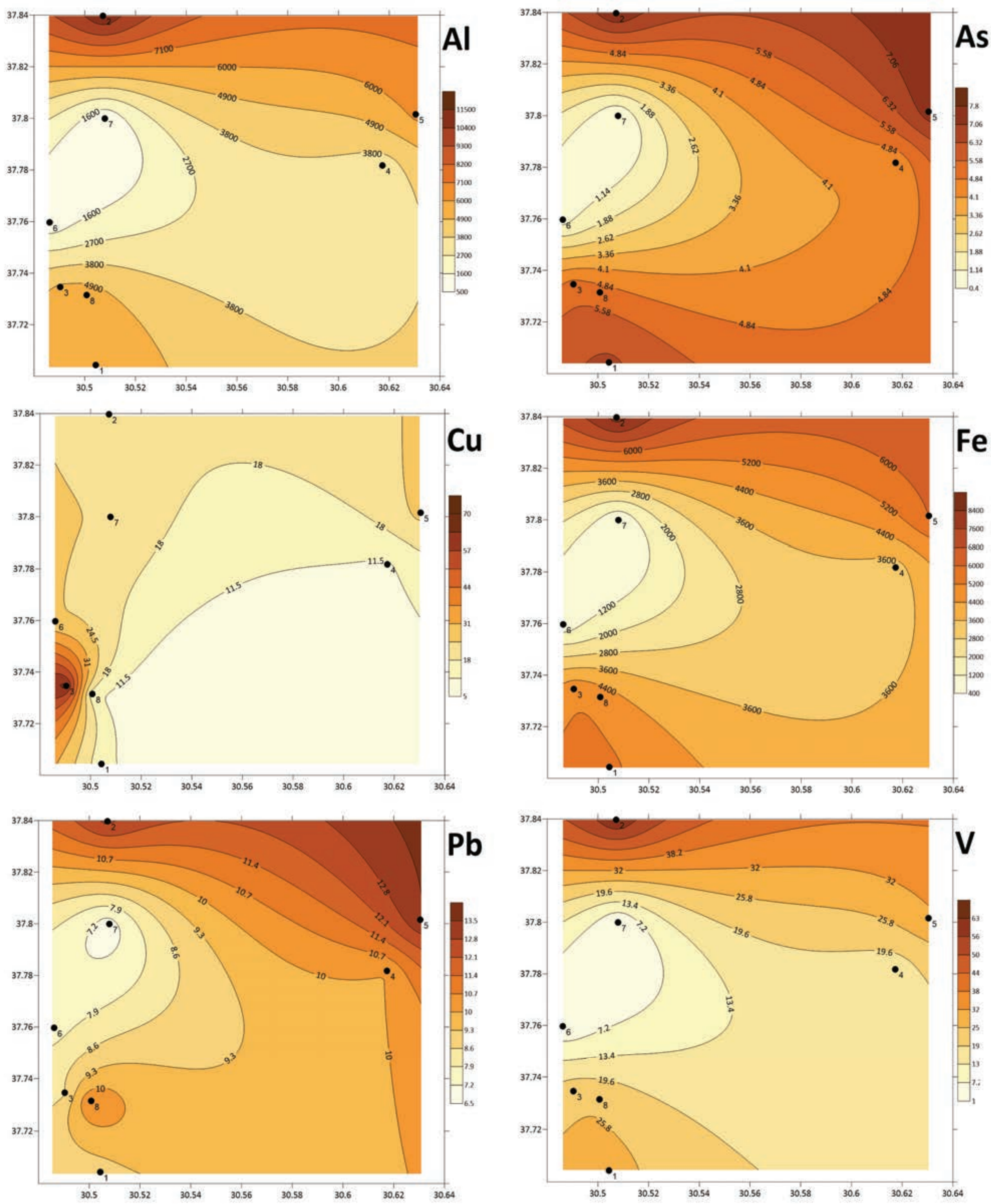


Figure 4a. Spatial Distribution of Al, As, Cu, Fe, Pb and V concentrations in studied locations.

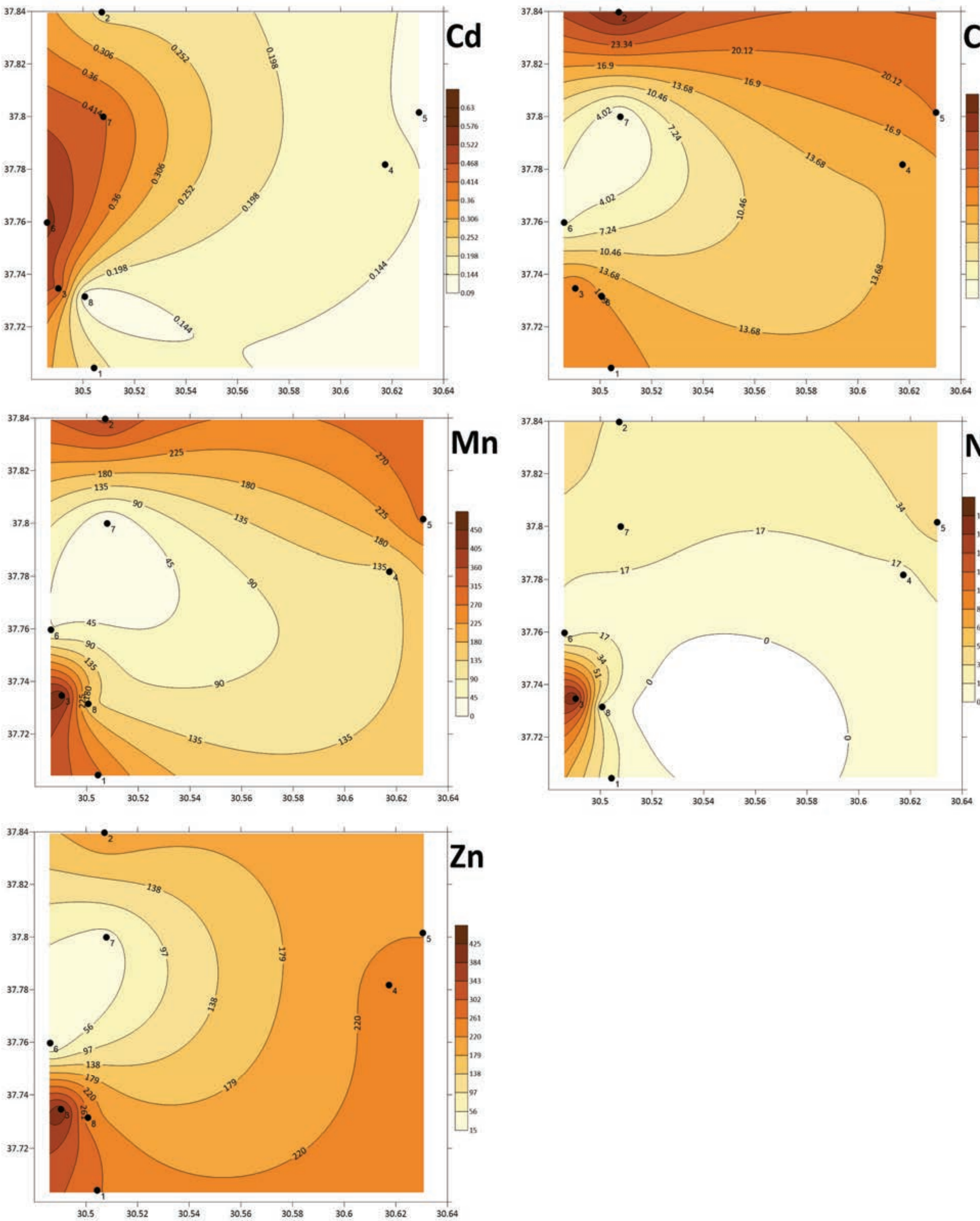


Figure 4. Spatial Distribution of Cd, Cr, Mn, Ni, and Zn concentrations in studied locations.

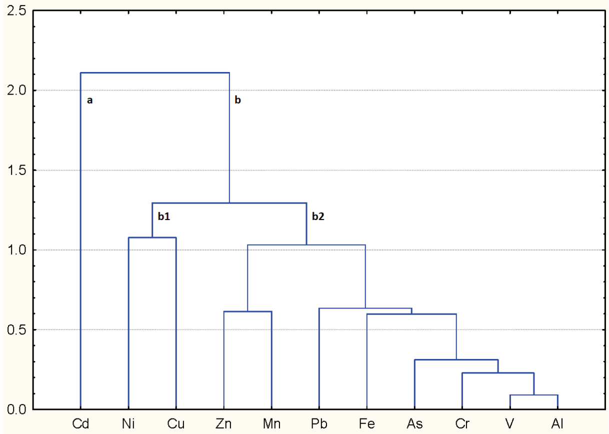


Figure 5. Dendrogram of elements in lichen samples.

Cluster analysis resulted in two main clusters of elements as given in Fig. 5. *Cluster a* consists of only Cd, while *cluster b* consists of the rest of the elements. The elements given in *cluster b1* show a strong correlation with each other (Ni-Cu: r = 0.95) as well as *cluster b2* consisting of correlated elements (Al – Cr: r = 0.98, Al – Fe: r = 0.98, Al – V: r = 0.99, As – Fe: r = 0.96, Cr – Fe: r = 0.99, Cr – V: r = 0.97, Cu – Ni: r = 0.95, Fe – V: r = 0.97, $p < 0.01$). Cluster analyses results of the elemental data indicate a strong correlation of the major 3 contaminants in the urban area, which are Ni, V and Cr.

As mentioned in the introduction of this paper, the results of air quality monitoring in Isparta between August 2006 and June 2010 by local authorities are given in terms of SO_2 (Fig. 6, IÇIM 2010) and PM_{10} (Fig. 7, IÇIM 2010). Such monitoring studies can be used as references to evaluate air quality especially in the industrial centres and in the cities heated by coal combustion like Isparta, where heavy metal deposition can be severe.

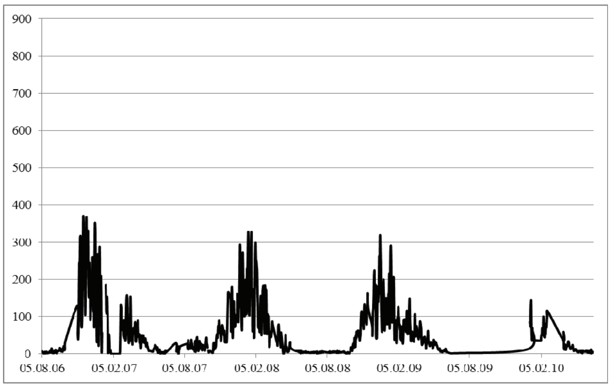


Figure 6. Annual SO_2 Data (2006-2010).

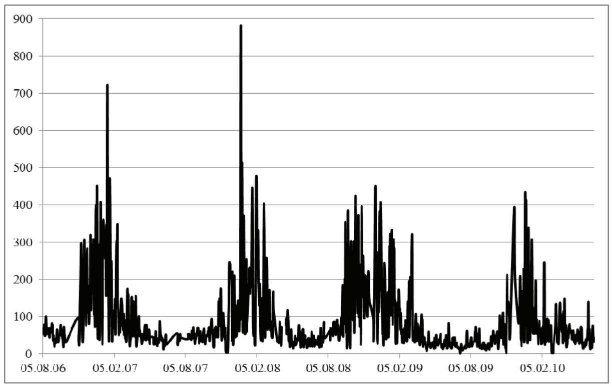


Figure 7. Annual PM_{10} Data (2006-2010).

In the Isparta city centre, the mean concentration of SO_2 in winter seasons is 122 $\mu g/m^3$ while that of PM_{10} is 91 $\mu g/m^3$. The levels of SO_2 concentration have been decreasing since the local authorities control the quality of coal combusted in the city. Both figures indicate that, though decreasing slightly from 2006 to 2010, there still is a considerable concentration of SO_2 and PM_{10} in the atmosphere, which in the background corresponds to the outcome of analytes given in this study.

The most effective factors determining the extent of pollution include height, wind direction, humidity and temperature, and distance to the source of pollution (ÇOBANOĞLU, 2015). Due to the topographic peculiarities of the locations, particles may have been blown by the prevailing wind, in the study area. Airborne elemental pollution in Isparta, which is higher than expected, seems to be associated with the extensive use of coal as fossil fuel, besides the topographic and climatic characteristics of the city. Therefore, the geographical location, position, and other topographic features of the city and the localities are crucial when discussing the results of the survey. Considering Isparta, the localities in South-Southwestern parts have higher altitudes than those in North and East parts. The prevalent winds blowing in the region sweep airborne particles from SW (9 m/s), and from S (8.1 m/s) directions towards North-western, Northern and North-eastern parts of the city. Consequently, this wind-sweep causes the North-eastern part be contaminated more than the other parts of the city due altitude.

According to the data given in Table 1, in locality **2** (Behind Campus, Koçtepe Village, 1118 m) Al (11,294.94 µg/g), As (7.76 µg/g), Cr (33.81 µg/g), Fe (8,733.10 µg/g) and V (62.31 µg/g); in locality 3 (Gölcük Nature Park, Picnic Area, 1385 m), Cu (65.80 µg/g), Mn (442.70 µg/g), Ni (169.13 µg/g) and Zn (420.12 µg/g) have maximum concentrations. In locality **6** (Gülbirlik Rose-oil Factory, 1215 m) Cd (0.55 µg/g); and in locality **5** (Küçük Hacılar Village, 972 m) Pb (13.48 µg/g) has maximum concentration.

The lichen specimens accumulated maximal concentrations of Cd, Cu, Mn, Ni, Zn in locality III (inside Gölcük Nature Park) and next to GNP (locality VI), and the rest of the elements in northern and the eastern localities surrounding the city. The high concentration of these elements in the mentioned locations indicate that the *Xanthoria parietina* specimens collected from these locations may have been contaminated by charcoal or dust. Origin of the emissions may be charcoal used in barbecue, and cars driven on the unimproved road. The elemental concentration detected in this locality is not affected directly from the urban area due the difference in the altitude and higher hills separating the urban area and the natural park, which means that localities III and VI have their local emission sources.

In locality II, airborne elements may origin from villages and exhaust gas from cars driven on the unimproved road, and also the airborne elements may have been blown by the prevailing wind, in the study area, from South-east to North-West, sweeping through the urban area. Since natural gas is not widely used in the centre, coal-fired heating is the dominant factor of emissions.

The comparison of average values obtained in this study with those of previous biomonitoring studies on *Xanthoria parietina*, in İzmir (YENISOY-KARAKAŞ & TUNCEL 2004), in İstanbul (İÇEL & ÇOBANOĞLU 2009) and in Kocaeli (DOĞRUL et al. 2012) to the reference material IAEA-336 ratios is given in Table 3. In the below table, the asterisk (*) indicates that since there is no data available in IAEA-336 certified list, results of Ni in previous studies have been compared to that of IAEA-336 reference material (*Evernia prunastri*) in this study.

Table 3. Comparison of *Xanthoria parietina* airborne elements' concentration to IAEA-336 ratios.

	İzmir (2004)		**İstanbul** (2009)		**Kocaeli** (2012)		**Isparta** present study		IAEA-336 Certified
	Average	Average to IAEA-336	Average	Average to IAEA-336	Average	Average to IAEA-336	Average	Average to IAEA-336	
Al	3,160.00	4.65	---	---	---	---	6,206.45	9.13	680.00
As	4.50	7.14	---	---	2.63	4.17	6.08	9.65	0.63
Cd	0.30	2.56	0.35	2.99	0.93	7.95	0.22	1.88	0.12
Cr	9.90	9.34	21.39	20.18	11.73	11.07	20.62	19.45	1.06
Cu	---	---	45.24	12.57	19.19	5.33	24.89	6.91	3.60
Fe	2,360.00	5.49	---	---	3,686.00	8.57	5,539.61	12.88	430.00
Mn	60.00	0.95	150.43	2.39	152.00	2.41	274.07	4.35	63.00
Ni	---	---	17.07	6.96	7.47	3.05	48.42	19.76	**2.45***
Pb	---	---	71.35	14.56	70.20	14.33	10.77	2.20	4.90
V	6.40	4.35	---	---	10.67	7.26	30.81	20.96	1.47
Zn	100.00	3.29	194.87	6.41	280.10	9.21	265.77	8.74	30.40

Compared to the previous studies, the present study shows significantly greater degrees of contaminations by means of average to IAEA-336 ratios. For instance, Cr show 19.45 times, Fe 12.88 times, Ni 19.76 times and V 20.96 times magnitude of contamination when compared to the IAEA-336 reference material. Having in consideration that İzmir, Kocaeli and Istanbul are 3 major cities in Turkey by means of population, vehicles, accommodation and industry, Isparta shows a great magnitude of contamination of airborne elements (Fig. 8). This comparison of previous studies in bigger cities indicates that, the airborne elemental pollution in Isparta city is higher, due to the extensive use of coal as fossil fuel.

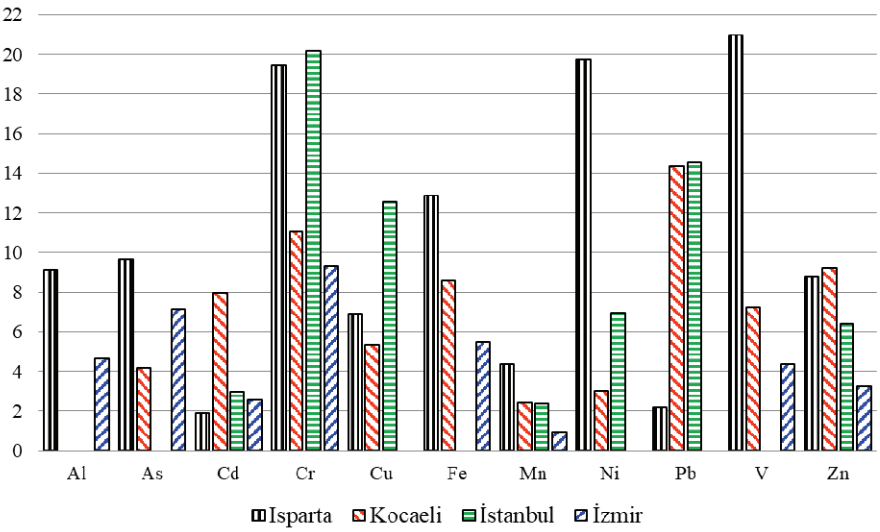


Figure 8. Comparison of average airborne elements' concentration to IAEA-336 ratios.

Compared to the concentrations of elements generally trapped (Ni >Cr >V >Fe >As >Al >Zn >Cu >Cd >Mn >Pb in descending order) by the lichen *Physcia aipolia* in the same region (YAVUZ & ÇOBANOĞLU, 2019), *X. parietina* accumulated more V than Cr; more Cu than Al and Zn; and more Mn than Cd in the present study (Ni > V > Cr > Fe > As >

Cu > Al > Zn > Mn > Cd > Pb in descending order). For differences in element contents, morphological differences of lichen species can be thought of as a reason, since *X. parietina* is larger lobed and less rough than *P. aipolia*.

CONCLUSIONS

In Isparta this is the first biomonitoring study using *Xanthoria parietina*. Thus, according to the YAVUZ & ÇOBANOĞLU (2019) study (based on *Physcia aipolia* (Erh. ex Humb.) Fürnr.), this study lays a database for future biomonitoring studies in the region. The airborne element deposition in the urban vicinity of Isparta and Gölcük Nature Park investigated through a biomonitoring organism indicates that the degree of elemental deposition is severe in some locations of the city, especially in terms of Cr, Fe, Ni and V elements.

Considering the contamination levels in GNP, this study advises a precise and careful landscape use in the park, if necessary, a restriction or limitation of human activities to ensure minimum anthropogenic effects, for a sustainable environment. As mentioned by STEINHARDT et al. (1999), to prevent environment degradation, it is important to monitor the changes and to evaluate the impacts in a long-term investigation, as a future study. With regard to contamination levels in the urban area, this study indicates the necessity to use technology on renewable energy or natural gas for heating in order to decrease the concentration of airborne elements in the atmosphere.

Air quality in Isparta has been evaluated based on the levels of SO_2 and PM_{10}, as reported by the local authorities. However, in the regions with dense industrial activities and coal combustion, surveying only these two parameters to determine the air quality can result in the neglect of the *biomonitoring* part. A more rigorous approach - like biomonitoring of lichens - is required. In this view, further results can be achieved and long-term effects can be observed instead of instant evaluations.

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Mustafa YAVUZ
İstanbul Medeniyet University, Faculty of Arts and Humanities, History of Science Department, Istanbul, Turkey.
Email: mustafay007@gmail.com

Gülşah ÇOBANOĞLU
Marmara University, Faculty of Arts and Science, Department of Biology, Istanbul, Turkey.
Email: gcoban@marmara.edu.tr

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A REVIEW OF THE DISTRIBUTION OF THE *MYCOMICROTHELIA* KEISSL. 1936 GENUS IN ROMANIA

VICOL Ioana

Abstract. Recent data on the *Mycomicrothelia* genus chorology have not been reported for Romania. The information found in literature revealed a low distribution of the *Mycomicrothelia* genus on Romanian territory. Atmospheric pollution could be a cause of the lack of species belonging to the *Mycomicrothelia* genus within forests from Romania. In this paper, the worldwide and national chorological data, substrate, taxonomy and cenotaxonomy of *Mycomicrothelia* genus are presented. As the main conclusion, the *Mycomicrothelia* genus has not been identified on an extended area from Romania.

Keywords: *Mycomicrothelia* genus, chorology, Romania.

Rezumat. O recenzie a distribuției genului *Mycomicrothelia* 1936 în România. Date recente asupra corologiei genului *Mycomicrothelia* nu au fost semnalate în România. Informațiile găsite în literatura de specialitate au evidențiat o distribuție redusă a genului *Mycomicrothelia* pe teritoriul României. Poluarea atmosferică ar constitui o cauză a absenței speciilor din genul *Mycomicrothelia* în pădurile din România. În acest articol sunt prezentate date corologice la nivel național și internațional, tipul de substrat, cenotaxonomia și taxonomia genului *Mycomicrothelia*. În concluzie, genul *Mycomicrothelia* nu a fost identificat pe o arie cât mai extinsă a teritoriului României.

Cuvinte cheie: genul *Mycomicrothelia*, corologie, România.

INTRODUCTION

The species from *Mycomicrothelia* Keissl. 1936 genus are widely distributed at the worldwide level (APTROOT et al., 2007; APTROOT, 2009; LÜCKING et al., 2011; CÁCERES et al., 2014; XAVIER-LEITE et al., 2015; BUNGARTZ et al., 2012; KINALIOĞLU, 2009).

Ancient forests represent refugia for epiphytic lichen species (MALÍČEK & PALICE, 2013). Nowadays, worldwide, native forests are threatened by changing their structure (PALTTO et al., 2011; BRUNIALTI et al., 2012).

The oldest information about the distribution of the *Mycomicrothelia* genus in Romania dates back to 1884 (HASZLINSZKY 1884 cited by MORUZI et al., 1967). The lichen species from *Mycomicrothelia* genus were identified in mountainous and hilly areas. The habitats where the lichen species from the *Mycomicrothelia* genus were found are the forests (BURLACU et al. 1969; CIURCHEA, 2004) and the arboretum (CIURCHEA & SZABÓ, 1966; CIURCHEA, 1972; CIURCHEA, 2004).

In addition are known other species widespread on the European (GIORDANI & INCERTI, 2008), American (CÁCERES et al., 2014; XAVIER-LEITE et al., 2015), Asia (URBANAVICHUS & ISMAILOV, 2013) and Australian (APTROOT, 2009) continents. Also, worldwide data about *Mycomicrothelia* genus are reported as follow: *Mycomicrothelia atlantica* D. Hawksw. & Coppins: Azorean Archipelago (BERGER & PRIEMETZHOFER, 2008); Republic of Dagestan (URBANAVICHUS & ISMAILOV, 2013); *Mycomicrothelia confluens* (Müll. Arg.) D. Hawksw.: Island of Reunion in the Indian Ocean (van den BOOM et al., 2011); *Mycomicrothelia confusa* D. Hawksw.: Boulogne District, Northern France (SÉRUSIAUX et al., 2003); Liguria, Italy (GIORDANI & INCERTI, 2008); *Mycomicrothelia conothele* (Nyl.) Hawksw.: West Midnapore District, West Bengal, India (SEN, 2014); *Mycomicrothelia conothelena* (Nyl.) D. Hawksw.: Sri Lanka (WEERAKOON & APTROOT, 2014); Similipal, Mayurbhanj, Odisha, India (Nayak et al., 2016); *Mycomicrothelia exigua* (Müll. Arg.) D. Hawksw.: North Western Ghats, India (PANDIT, 2015); *Mycomicrothelia fumosula* (Zahlbr.) D. Hawksw.: Uthai Thani, Khao Nang Rum, Thailand (APTROOT et al., 2007); *Mycomicrothelia hemisphaerica* (Müll. Arg.) D. Hawksw.: Uthai Thani, Khao Nang Rum, Thailand (APTROOT et al., 2007); Osa Peninsula, Costa Rica (BREUSS, 2008); North Western Ghats, India (PANDIT, 2015); *Mycomicrothelia lateralis* Sipman: Paluma Village, Queensland, Australia (APTROOT, 2009); *Mycomicrothelia megaspora* Aptroot & M. Cáceres: Brasil (CÁCERES et al., 2014; XAVIER-LEITE et al., 2015); *Mycomicrothelia miculiformis* (Nyl. ex Müll. Arg.) D. Hawksw.: Petchabhun, Nam Nao N.P., Thailand (APTROOT et al., 2007); Berry Springs Nature Park, Australia (APTROOT, 2009); *Mycomicrothelia minutissima* (C. Knight) D. Hawksw.: New Zealand (de LANGE et al., 2018); *Mycomicrothelia minutula* (Zahlbr.) D. Hawksw.: Cascades, South Hobart, Tasmania (APTROOT, 2009); *Mycomicrothelia modesta* (Müll. Arg.) D. Hawksw.: Fakahatchee Strand Preserve State Park, Florida (LÜCKING et al., 2011); *Mycomicrothelia obovata* (Müll. Arg.) D. Hawksw.: North Western Ghats, India (PANDIT, 2015); *Mycomicrothelia oleosa* Aptroot: Bosque Esquinas and La Gamba, Costa Rica (BREUSS, 2008); Brasil (CÁCERES et al., 2014; XAVIER-LEITE et al., 2015); *Mycomicrothelia queenslandica* (Müll. Arg.) Sipman: Balt's Spur, Tasman Peninsula (APTROOT, 2009); *Mycomicrothelia pachnea* (Körb.) D. Hawksw.: virgin forest reserve Rajhenavski Rog, Slovenia (BILOVITZ et al., 2011); *Mycomicrothelia subfallens* (Müll. Arg.) D. Hawksw.: Chiang Mai, Doi Inthanon N.P., Mae Cham road (APTROOT et al., 2007); Black Jungle (Northern Territory), Garners Beach (Queensland), Lankelly Ck, Australia (APTROOT, 2009); Fakahatchee Strand

Preserve State Park, Florida (LÜCKING et al., 2011); Brasil (CÁCERES et al., 2014; XAVIER-LEITE et al., 2015); Floreana and Santiago, Galapagos (BUNGARTZ et al., 2012); *Mycomicrothelia thelena* (Ach.) D. Hawksw.: Floreana and San Cristóbal, Galapagos (BUNGARTZ et al., 2012); Bío-Bío Region, Chile (PEREIRA et al. 2016); *Mycomicrothelia wallrothii* (Hepp.) D. Hawksw.: central, eastern, and southern forest districts, Estonia (LÕHMUS et al., 2006). *Mycomicrothelia willeyana* (Müll. Arg.) D. Hawksw.: Fakahatchee Strand Preserve State Park, Florida (LÜCKING et al., 2011); Čepkeliai state nature reserve, southern Lithuania (MOTIEJŪNAITĖ, 2015).

Most of the mentioned lichen species were found in protected areas *i.e. M. oleosa* (CÁCERES et al., 2014), *M. walrothii* (MOTIEJŪNAITĖ, 2015), Amazonian remnant forests *i.e. M. megaspora* and *M. subfallens* (XAVIER-LEITE et al., 2015) and within sites with socio-cultural importance, for instance *M. conothele* (SEN, 2014). *Mycomicrothelia melanospora* unlike *M. wallrothii* has not been identified in the reviewed papers therefore it seems to have a restricted distribution (CIURCHEA, 2004). A few lichen species from *Mycomicrothelia* genus are somehow widely distributed such as: *M. hemisphaerica* (APTROOT et al., 2007; BREUSS, 2008; PANDIT, 2015), *M. subfallens* (APTROOT et al., 2007; APTROOT, 2009; LÜCKING et al., 2011; BUNGARTZ et al., 2012; CÁCERES et al., 2014; XAVIER-LEITE et al., 2015; PEREIRA et al. 2016).

The aim of this study consists in the mapping of the *Mycomicrothelia* genus in Romania. The objective of the study is based on the characterization of the *Mycomicrothelia* genus with its substrata, habitat type, cenotaxonomy, taxonomy and worldwide distribution point of view.

MATERIALS AND METHODS

Information about chorology of the *Mycomicrothelia* genus in Romania were obtained from literature (CIURCHEA, 2004). The nomenclature of lichen species, taxonomy and cenotaxonomy is according to CIURCHEA, 2004. Specimens from the Collection of the Babeş-Bolyai University Herbarium (Cluj-Napoca, Cluj County) are abbreviated as H.U.C. Also, collections of the Mycological Herbarium from Bucharest (BUCM) were consulted to find out the studied specimens.

RESULTS AND DISCUSSIONS

In Romania, the *Mycomicrothelia* genus is represented by two species, as follows: *Mycomicrothelia melanospora* (Hepp.) D. Hawksw. and *Mycomicrothelia walrothii* (Hepp.) D. Hawksw. (CIURCHEA, 2004). In literature, the chorology of the *Mycomicrothelia* genus in Romania is less known (CIURCHEA, 2004).

1) ***Mycomicrothelia melanospora*** (Hepp.) D. Hawksw. (Fig. 1)

Bistriţa-Năsăud County: Arcalia Scientific Center Park (CIURCHEA & SZABÓ, 1966; CIURCHEA, 1972; CIURCHEA, 2004; H.U.C. nr. 550693); Botoşani County: Moldavian Plateau, at Gorovei (CIURCHEA, 2004); Caraş-Severin County: Banat Mountains, Danube Defile at Cozla and Coronini (BURLACU et al. 1969; CIURCHEA, 2004).

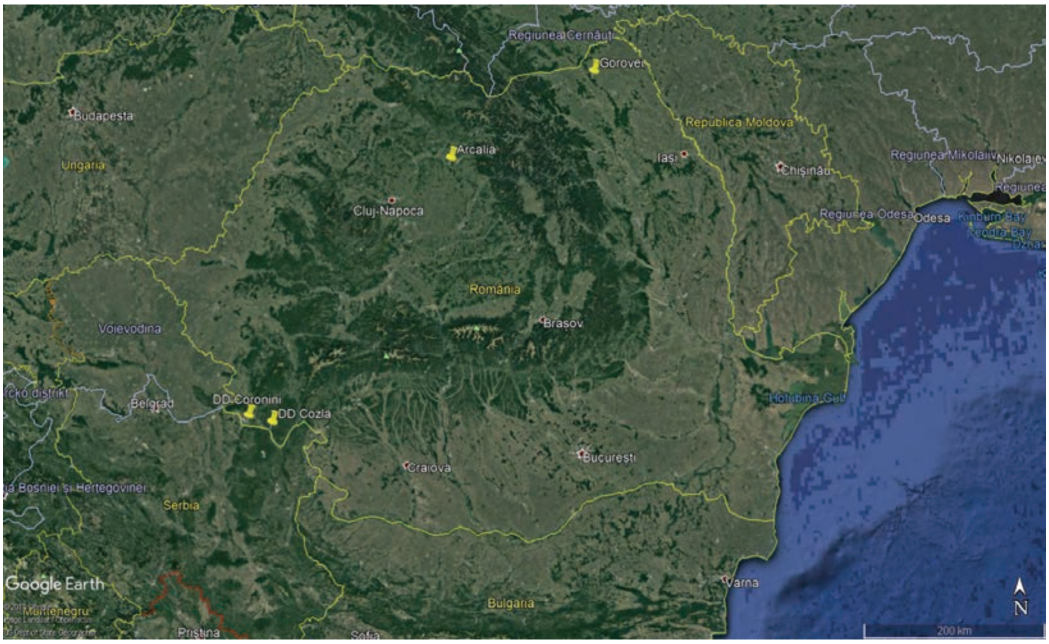

Figure 1. The spatial distribution of *Mycomicrothelia melanospora* in Romania (Source: Google Earth Pro V 7.3.2.5776. (December 14, 2015). Romania. 45° 52' 22.05"N, 26° 08' 58.69"E, Eye alt 1141.41 km. SIO, NOAA, U.S. Navy, NGA, GEBCO. US Dept of State Geographer. Landsat/Copernicus 2018. http://www.earth.google.com [February 11, 2019].

2) ***Mycomicrothelia walrothii*** (Hepp.) D. Hawksw. (Fig. 2)
Hunedoara County: Retezat Mountains (CRETZOIU, 1941; MORUZI et al., 1967; CIURCHEA, 2004).

Figure 2. The spatial distribution of *Mycomicrothelia walrothii* in Romania (Source: Google Earth Pro V 7.3.2.5776. (December 14, 2015). Romania. 45° 52' 22.05"N, 26° 08' 58.69"E, Eye alt 1141.41 km. SIO, NOAA, U.S. Navy, NGA, GEBCO. US Dept of State Geographer. Landsat/Copernicus 2018. http://www.earth.google.com [February 11, 2019].

The Romanian Red List does not present any data regarding the conservation status of the species belonging to the *Mycomicrothelia* genus (SÂRBU et al., 2007; ARDELEAN et al., 2013). The low distribution of *Mycomicrothelia* in Romania could be attributed to atmospheric pollution, destruction and fragmentation of natural habitats. The studied species grew up on corticolous substrata, especially on conifers, the smooth bark of *Betula* (birch) and other deciduous trees (Table 1). The two lichen species of the *Mycomicrothelia* genus belong to the *Xanthorion* and *Graphidion* communities. Thus, these lichen species prefer both nitrophilous and acidophilous bark (CIURCHEA, 2004).

Table 1. The substrata colonized by species of the *Mycomicrothelia* genus (CIURCHEA, 2004).

Species	Substrata
Mycomicrothelia melanospora	Smooth bark of deciduous arbuscles *Picea abies* (L.) H. Karst. Coniferous trees *Acer negundo* L. *Acer campestre* L. *Fraxinus ornus* L.
Mycomicrothelia walrothii	On birch trunks

The sociology of the studied genus is represented by the following cenotaxons: *Arthonio-Lecidelletea elaeochromae* Drehwald 1993 including *Graphidetalia scriptae* Hadač 1944, *Graphidion scriptae* Ochsner 1928, and *Pyrenuletum nitidae* Hil 1925 on the one hand and *Physcietea* Tomaselli et De Micheli 1957 that include *Physcietalia adscendentis* Hadač 1944 em Barkm. 1958, *Xanthorion parietinae* Ochsner 1928 and *Physcietum adscendentis* Frey et Ochsner 1926 (Table 2). The taxonomy of the *Mycomicrothelia* genus is presented in Table 3.

Table 2. The cenotaxonomy of the studied lichen species (CIURCHEA, 2004).

Species	Class	Order	Alliance	Association
Mycomicrothelia melanospora	*Physcietea* Tomaselli et De Micheli 1957	*Physcietalia adscendentis* Hadač 1944 em Barkm. 1958	*Xanthorion parietinae* Ochsner 1928	*Physcietum adscendentis* Frey et Ochsner 1926
	Arthonio-Lecidelletea elaeochromae Drehwald 1993	*Graphidetalia scriptae* Hadač 1944	*Graphidion scriptae* Ochsner 1928	*Pyrenuletum nitidae* Hil 1925
Mycomicrothelia walrothii	N/A	N/A	N/A	N/A

Legend: N/A data are not available

Table 3. The taxonomy of studied lichen species (www.speciesfungorum.org).

Species	Kingdom	Division	Class	Order	Family
Mycomicrothelia melanospora ***Mycomicrothelia walrothii***	Fungi R. T. Moore 1980	Ascomycota Caval. Sm. 1998	Dothideomycetes O. E. Eriks. et Winka 1997	Pleosporales Luttr. ex M.E. Barr (1987)	Arthopyreniaceae Walt. Watson (1929)

CONCLUSIONS

In Romania, the *Mycomicrothelia* genus is rather poorly represented; therefore, further field studies are needed to reveal new localities where these lichen species could be distributed.

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Vicol Ioana
Institute of Biology of the Romanian Academy of Sciences, Spl. Independentei no. 296, sect. 6, 060031, Bucharest, Romania.
E-mail: ioana.vicol@ibiol.ro

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PARASITOLOGICAL STUDIES OF THE SPECIES FROM GENUS *APODEMUS* (RODENTIA, MURIDAE) FROM THE "PLAIUL FAGULUI" NATURAL RESERVE, REPUBLIC OF MOLDOVA

CHIHAI Oleg, ERHAN Dumitru, NISTREANU Victoria, LARION Alina, TĂLĂMBUŢĂ Nina, RUSU Ştefan, MELNIC Galina, ZAMORNEA Maria

Abstract. The research was carried out in the „Plaiul Fagului" Reserve in THE spring-summer period of 2015. During the study period, 202 individuals from 6 small rodent species were registered. The diversity was higher in spring, when all 6 species have been recorded, and lower in autumn with 4 species. In all the studied biotopes the *Apodemus* genus species (*A. flavicollis*, *A. sylvaticus*, *A agrarius*) were dominant. For parasitological studies, only the species of the genus *Apodemus* were considered, because they had the highest abundance and represented more than 80% of all small rodent community. The taxonomic structure of helminth fauna in the investigated specimens falls into 3 classes, 6 families, 7 genera and 8 species. The diversity of parasitic invasions is represented by 4 species of the class Cestoda, 3 species of class Secernentea and 1 species of the class Adenophorea. In *A. flavicolis* the most diverse parasite structure was determined, which is represented by 4 parasite species from class Cestoda, 3 species from class Secernentea and 1 species from the Adenophorea class. From the total of 7 parasite species, 2 have a zoonotic impact (*Syphacia stroma*, *Syphacia obvelata*). The helminth fauna in studied rodent species consists of 8 parasite species, of which 3 species of biohelminths (37.5%), 2 species of geohelminths (25.0%) and 2 species of ageohelminths (25.0%). The most abundant parasite species proved to be *Syphacia stroma* and *Syphacia obvelata*.

Keywords: parasite fauna, *Apodemus* species, reserve, forest, paludous ecosystem, ecotone.

Rezumat. Studii parazitologice ale speciilor genului *Apodemus* (Rodentia, Muridae) din Rezervația naturală „Plaiul Fagului", Republica Moldova. Cercetările s-au efectuat în Rezervația „Plaiul Fagului" în perioada primăvară-toamnă a anului 2015. Au fost capturați în total 201 indivizi de rozătoare mici din 6 specii. Diversitatea a fost mare mare în primăvară, când toate cele 6 specii au fost înregistrate, iar toamna s-au înregistrat doar 4 specii. În toate biotopurile studiate speciile genului *Apodemus* (*A. flavicollis, A. sylvaticus, A. agrarius*) au fost dominante. Pentru studiile parazitologice s-au luat în considerare numai speciile din genul *Apodemus*, deoarece au avut cea mai mare abundență și au constituit mai mult de 80% din toată comunitatea de rozătoare mici. Structura taxonomică a helmintofaunei la specimenele investigate este constituită din 3 clase, 6 familii, 7 genuri şi 8 specii. Diversitatea invaziilor parazitare este reprezentată de 4 specii parazitare din clasa Cestoda, 3 specii din clasa Secernentea și o specie din clasa Adenophorea. La *A. flavicolis* sa determinat cea mai diversă faună parazitară, este formată din 4 specii de paraziți din clasa Cestoda, 3 specii din clasa Secernentea și 1 specie din clasa Adenophorea. Din totalul de 8 specii de paraziți 2 sunt cu impact zoonotic (*Syphacia stroma*, *Syphacia obvelata*). Fauna de helminți la speciile de rozătoare studiate constă din 8 specii de paraziți, din care 3 specii de biohelminți (37,5%), 2 specii de geohelminți (25,0%) și 2 specii de ageohelminți (25,0%). Cele mai abundente specii de paraziți s-au dovedit a fi *S. stroma* și *S. obvelata*.

Cuvinte cheie: parazitofaună, speciile genului *Apodemus*, rezervație, pădure, ecosistem palustru, ecoton.

INTRODUCTION

Rodents are extremely important elements of terrestrial ecosystems, they are consumers of secondary and tertiary production, serve as a trophic resource for raptors, thus being important links of the food chain. Small rodents are the most abundant and prolific animal group, with wide limits of ecological valence, having major economic and epidemiological importance. Many species directly or indirectly cause damages to agriculture and forestry on the one hand, and on the other hand are involved in the transmission of various pathogens, including parasites, in humans, domestic and wild animals (STOJCEVIC et al., 2004; GUABANYI et al., 2015). For example, helminths from the genus *Trichinella*, *Angiostrongylus*, *Capillaria*, *Hymenolepis*, *Raillentina*, *Echinococcus*, *Schistosoma*, *Paragonimus* and *Echinostoma* registered in small rodents have impact upon public health, while *Capillaria hepatica* and *Angyostrongylus cantonensis* cause severe syndromes in humans and animals (CHECHULIN et al., 2011; FUEHRER et al., 2011).

The small rodents of the genus *Apodemus* are dominant species in the mammal fauna of the R. Moldova. They inhabit various types of forest ecosystems: woods, forest shelter belts, tree plantations, as well as the ecotones between forest and adjacent habitats. In previous studies undertaken in the "Plaiul Fagului" reserve these species proved to be common and widespread, with dominant and eudominant ecological significance in all types of ecosystems from the reserve (MUNTEANU et al., 1995; MUNTEANU & TURCANU, 2005; NISTREANU et al., 2015).

Infestation in humans can occur through direct contact with rodent excretions or consumption of food contaminated by fur, feet, urine or faeces, and indirectly by ectoparasite vectors' bites, such as fleas and ticks. In carnivorous animals such as fox, dogs, cats (HILL & DUBEY, 2002; ECKERT & DEPLAZES, 2004; KAPEL et al., 2006) infestation occurs through the direct consumption of infected rodents.

The extensive description of the parasite fauna in small rodents in the Republic of Moldova for the first time was carried out by ANDREICO (1960, 1961) in period 1958-1960. Thus, the species of the Trematoda class have a ratio of 2.14%, Cestoda - 17.54%, Nematoda - 61.7% and Acanthocephala - 0.58%. The Trematoda class includes 3 species, Cestoda - 16 species, and Nematoda - 18 species of parasites. Within the helminth fauna of investigated rodents, parasites specific to man and domestic animals were found: *Echinococcus multilocularis*, *Mesocestoides* sp., *Hymenolepis diminută*, *Strobilocercus fasciolaris*, *Tricihinela spiralis*, *Hepaticola hepatica*, *Syphacia stroma* and *S. obvelata* (ANDREICO, 1960, 1961). Thus, the monitoring of parasite fauna in small rodents in various ecosystems bears biological, medical and veterinary importance in preventing the transmission of pathogens to humans and other animals involved in the biological cycles of parasites with zoonotic and epizootic importance.

The aim of this study is to reveal the diversity of the parasite fauna of the most widespread species of rodents from the "Plaiul Fagului" Reserve, Republic of Moldova.

MATERIAL AND METHODS

The reserve is located in the Ungheni district, 70 km north-west from the city of Chisinau, with the coordinates N 47°18' and E 28°02'. The landscape is fragmented, with steep slopes and deep valleys, almost similar to a mountain landscape. The studies on small rodents were carried out at the ecotone zone of forest and paludous ecosystem. The tree and bush vegetation is rather abundant and rich, represented by oak, hornbeam, ash tree, hazelnut, horn, etc. The grassy vegetation is abundant and dense, represented by hygrophilous and meadow species. The studied ecosystems represent recreational zones for visitors and direct or indirect contact with rodents is particularly high, thus increasing the risk of wild animal parasites spreading to humans. The studies were performed in the spring – autumn period of 2015. Small rodents were caught with live traps placed in line at a distance of 5 m from each other, which is recommended for biotopes with well-developed bush vegetation and abundant herbaceous vegetation (PELIKAN et al., 1975; CHICU et al., 2012). The traps were baited with pieces of bread imbued in sunflower oil. About 1500 trap-nights have been worked out. The following parameters were recorded for the caught animals: species, sex, age, physiological and reproductive state.

The parasitological studies were carried out within the laboratory of Parasitology and Helmintology of the Institute of Zoology. The individuals of *Apodemus flavicollis* collected for parasitological investigations were euthanized with *chloroformi pro narcosi* solution that inhibits the conductibility at the level of heart centres, causing instant death without suffering. Laboratory investigations were performed by total rodent dissection and microscopic examination of the muscles (masseter, arms and diaphragm muscles), of thoracic organs (trachea, lungs, heart) and of abdominal organs (oesophagus, stomach, intestine, colon, liver, spleen, kidney, urinary bladder) to establish parasitological indices. The identification of parasite species was carried out after the standard keys (RYJIKOV et al., 1978, 1979). For the parasitological assessment, the prevalence (%), the intensity (specimens per animal) and the abundance (specimens per lot) of the parasitic species in the rodents were determined.

In ecological analysis, the indexes of abundance, frequency and ecological significance (W) were calculated. The species with a significance lower than 1% in the studied biotope are considered accidental; between 1.1 – 5% - subdominant; between 5.1-10% – dominant and when W > 10% the species is eudominant. The obtained results were statistically processed in the Excel software.

RESULTS AND DISCUSSIONS

During the study period, 202 individuals from 6 species were registered: *Apodemus flavicollis* (Melchior, 1834), *A. sylvaticus* (Linnaeus, 1758), *A. agrarius* (Pallas, 1771), *Myodes glareolus* (Schreber, 1780), *Microtus subterraneus* (de Selis-Longchamps, 1836) and *M. rossiae meridionalis* (Ognev, 1924) (Fig. 1). The trappability index varied between 6% and 23% in the spring-summer period and reached 30% in autumn at the forest-meadow ecotone. The diversity was higher in spring, when all 6 species have been recorded, and lower in autumn with 4 species (genus *Apodemus* and *M. glareolus*). Conversely, the density of the species was much higher in autumn than in spring-summer period.

In all the studied biotopes the dominant species was the yellow-necked mouse (*A. flavicollis*), representing almost half of the entire small rodent community (Fig. 1) and had dominant ecological significance (W=8.85%). It was followed by *A. sylvaticus* with 27.72% that prefers the ecotone zone and had dominant ecological significance (W=7.43%) and *A. agrarius* (19.8%) that prefers wet habitats and was dominant in the ecotone with eudominant ecological significance (W=14.32%). A rather high abundance of almost 15% was seen for the bank vole (*M. glareolus*), which is a forest species, widespread in the forest biotopes of the reserve, with dominant significance (W=5.92%). At the ecotone between forest and meadow, the field vole was registered in low numbers with subdominant significance, as well as the pine vole, which is an exclusively forest species and is rather rare on the republic's territory (Fig. 1). The last two species had accidental ecological significance.

The species of the genus *Apodemus* are common and widespread in deciduous forests and can be found within various forest biotopes and their ecotone. Their dominance in forest ecosystems has been recorded in various types of forests throughout the republic (MUNTEANU, 2009; SAVIN et al., 2009; SAVIN & NISTREANU 2009; SAVIN et al., 2011; BURLACU et al., 2016). The *Apodemus* species have large limits of ecological valence and can quickly adapt to changes in ecological conditions. Therefore, in the last years these three species are the most prosperous among other rodent species, being dominant and eudominant in various types of ecosystems, including the forest ones and their ecotones. Their adaptive potential lies in their solitary way of life, the use of a wide spectrum of trophic resources, the inhabitation of various types of biotopes, intense migration to optimal habitats during the year, as well as high reproductive potential.

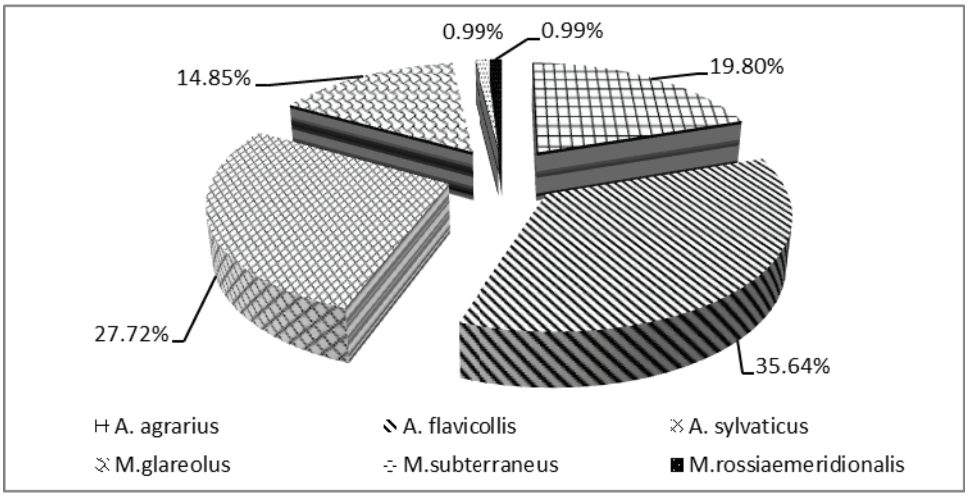

Figure 1. Abundance of small rodent species in studied biotopes.

For parasitological studies only the species of genus *Apodemus* were considered, because they had the highest abundance and represented more than 80% of all small rodent community. Thus, 82 individuals were subjected to parasitological studies: 39 individuals of *A. flavicollis*, 27 individuals of *A. sylvaticus* and 16 individuals of *A. agrarius* of both sexes (Table 1).

Table 1. Studies rodent species of genus *Apodemus*.

Order	Family	Species	nr	%	♀	♂
Rodentia	Muridae (Gray,1821)	*Apodemus flavicolis* (Melchior, 1837)	39	47,5	30	9
		Apodemus sylvaticus (Linnaeus, 1758)	27	33,0	21	6
		Apodemus agrarius (Pallas, 1771)	16	19,5	13	3
		Total	82	100	64	18

The taxonomic structure of parasite species is included in 3 classes, 7 families, 8 genera and 9 species (Table 2).

Table 2. Taxonomic structure of the parasite fauna.

No	Species	Total
	Class Cestoda Fam. Catenotaeniidae	4 species
1.	*Skrjabinotaenia lobata* (Baer, 1925)	
2.	*Catenotaenia cricetorum* (Kirshenblat,1949)	
3.	Fam. Anoplocephalidae *Paranoplocephala omphaloides* (Herman, 1783)	
4.	Fam. Hymenolepididea *Rodentolipis straminea* (Goeze, 1782)	
	Class Secernentea Fam. Oxyuridae	3 species
5.	*Syphacia obvelata* (Rudolphi, 1802)	
6.	*Syphacia stroma* (Linstow, 1884)	
7.	Fam. Heligmosomidae *Heligmosomoides polygyrus* (Dujardin, 1845)	
	Class Adenophorea Fam. *Trichuridae*	1 species
8.	*Trichuris muris* (Scrank, 1788)	

The diversity of the parasite fauna in *A. flavicolis* is represented by 7 species, with the prevalence for *Paranoplocephala omphaloides* – 13.3%, intensity – 1 (1) and abundance – 0.1, *Catenoteania cricetorum* – 6.66%, 1 (1), 0.1, respectively, *Skrjabinotaenia lobata* – 13.3%, 1.5 (1-2), 0.2, and 4 species of Nematods, i.e. *Syphacia stroma* – 53.3%, 109 (24-283), 58.4, *Syphacia obvelata* – 40.0%, 22.5 (5-53), 9.0, *Heligmosoma polygyrus* – 6.66%, 5 (5), 0.3, and *Trichuris muris* – prevalence – 20.0%, intensity – 2 (1-4) and abundance – 0.4 (Table 3).

Within the host species *A. sylvaticus*, the prevalence with *Rodentolepis straminea* is 25.0%, intensity – 3 (3) and abundance – 0.8, while for *Syphacia stroma* they are 75.0%, 33 (15-59) and 24.8 respectively.

For the species *A. agrarius*, the level of prevalence with *R. straminea* is 25.0%, of intensity – 1 (1) and of abundenţei – 0.25, while *S. obvelata* – 25.0%, 5 (5) and 1.25 respectively.

Thus, in the rodent hosts, *A. flavicolis* was determined to be the most diverse structure, including 4 parasite species from the Cestoda class (*Paranoplocephala omphaloides*, *Catenoteania cricetorum*, *Skrjabinotaenia lobata*, *Rodentolipis straminea*), 3 species from the Secernentea class (*Syphacia obvelata*, *S. stroma*, *Heligmosomoides polygyrus*) and 1 species from the Adenophorea class (*Trichuris muris*). It must be mentioned that, of the total of 7 registered parasite species, 2 have a zoonotic impact (*S. stroma*, *S. obvelata*) (Table 3).

Table 3. Diversity of parasite fauna in the studied species of the *Apodemus* genus.

Species		**Prevalence, %**	**Intensity, ex/ind.**	**Abundance, ex/lot**
host	**parasite**			
A. flavicollis	**Cestoda**			
	Paranoplocephala omphaloides	13.3	1 (1)	0.1
	Catenoteania cricetorum	6.66	1 (1)	0.1
	Skrjabinotaenia lobata	13.3	1.5 (1-2)	0.2
	Secernentea			
	Syphacia stroma	53.3	109.5 (24-283)	58.4
	Syphacia obvelata	40.0	22.5 (5-53)	9.0
	Heligmosomoides polygyrus	6.66	5 (5)	0.3
	Adenophorea			
	Trichuris muris	20.0	2 (1-4)	0.4
A. sylvaticus	**Cestoda**			
	Rodentolepis straminea	25.0	3 (3)	0.8
	Secernentea			
	Syphacia stroma	75.0	33 (15-59)	24.8
A. agrarius	**Cestoda**			
	Rodentolepis straminea	25.0	1 (1)	0.25
	Secernentea			
	Syphacia obvelata	25.0	5 (5)	1.25

The weighted structure of parasitic invasions is specific to each host. In *A. flavicolis* the prevalence of the species from the Cestoda class is of 40.0%, intensity – 1.14 (1-2), abundance – 0.5, while that of nematodes is of 73.3%, 92.9 (1-283) and 68.1 respectively. The total prevalence is 86.7%, total intensity – 79 (1-283) and total abundance – 68.5.

In *A. sylvaticus*, the prevalence of the species from the Cestoda class is 25.0%, intensity – 3 (3), abundance – 08 and the prevalence of the nematode species is of 75.0%, intensity – 33 (15-59), abundance – 24.8. The total prevalence is 75.0%, total intensity – 34 (3-59) and total abundance – 24.8.

In *A. agrarius*, the prevalence of the species from the Cestoda class is 25.0%, intensity – 1 (1), abundance – 0.25, while in nematod species is of 25.0%, 5 (5) and 1.25 respectively. The total prevalence is 50.0%, total intensity– 3 (1-5) and total abundance – 1.5.

The increase in the invasive indices of both *A. flavicolis* and *A. sylvaticus* is due to the fact that some of the Nematoda species are geohelminths (*Heligmosomoides polygyrus*, *Trichuris muris*) that do not require intermediate hosts, the larvae of which are resistant, live freely and nourish in nature with successional development (*Syphacia stroma*, *Syphacia obvelata*), whose females deposit fertilized eggs in the perianal region of the host and the infestation occurs by self-invasion or individual contact between the hosts, thus omitting the development in the environment, or their eggs are carried by predators (*Vulpes vulpes*) that consume the infested hosts. The species of biohelmines represented by 4 Cestoda species (*Paranoplocephala omphaloides*, *Catenoteania cricetorum*, *Skrjabinotaenia lobata*, *Rodentolepis straminea*) have a lower share, since they require more hosts in their development cycle. These qualities favour the persistence and spread of parasite species both within the biotope between individuals of the host species and within other biotopes.

From the mentioned above we can conclude that the helminth fauna in studied rodent species consists of 8 parasite species, of which 3 species of biohelminths (37,5%), 2 species of geohelminths (25,0%) and 2 species of ageohelminths (25,0%).

The results of the researches performed in the Republic of Moldova at the beginning of the 1960s are different from ours, where the infestation level with Cestoda species varies depending on the host. Thus, the prevalence of the species *Paranoplocephala omphaloides* in *Microtus arvalis* was of 0.76%, of *Catenoteania cricetorum* in *M. arvalis* – 1.51%, on *Clethrionomys glareolus* – 22.32%, and of *Skrjabinotaenia lobata* in *A. flavicollis* constituted 4.37%, while in *A. sylvaticus* – 2.67%. Some Nematode species, such as *Heligmosomoides polygyrus* in *A. flavicollis* constituted 0.95%, in *A. sylvaticus* – 1.06%, *Trichocephalus muris* in *A. sylvaticus* – 1.62% and in *Mus musculus* – 2.5%. The most abundant species proved to be *Syphacia obvelata* in *A. flavicollis* with an intensity of 21.92% and *Syphacia stroma* with

10.47% (ANDREICO & SHUMILO, 1970). In Russia the helminth fauna in *A. flavicollis* is represented by *S. stroma* with a prevalence of 76.2%, of *Heligmosomoides polygyrus* with 29.3%, *Syphacia obvelata* with 15.7% and of *Trichocephalus muris* with 0.82% (ROMASHOVA, 2003). Some parasite species have been registered in Lithuania, as follows: *T. muris* with a prevalence of 33.3% in *Clethrionomys glareolus* and 16.7% in *Microtus agrestis*; *Syphacia* sp. – 33.3% in *M. agrestis* (MAZEIKA et al., 2003).

In comparison to our data, some authors from Russia (ROMASHOVA, 2003) report more diverse helminth fauna, distributed in many habitats of the host *A. flavicollis* (174 individuals). 1 species (*Syngamus* sp.) was registered in the lungs, in the thoracic cavity – 2 species (*Alaria alata*, *Macrocanthorynchus catulinus*), in the liver – 4 species (*Taenia hydatigena larvae*, *Hydatigera teaniaformis larvae*, *Skrjabinoplagiorchis vigisi*, *Capilaria hepatica*), in the small intestine - 5 species (*Syphacia stroma*, *Heligmosomoides polygyrus*, *Anoplocephaloides dentata*, *Plaghiorchis elegans*) and in the large intestine - 3 species (*Syphacia obvelata*, *Ganguloterakis spumosa*, *Trichocephalus muris*).

The obtained data elucidates the potential of the parasitic pollution risk of the interfering area between natural and anthropized ecosystems and, as a result, the transmission of invasive forms from wild animals to domestic animals, including to humans. At the same time, the rodents are components of the trophic chain of larger predators, and, in turn, are vectors of invasive forms in the environment and ensure the functional stability of the host-parasitic systems within the investigated biocoenoses.

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CONCLUSIONS

1. In the study period, 202 individuals from 6 species were registered. The diversity was higher in spring, when all 6 species have been recorded, and lower in autumn with 4 species. In all the studied biotopes, the *Apodemus* genus species (*A. flavicollis*, *A. sylvaticus*, *A.agrarius*) were dominant.
2. The taxonomic structure of parasite fauna is represented by 3 classes, 7 families, 8 genera and 8 species.
3. The helminth fauna in the studied rodent species consists of 8 parasite species, of which 3 species of biohelminths (37.5%), 2 species of geohelminths (25.0%) and 2 species of ageohelminths (25.0%).
4. The most abundant parasite species proved to be *Syphacia stroma* and *Syphacia obvelata*.

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Chihai Oleg, Erhan Dumitru, Nistreanu Victoria, Larion Alina, Tălămbuţă Nina, Rusu Ştefan, Melnic Galina, Zamornea Maria
Institute of Zoology, Academiei str.1, MD – 2028, Chisinau, Republic of Moldova.
E-mail: olegchihai@yahoo.com

Tălămbuţă Nina
Free International University of Moldova, Vlaicu Parcalab 52, MD – 2012, Chisinau, Republic of Moldova.
E-mail: olegchihai@yahoo.com

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THE IMPORTANCE OF AMINO ACIDS FOR THE DEVELOPMENT OF BEE COLONIES

VRABIE Valeria, DERJANSCHI Valeriu, CIOCHINĂ Valentina

Abstract. For a normal growth and development, bee colonies need a balanced nutrition in essential and functional amino acids. The bees' necessity of amino acids varies depending on the age, being higher for young bees. Preferences in certain amino acids are caused by the maintenance of the various functions of the bees' body and their social activity. Amino acids have an essential role in the formation of nutritional motivation and in the selective collection of pollen from various floral species, which are the main source of amino acids. The comparative analysis of free amino acids in three types of pollen revealed a greater amount in acacia pollen in comparison to poly flower and sunflower pollen. The amino acids leucine and lysine have the highest percentage in total essential amino acid content, and aspartic acid, glutamic acid and proline from the total non-essential amino acids pattern. Also, the content and the correlation of essential and functional amino acids in protein feed determines its preferences and accessibility for bees and underlies the prospecting of protein feed, which is increasingly applied in agricultural practice to compensate the deficiency of amino acids in case of lack or insufficiency of pollen in nature.

Keywords: amino acids, pollen, honey bee, nutrition, development.

Rezumat. Importanța aminoacizilor pentru dezvoltarea familiilor de albine. Pentru o creştere şi dezvoltare normală, familiile de albine au nevoie de o nutriţie echilibrată în aminoacizi esenţiali şi funcţionali. Necesarul în aminoacizi variază în dependenţă de vârsta albinelor, fiind mai mare pentru albinele tinere. Preferinţele în anumiţi aminoacizi sunt cauzate de menţinerea diverselor funcţii ale organismului albinelor şi de activitatea lor socială. Aminoacizii au un rol esenţial în formarea motivaţiei nutriţionale şi în colectarea selectivă a polenului de la diverse surse florale, care reprezintă principala sursă de aminoacizi. Analiza comparativă a aminoacizilor liberi în trei tipuri de polen a relevat un conţinut mai mare al acestora în polenul de salcâm spre deosebire de polenul poliflor şi polenul de floarea-soarelui. Aminoacizilor, leucina și lizina, le revine o pondere mai mare din conţinutul total al aminoacizilor esenţiali, iar acidului aspartic, acidului glutamic şi prolinei – din cel al aminoacizilor neesenţiali. De asemenea, conţinutul şi co-raportul aminoacizilor esenţiali şi funcţionali în hrana proteică determină preferinţele şi accesibilitatea acesteia pentru albine şi stau la baza prospecţiunii furajelor proteice, care tot mai des se aplică în practica agricolă pentru a suplini deficitul de aminoacizi în cazul lipsei sau insuficienţei polenului în natură.

Cuvinte cheie: aminoacizi, polen, albine, nutriție, dezvoltare.

INTRODUCTION

The requirement of bee colonies regarding certain nutrients varies according to the levels of social organization of the bees, and it depends on the seasons of the year. It is known that the autumn feeds with sweet sugar syrup are primordial for the bee colonies to survive the winter conditions, while early spring feeding is necessary to restore the strength of the bee colony after winter and increase its productivity during the active harvesting period. Early spring feeding with high protein content is absolutely necessary for the brood growth and development, and also determines the bee lifespan (HAYDAC, 1970; ALGARNI, 2006; MATTILA & OTIS, 2006; BRODSCHNEIDER & CRAILSHEIM, 2010). Also, protein-rich food during this period is beneficial to the bees' health and the ability to resist infections and parasites (ALAUX et al., 2010).

Proteins are necessary as a source of amino acids that are reused in the biosynthetic processes of the bee organism. In many studies, bee protein requirement depends on age: for larvae – 40 mg per day (HRASSNIGG & CRAILSHEIM, 2005) and for adult bees – 0,68 mg per day (SCHMIDT & BUCHMANN, 1985; BRODSCHNEIDER & CRAILSHEIM, 2010). Also, brood and young bees consume more essential amino acids compared to mature bees, which require amino acids predominantly to maintain somatic functions (enzyme production, tissue regeneration, immunity formation) or reproduction (PAOLI et al., 2014). It has been established that royal jelly factors, namely protein and amino acid composition, can play a crucial role in honey bee development (MALESZKA, 2018).

For normal growth and development, bees need ten essential amino acids: valine, leucine, isoleucine, threonine, methionine, lysine, arginine, phenylalanine, tryptophan and histidine (DE GROOT, 1953). These amino acids are the same as those needed by other animal taxa. Thus, it can be assumed that bees do not vary in their nutritional requirements concerning amino acids (VANDERPLANCK et al., 2014). The main sources of amino acids and proteins for bees are pollen and bee bread. Pollen collected from different floral species has different nutritional values for bees.

Often the need of amino acids for bees is analyzed in terms of their content in different sources of pollen. It has been demonstrated that the content of proteins and amino acids in pollen depends on the plant and can vary between 3.8 and 40.8%, the average being 25% (SZEZĘSNA, 2006). It was noted that the maximum concentration of one or another amino acid is not identical to one and the same plant. Nutrition with only one type of pollen, which has an insufficient amount of protein, does not cover the essential amino acid requirements of a bee's body. SCHIMDT et al. (1987, 1995) have shown that only a mixture of different types of pollen has a beneficial effect on the development and performance of the bee colony. For example, according to the results obtained by DE GROOT (1953), bees require 4% of isoleucine from the total available amino acids. Only 2% of isoleucine is contained in one type of pollen, which results in the consumption of a double quantity of pollen to supplement it, or to mix different types of pollen containing a larger amount of essential amino acids (STACE, 1996). Thus, it seems that amino acid composition has a greater influence on the amount of pollen required by bees than crude proteins content (NICOLSON, 2011). The plant species that contain in pollen proteins a higher amount of essential amino acids are considered to be more valuable from the nutritional point of view for bees and are more frequently visited by them. Also, these poly flower pollen mixtures increase some immune functions and confer antiseptic protection to bees (ALAUX et al., 2010). It has been established that amino acids from pollen sources influence the sensitivity of the glucose receptors of the amino acids themselves, thus contributing to the formation of conditional reflexes between food quality and its flavor (ZACEPILO et al., 2012). The content of proteins and amino acids in food is absolutely essential for the development of the hypopharyngeal gland and enzyme secretion respectively, which in turn depends on the amount of nectar harvested. A direct correlation between the activity of the secretory glands (enzyme activity), the ability to process nectar within the hive (hive) and the production of honey has been demonstrated (JEREBKIN, 1965).

Thus, amino acids play an important role in the formation of nutritional motivation and in the selective collection of pollen from various floral sources.

Based on the information mentioned above, the purpose of the work is to compare the free amino acid content in different pollen samples in order to identify those sources that contain the optimal content and spectrum of amino acids needed for the growth and development of bee colonies.

MATERIAL AND METHODS

Three types of pollen –acacia, poly flower and sunflower – were taken in the study. Honey samples were collected from the Center Zone of the Republic of Moldova.

The amino acid analysis was performed at the AAA-339M (Czech Republic) amino acid analyzer by the ion-exchange chromatography method (MOORE et al., 1958).

RESULTS AND DISCUSSIONS

The amino acid analysis in the pollen samples taken in the study according to the ion exchange liquid chromatography method revealed 17 amino acids. Tryptophan was identified in extremely small amounts, which did not allow its comparative analysis with other amino acids in the samples. Aspartic acid includes both aspartic acid and asparagine and glutamic acid includes both glutamic acid and glutamine (in the process of detection asparagine is combined with aspartate and glutamine with glutamate and so they have the identical picks that reflect the quantity of extraction).

In the investigation of the content of free amino acids in acacia pollen, poly flower pollen and sunflower pollen, a higher amount was determined in acacia pollen, namely 13.2 mg/100 mg. In poly flower pollen this value is 11.95 mg/100 mg, and in sunflower pollen – 8.35 mg/ 100 mg (Fig. 1).

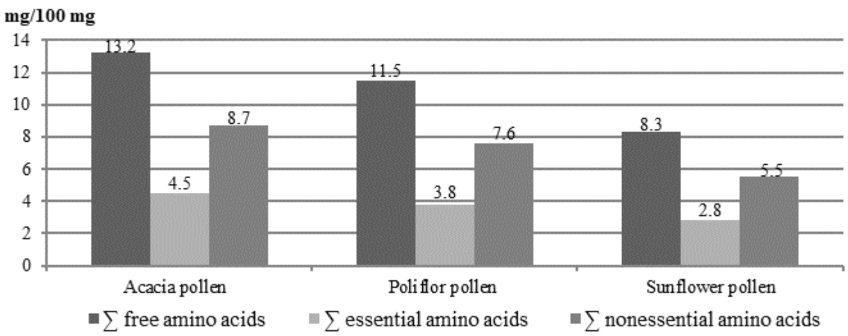


Figure 1. The content of free, essential and non essential amino acids (mg/100 mg) in acacia pollen, poly flower pollen and sunflower pollen.

The total content of essential and non-essential amino acids is also higher in acacia pollen (4.5 and 8.7 mg/100 mg, respectively) compared to poly flower pollen (3.8 and 7.6 mg/100 mg, respectively) and sunflower pollen (2.8 and 5.5 mg/100 mg, respectively) (Fig. 1).

In order to reveal the biological value of pollen collected by bees, the ratio of essential and non-essential amino acids to the total free amino acid content was analyzed. Thus, the share of essential amino acids compared to the total free amino acid content in acacia pollen is 34% and of nonessential amino acids – 65%. This ratio respectively in poly flower pollen is 33% and 65.2%, and in sunflower pollen – 33.7% and 65%.

Hence, the nutritional value of the pollen for bees is primarily defined by its absolute and relative content of essential amino acids. All analysed pollen types have about the same share of essential and non-essential amino acids, indicating that they have nearly the same nutritional value for bee colonies. However, acacia pollen in according to essential amino acid share denotes better nutritional qualities than poly flower pollen and sunflower pollen.

At the same time, the significance of pollen proteins and their preference for bees depends on the content of certain amino acids with key functions for the optimal growth and development of bee colonies.

For these reasons it was proposed to analyse the content of each amino acid in part in the pollen samples taken in the study (Figs. 2 and 3).

The analysis of essential amino acids revealed a higher content of leucine and lysine amino acids in acacia pollen, valine, isoleucine, threonine, methionine, phenylalanine in poly flower pollen and histidine in sunflower pollen (Fig. 2). Thus, obtained data determined that the leucine and lysine have the highest percentage from the total essential amino acid content, data which coincides with other studies (SZEZĘSNA, 2006).

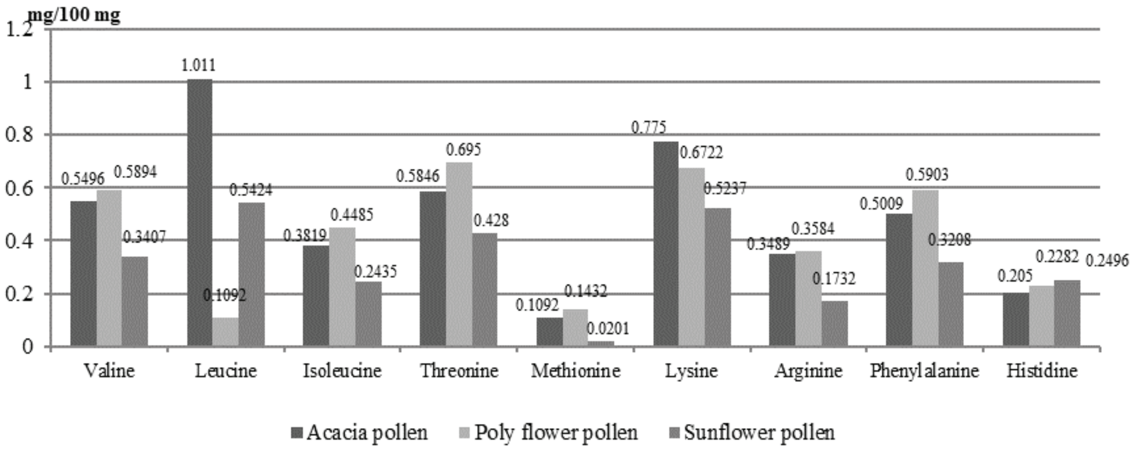


Figure 2. The comparative content of essential amino acids (mg/100 mg) in three types of pollen.

It is known that a significant index for the bee's vital activity is the content of branched chain amino acids (valine, leucine and isoleucine), which in acacia pollen is about 14.6%, in poly flower pollen – 10.03%, and in sunflower pollen – 13.5%. It has been established that leucine, isoleucine and valine are the most required amino acids for bees, and their deficiency limits the development of the bee colony. Also, isoleucine is the necessary nutritional factor in bee feed, which should account for no less than 4% of the protein content (HAYDAC, 1970). In acacia and sunflower pollen this ratio is 2.9%, and in poly flower pollen – 3.9% compared to the total free amino acid content.

It was determined that the lysine-arginine ratio as well as the high lysine content is an important index, determining the protein quality required for bee feeding and bee preferences for certain types of pollen (FETEA et al., 2011). In acacia pollen, this index is 2.22, in poly flower pollen – 1.87, and in sunflower pollen is 3.02.

Some pollen sources contain more methionine (1.2% in poly flower pollen) and histidine (2.9% in sunflower pollen).

Recently there is growing interest in biochemistry, physiology and nutrition of amino acids in growth, health and disease of humans and other animals. The new findings in this field of research led to the new concept of functional amino acids (WU, 2013). The functional amino acids which are also some non-essential amino acids participate in key metabolic pathways of living organisms.

The analysis of non-essential amino acids in pollen samples revealed a higher content of alanine, glycine, proline, aspartic acid and asparagine, glutamic acid and glutamine in acacia pollen; of cysteine, serine and tyrosine in poly flower pollen. The content of individual amino acids in sunflower pollen is lower compared to pollen of acacia and poly flower (Fig. 3). From the data obtained in presented study as well as from the data obtained by other authors, it was established that in pollen amino acids – proline, glutamic acid and aspartic acid have the highest percentage from the total non-essential amino acid content.

In the conditions of the lack of pollen in nature, early spring protein feeding is more than needed to supplement the protein and amino acid deficiency in food, which are necessary for the growth and accumulation of workers in bee colonies at the acacia harvesting. Such stimulating feeding are an ever more frequent bee-keeping practice, that make the earlier egg laying by queen, the restoring of bee colony size and the rapidly colony development (EREMIA, 2009; FETEA et al., 2011). It should be noted that when replacing pollen with other protein-rich feed, it is advisable to consider their nutritional value derived from the amino acids pattern, as well as their amount, especially of essential ones. HERBERT et al. (1977) demonstrated that the optimal protein level in bees feed should be 20-30%. At the same time the 50% content should be avoided.

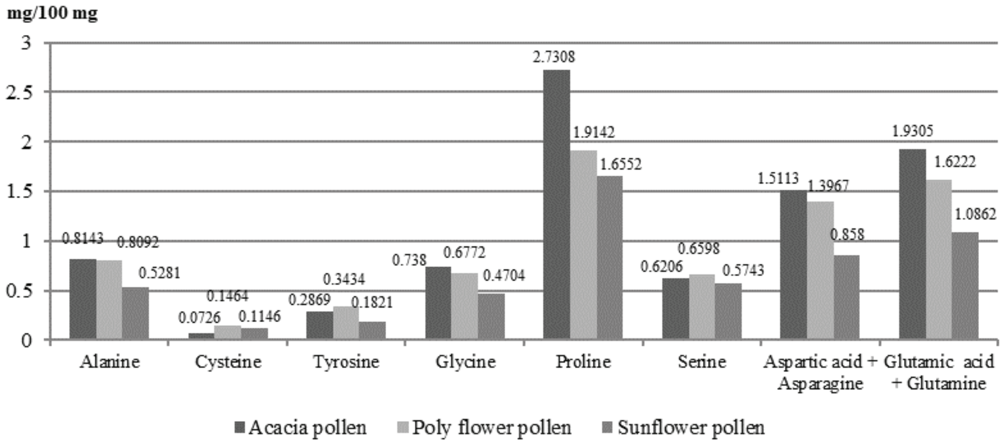
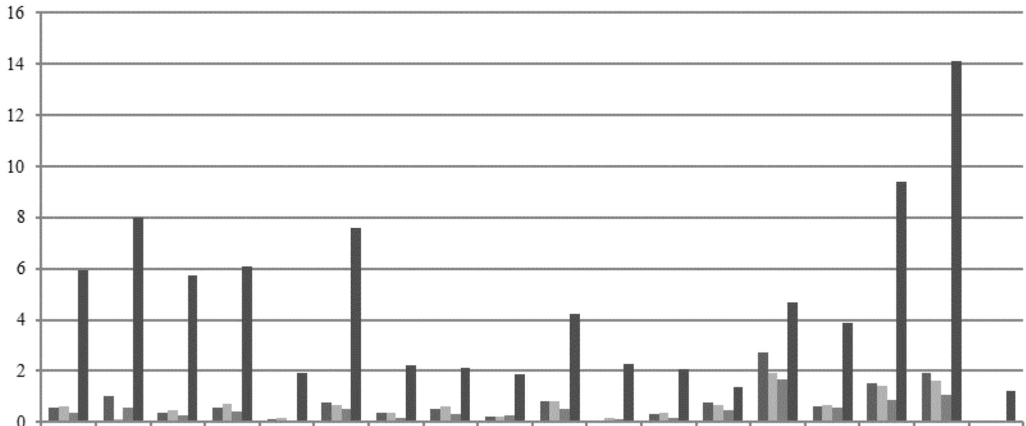


Figure 3. The comparative content of non-essential amino acids (mg/100 mg) in three types of pollen.

Pollen of poor quality has a negative effect on brood rearing, offspring size and can lead to additional nectar foraging. This aspect determines activities for the selection of good quality protein feed for bee colonies.

In exploratory work, the biochemical peculiarities of whey were studied as a protein supplement and a source rich in essential and functional amino acids for the early spring bee colony feeding, and proved the advantage of this product compared to pollen or other protein feeds (VRABIE et al., 2013; DERJANSCHI et al., 2014).

Whey proteins contain a significant amount of such essential amino acids for bees as leucine, isoleucine and valine or branched chain amino acids and also of methionine and histidine. In comparison with pollen, whey contains a higher level of tryptophan. In pollen only trace amount of this amino acid was detected. In whey, as in pollen, the higher content of glutamic and aspartic acids was established (Fig. 4).



	Val	Leu	Ile	Thr	Met	Lys	Arg	Phe	His	Ala	Cys	Tyr	Gly	Pro	Ser	Asp	Glu	Trp
Acacia pollen	0.55	1.011	0.382	0.585	0.109	0.775	0.349	0.501	0.205	0.814	0.073	0.287	0.738	2.731	0.621	1.511	1.931	0
Poly flower pollen	0.589	0.109	0.449	0.695	0.143	0.672	0.358	0.59	0.228	0.809	0.146	0.343	0.677	1.914	0.66	1.397	1.622	0
Sunflower pollen	0.341	0.542	0.244	0.428	0.02	0.524	0.173	0.321	0.25	0.528	0.115	0.182	0.47	1.655	0.574	0.858	1.086	0
Whey	5.93	7.98	5.73	6.1	1.94	7.61	2.2	2.13	1.87	4.21	2.28	2.08	1.38	4.67	3.88	9.41	14.14	1.23

Figure 4. The comparative content of amino acids (mg/100 mg) in three types of pollen and whey.

As it was mentioned above, the ratio of lysine and arginine determines the nutritional value of bees' protein. In pollen from various floral sources this ratio is vary from 1.87 to 3.0, while in whey – 3.45, which is another argument in using whey as a protein pollen substitutes.

Taking into account the nutritional qualities of whey and the high content of essential amino acids for bee growth and development, whey and whey products can be proposed as a protein supplement in the absence of pollen in nature.

Thus, amino acids play an important role in the vital activity of honey bees. Leucine, isoleucine and valine have been shown to enhance the protein synthesis process (KIMBALL & JEFFERSON, 2006). On the other hand, leucine and isoleucine are key amino acids in the formation of haemolymph proteins and regulate the functional balance of the internal secretion glands. Along with valine, leucine and isoleucine play an important role in the transition from larva to pupa. Valine is also essential in functional nervous system (MALAIU, 1976). Methionine is actively involved in the regulation of protein and lipid metabolism, and in the neutralization of toxic substances, while histidine is particularly necessary for growing brood (MALAIU, 1976). Also, as a result of decarboxylation, histidine converts to histamine, which is a component part of bee venom (DE GROOT, 1953). Tryptophan, however, is present in trace amounts in pollen and it is important in maintaining reproductive functions, producing nicotinic acid, synthesizing proteins for feeding larvae and contributing to pigmentation of the bee's body (DI PASQUALE et al., 2016). It was demonstrated that proline as well as glycine, that are in significant amount in all types of investigated pollens (Fig. 3), exert a stimulating effect on growth in unfavourable conditions (HAYDAC, 1970; MALAIU, 1976) and the amount of these amino acids in pollen represent an attraction factor for bees. Proline significantly influences the flying capacities of honey bees (MICHEU et al., 2000). Some non-essential amino acids are indispensable for certain physiological and biochemical processes. Thus, it has been established that glutamic acid is important for the formation of olfactory memory in bees (LOCATELLI et al., 2005) and glutamine serves as a "fuel" for cells that divide and is considered "essential condition" in metabolic stress cases (KRISSANSEN, 2007).

CONCLUSIONS

Essential and functional amino acids are necessary for the normal growth and development of bee colonies, especially for the growth of brood and young bees. The balanced content and composition in these amino acids contributes to maintaining of basic somatic functions and reproductive functions in adult bees.

Amino acids have an essential role in the formation of nutritional motivation and in the selective collection of pollen from various floral sources

The comparative analysis of free amino acids in three types of pollen revealed a greater content of them in acacia pollen compared to poly flower pollen and sunflower pollen. Amino acids leucine and lysine have the highest level from the total essential amino acid content, and aspartic acid, glutamic acid and proline – from the total non essential amino acid content.

The content and ratio of essential and functional amino acid in protein diet determine its preferences and accessibility for bees and underpin the prospecting of protein feed, which is increasingly applied in agricultural practice to compensate the deficiency of amino acids in case of lack or insufficiency of pollen in nature.

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Vrabie Valeria,
The Institute of Physiology and Sanocreatology,
Academiei Str., No. 1, Chișinău, Republic of Moldova.
E-mail: valvrabie@yahoo.com

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DIVERSITY OF CARABID ASSEMBLAGES IN URBAN AND SUBURBAN ECOSYSTEMS IN CENTRAL EUROPE

ŠUSTEK Zbyšek

Abstract. The study represents a synthesis of investigation of Carabid assemblages in 57 sites (13 alluvial sites, 18 mesohydrophilous forests and 25 urban parks, gardens and cemeteries) studied in two Central European cities (Bratislava and Brno) since 1978 up to 2006. In both cities, but especially in Bratislava, seminatural ecosystems penetrate deeply into the center. In addition, there also exist secondarily restored ecosystems that have reached, structurally and physiognomically, a considerable degree of naturalness. In all types of ecosystems 162 Carabid species were recorded. They represent about ¼ of the Central European Carabid fauna and about half of the lowland fauna in this area. However, the species richness in individual sites strongly varies. In the suburban zones, at city margins or in some restored sites with continuous tree vegetation even in the city center it is very similar to the corresponding ecosystems in free landscape (about 30 species in flood plain forests and 20-25 species in mesohygrophylous deciduous forests). But in general there is a strong tendency to declining of species number toward the city center. A special situation is in urban parks and gardens in residential quarters with discontinuous tree vegetation, where the Carabid assemblages predominantly consist of the species characteristic for the arable land, but their number is usually much lower. This number is much lower in spite of summer nocturnal migration waves of flying arable land Carabid species, which are attracted to the city center by extensive illuminations and make possible to colonize the patches of grassy vegetation in city center.

Keywords: Carabidae, urban ecosystems, Central Europe, community ecology, species diversity.

Rezumat. Diversitatea cenozelor de Carabide din ecosistemele urbane şi suburbane din Europa centrală. Acest studiu reprezintă o sinteză a cercetărilor cenozelor de Carabide din 56 localităţi (13 din aluvii, 18 din pădurile mesohidrofile şi 25 din parcuri, grădini şi cimitire) efectuate în două oraşe central europene (Bratislava şi Brno) din anul 1978 până în 2006. În ambele oraşe, dar în mod special în Bratislava, ecosistemele seminaturale pătrund adânc în centru. În afară de acestea, în oraşe există şi ecosisteme restituite secundar care au atins, structural şi fizionomic, un grad remarcabil al caracterului natural. În toate tipurile de ecosisteme, au fost înregistrate 162 de specii de Carabide care reprezintă aproximativ un sfert din numărul speciilor din fauna Carabidelor din Europa centrală şi o jumătate din fauna de câmpii. Însă, numărul speciilor din localităţile individuale este extrem de variabil. În zonele suburbane, pe lângă marginile oraşului sau în unele ecosisteme restituite cu vegetaţie continuă de arbori, chiar în centrul oraşului, numărul speciilor este foarte asemănător celui din ecosistemele analogice din peisajul natural (aproximativ 30 de specii în păduri de luncă, 20-25 de specii în păduri mesohidrofile). Dar, în general, există o tendinţă puternică de reducere a numărului speciilor în centrul oraşului. O situaţie deosebită există in parcuri şi grădini din cartiere rezidenţiale de vile , cu vegetaţie de arbori discontinuă, unde cenozele de Carabide constau din specii caracteristice pentru câmpuri, dar în general, numărul speciilor la o localitate concretă este mult mai scăzut. Numărul lor este mult mai mic, dimpotrivă ,in migraţiile nocturne de vară ale multor specii zburătoare, caracteristice pentru câmpuri, care sunt atrase de către iluminaţia enormă a unor locuri şi face posibilă colonizarea pajiştilor din centrul oraşului.

Cuvinte cheie: Carabidae, ecosisteme urbane, Europa Centrală, ecologia cenozelor, diversitatea speciilor.

INTRODUCTION

Urban ecosystems represent, in dependence on the city size, form of its territory and character of surrounding landscape, an enormously complex mosaic of ecosystems, in which almost natural habitats can neighbor with strongly influenced habitats, without continuously surviving populations of individual species (NIEMELA 2011; MĂGURA et al., 2008, 2018). Depending on the historical development of the city and the character of geographical relief, seminatural habitats can occur deep in city center and act as biocorridors. The intensive illumination attracts many insects into the city center (ŠUSTEK 1999a; OWENS 2019), where they can colonize the suitable habitats, especially in grassy plots and parks and cemeteries with sparse wooden vegetation.

Carabid assemblages in urban ecosystems were a focus of many authors. In Europe they were studied in Kiel (TOPP, 1972), Leipzig (KLAUSNITZER & RICHTER, 1980; KLAUSNITZER et al., 1980), Warsaw (CZECHOWSKI, 1980a; 1980b; 1981a; 1981b; 1982), Moscow (DUSHENKOV, 1983), Brno (ŠUSTEK, 1979; 1983; ŠUSTEK & VAŠÁTKO 1984a; 1984b), Nitra (MAJZLAN & FRANTZOVÁ, 1995), Birmigham (SMALL et al., 2003), Helsinki (ALARUIKKA et al., 2002; VENN et al., 2003), Berlin (DEICHSEL, 2006) and Debrecen (MĂGURA et al., 2008; 2018), while in West Mediterranean in Madrid (ŠUSTEK, 2012), in East Asia in Pyongyang (ŠUSTEK, 2011) and in USA in Central Minnesota (GANDHI et al., 2011). Recently, urban carabid communities were studied in Lvov, Kijev, Charkow, Donetsk and Dneprov (NIKOLENKO, 2018; PUTCHKOV et al., 2019). In Bratislava the carabids were studied by ŠUSTEK (1984a), but among his results only various more general analyses of community structure (ŠUSTEK, 1980; 1987) or species behaviour were published (ŠUSTEK 1999a, 1999b), while the list of species found in each locality has remained unpublished because of the large extent of the tables. A synthesis of many papers on urban fauna and urban ecology in general was recently compiled by NIEMELÄ et al. (2011). The carabid fauna of Devínska Kobyla was also studied by KORBEL et al. (1997), MAJZLAN & BAŤALÍK (1997), ŠUSTEK (2004a) and MAJZLAN et al. (2005).

The aim of this paper is to synthesize the results of samplings carried out in Brno and Bratislava in the period 1978 – 2006 in 57 localities (11 localities in Brno, 46 in Bratislava - eight of them were studied repeatedly) representing an ecological gradient ranging from seminatural oak-hornbeam or floodplain forests on the city margin to gardens in residential quarter and parks or abandoned places in the very city interior.

MATERIAL AND METHODS

The beetles were pitfall-trapped. The number of traps varied according to size and character of the studied plots and possibility to hide them before the public. In seminatural, less frequented sites, five traps were installed in a line in distances of 10 m. In the city center number of traps was limited to 1-2. The traps were exposed each year from early April until late October, in 2005/2006, including the whole winter. They were emptied approximately once a month. The samples from Devínska Kobyla, Dúbravská Hlavica, Horský park, Mlynská Dolina, Briežky and Koliba were collected by Milada Holecová, those from Brno Ráječek and Soběšice by Aleš Merta, while those from Kraví Hora by Jaroslav Vašátko. All beetles were identified by the author using the keys by KULT (1947) and HŮRKA (1996). The nomenclature is taken from HŮRKA (1996) and the complete specific names are alphabetically ordered in Annex 1.

The carabids were characterized by their preference for humidity and shadowing using two semiquantitative scales (1 – xerophilous to 8 polyhydrophilous; 1 – open landscape species to 4 – species requiring complete shadowing by tree vegetation) proposed by ŠUSTEK (2004b) (Annex 1). The characteristics of ecological requirements were taken from BURMEISTER (1939), LARSSON (1939), LINDROTH (1949), THIELE (1977) and HŮRKA (1996), and précised by results of numerous zoocoenological studies made in Central Europe. On this basis, the shadowing and humidity index of community was calculated for each year as arithmetical average of all species weighted by number of each species. The obtained values were used for the direct ordination of the communities (POOLE, 1974).

The dominance is characterized by the following scale: > 10% eudominant, 5–10% dominant, 2–5% subdominant,1–2% recedent, < 1% subrecedent (SCHWERDTFEGER, 1975).

The hierarchical classification was made by the UPGMA method and the indirect ordinations were made by the principle coordinate method. In both cases, the Horn index reflecting the proportional similarity was used. For the canonical correlation analysis, three factors characterizing the individual sites were chosen: altitude, surface and coverage of the layers F0 – F3. The equitability calculated on the base of Shannon Wiener's index was used as a diversity measure. All calculations were executed by the Program Past, version 2012 (HAMMER, 2012).

STUDY PLOTS

Here a general characteristic of study plots is presented. For the quantitative characteristiocs and abbreviations of locality names see Annex 2.

Bratislava – suburbs

- Devínska Kobyla and Dúbravská hlavica – four plots in mature oak-hornbeam forests in the State Nature Reserve Devínska Kobyla
- Horský park – a forest park founded in the late 19th century on the west slopes of foothills of the Little Carpathians, surrounded by residential quarter with family houses, four different plots
- Kalvária: a mature oak-horn beam stand isolated between the proper city center and residential part with family houses surrounded by gardens, arisen secondarily on the place of former pastures in mid 19th century
- Koliba and Briežky – oak-hornbeam forests on southern slopes of Little Carpathians, immediately at the margins of residential quarter with family houses and gardens
- Mlynská dolina – a mature oak-hornbeam stand with admixed locust trees on a steep western slope in western part of Bratislava
- Sitina: a mature oak-horn beam stand with admixed locust trees and cherries, arisen secondarily on the place of former vineyards in mid 19th century
- Vrakuňa forest – a profoundly altered remnant of a former floodplain forest at the Little Danube, locust trees predominate
- Vrakuňa oxbow – reed and nettle stand around the Little Danube dead arm
- Vrakuňa ruderal – a dump of construction wastes in vicinity of the Little Danube dead arm, discontinuous ruderal herbage vegetation
- Vrakuňa wheat field – a field in the eastern part of the city, adjacent to the Vrakuňa forest locality
- Vydrica sanatory – alluvium of the Vydrica creek, high tree vegetation, Little Carpathians
- Vydrica ZOO - alluvium of the Vydrica creek, sparse tree and shrubby vegetation on the creek bank
- Vydrica Slovák – a small remnant of floodplain forest along the Vydrica creek
- Vydrica crossing – a narrow strip of shrubs and tree vegetation the along the Vydrica creek at Botanical garden
- Železná studnička – natural oak-hornbeam forest in the valley of the Vydrica creek, in Little Carpathians

Bratislava - city center

- Americké námestie square - urban park, grassy plots and sparse trees and shrubs
- Bajkalská street – a large meadow-like abandoned area at the crossing of the Bajkalská and Ružinovská streets
- Hlavné námestie square – urban park in the very historical center, grassy plots sparse trees and shrubs, in late 1990-ies all vegetation removed
- Hradný vrch – southern slope of the Bratislava castle hill, secondary shrub vegetation
- Kollárovo námestie square – urban park, grassy plots and sparse trees and shrubs
- Líštiny, grassy plot in surrounding of buildings of the Slovak Academy of Sciences within the garden area in the western part of Bratislava
- Líštiny, vineyard – an abandoned vineyard in the garden area in the western part of Bratislava
- Medická záhrada - park, grassy plots and sparse trees and shrubs
- Notre Dam – a small plot with high trees and shrubs at the Notre Dam church
- Ondrejský cintorín – cemetery founded in 1784, used until 1950-ies, now transformed into a park, most monuments removed, grassy and sparse shrub vegetation under dense high trees
- Prior, small and large plots – two plots densely covered by thujas, at the Prior store in the Kamenné námestie square, now turned into grassy plots
- Petržalka – poplar stand – a remnant mature floodplain forest on the Danube right bank
- Sad Janka Kráľa – urban park founded in late 18th in the Danube alluvium, grassy plots and sparse shrubs under dense tree vegetation
- Šafárikovo námestie square - urban park, grassy plots and sparse trees and shrubs
- Uršulínska street– a small grassy plot along the City hall

Brno

- Břenkova street – a garden in the residential quarter founded in late 1920-ies, sparse fruit trees
- Čertova rokle and Hakenova streets– secondary tree (pines and oaks) and shrub vegetation on slopes of deep erosion rills, until early 1960-ies a military exercise area, since late 1968 a modern housing estate
- Kraví hora – a grassy plot in the extensive “Schrebergarten” colony
- Líšeňská – an apricot and apple orchard in the eastern part of the city
- Lužánky – park founded in 1780ies in the alluvium of the Ponávka creek, grassy plots and sparse shrubs and trees
- Námestí 28. října – an urban park founded in 1890-ies in the alluvium of the Ponávka creek, grassy plots and sparse shrubs and trees
- Ráječek – a remnant of a floodplain forest along the Svitava river
- Soběšice – a reed stand on shores of a small fish pound in northern part of Brno
- Špilberk southern slope –park with secondary, predominantly shrubby vegetation around the medieval fortres, up to 19th century deforested
- Špilberk northern slope - park with secondary high tree vegetation around the medieval fortres, up to 19th century deforested

RESULTS

Structure of assemblages

In all localities 162 species were recorded. They represent approximately 25 % of the species recorded in Moravia or Slovakia (HŮRKA, 1996) and most of all species known to occur in forest and non-forest ecosystems at the altitudes of 130 – 380 m or in the oak to oak-beech vegetation tier (RAUŠER & ZLATNÍK, 1966; ZLATNÍK, 1976, ŠUSTEK, 2000).

In two shore and 13 floodplain sites 9,631 individuals belonging to 113 species were caught (Annex 3). The species number in individual sites ranges from 11 to 28 (mean 24.27, s.d. 12.12, while the numbers of individuals in one-year samples move from 77 to 1962 (mean 646.07, s.d. 498.87). There are 17 species (in decreasing order of presence: *P. assimilis, P. atrorufus, P. niger, P. strenuus, C. granulatus, P. anthracinus, P. melanarius, P. nigrita, A. parallelopipedus, L. caerulescens, N. brevicollis, O. obscurus, A. moestum, A. dorsalis, B. bullatus, E. micans, P. oblongopunctatus* and *S. pumicatus*) occurring in 40.0-86.7% of sites and representing even 80,9% of all individuals. These species were eudominant or subdominant in most of sites studied. Besides it, several strongly hydrophilous species like *O. helopioides, B. biguttatum, D. globosus* or *B. peltatus* occurred abundantly at least in one site (Annex 3).

In some sites, an interference with neighboring mesohygrophilous forests or non-forest habitats exists. In all sites along the Vydrica creek it is shown first of all by the occurrence of the mesohygrophilous *A. paralelopipedus* and *P. oblongopunctatus*, while in the sites Vrakuňa oxbow and Vrakuňa forest by the open landscape species *A. dorsalis, P. rufipes* and *T. quadristriatus* (Annex 5). Other xenocoenous species occurred in shore and floodplain habitats only rarely.

In the mesohydrophilous forests 7,480 individuals belonging to 74 species were trapped (Annex 4). The species number in individual sites ranges from 5 to 27 (mean 13.8, s.d. 5.6), while numbers of individuals in one-year samples move from 21 to 1492 (mean 299.2, s.d. 303.93). 12 species (in decreasing order of presence *A. parallelopipedus, C. coriaceus, C. nemoralis, H. atratus, A. parallelus, C. hortensis, C. glabratus, C. intricatus, P. rufipes, P. diligens, C. convexus* and *C.*

ullrichi) occurred in 40-100% of sites and represented 81.2% of individuals (Annex 4). Among them, the expansive open landscape species *P. rufipes* was xenocenous in the forest-like habitats, but it was represented in them by 22 individuals only. Further strongly represented xenocoenous species were *H. tardus* and *A. saphyrea* and *A. familiaris* in Bratislava Klavária. Otherwise, open landscape species (*Harpalus* ssp. *Ophonus* spp. and *Amara* spp.) were little represented in the forest or forest-like habitats. A remarkable occurrence was seen of *A. bombarda* in Devínska Kobyla and Dúbravská hlavica because of local occurrence in Slovakia. The interference with the massive of Little Carpathians was manifested by occurrence of *P. burmeisteri, T. pilisensis, T. pulchellus, C. glabratus, C. violaceus* and *C. attenuatus* in the site at northern margin of Bratislava (Koliba, Briežky, Železná studnička).

In 25 localities without continuous tree vegetation, 1,924 individuals were recorded belonging to 80 species (Annex 5). The species number in individual sites ranged from 3 to 29 (mean 9.89, s.d. 6.40), while number of individuals from 4 to 332 (mean 75.61, s.d. 95.08). The species were very unequally represented in individual sites. Only two species (*Anchomenus dorsalis* and *Pseudoophonus rufipes*) were present in 56% of sites, next four species (*Bembidion lampros, Harpalus affinis Pterostichus melanarius, Amara aenea*) in 40-48% of sites. These six species represented altogether 58.23% of individuals (Annex 5). 12 species occurred in 20-32% of sites and represented 19.58 of individuals. In contrast, 29 species were recorded in only one site, 16 species in two localities and 12 in three localities (Annex 5). The abundance of species varied extremely, from 1 individual to several tens of individuals. This variability is best indicated by the variance coefficients ranging mostly from 1.79 to 5.0.

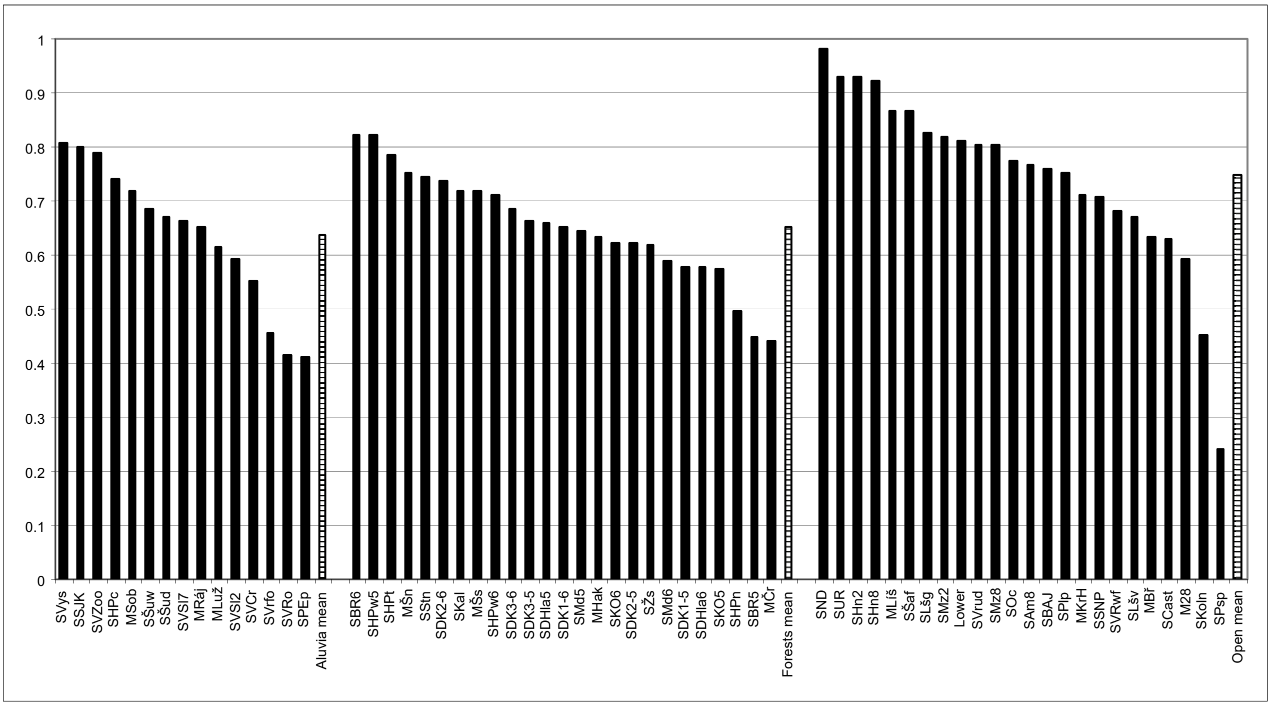

Figure. 1. Equitability of Carabit assemblages in three types of habitats in urban and suburban landscape in Bratislava and Brno (abbreviations of locality names see Annex 2).

The equitability of assemblages in all three basic habitat types differs considerably (Fig. 1), but in all types there are assemblages with balanced representation of competing species of similar ecological requirements or they represent ecotonal assemblages with more or less balanced representation of species of different ecological requirements. In particular it is visible in habitats with sparse tree vegetation or without it in the city center, where a small number of different species temporarily meets in one site. From this reason the equitability in assemblages from the city center is in general higher. However, in all three types of habitats there are assemblages with 1-2 eudominant species that successfully survive in disturbed habitats. The equitability of such assemblages is low. Examples of such assemblages are Poplar stand in Bratislava-Petržalka with eudominant *P. assimilis*, Bratislava Briežky with enormously dominant *P. diligens* Prior, small plot with increased abundance of *B. lampros.*

Classification and ordination of the assemblages

The studied assemblages form three large clusters at the similarity level 0.10, They correspond to three basic habitats type – alluvial and riparian habitats dominated by the polyhrophilous species *P. assimilis* or *A. moestum*, mesohygrophilous oak-hornbeam forests with dominance of *A. parallelopipedus* and the habitats with no or sparse tree vegetation (Fig. 2) with predominance of the expansive *P. rufipes*. The cluster of assemblages from alluvial habitats is structured according to alternative predominance of three polyhygrophious species *P. anthracinus, P. nigrita, P. atrorufus* or two less hygrophilous species *N. brevicollis* or *A. parallelus*. The assemblages from mesohygrophilous forests form smaller clusters according to predominance of *P. diligens*, species combination of *C. hortensis, C. convexus* and *A. bombarda* or combination of *C. coriaceus* and *C. nemoralis* or by exclusively predominant *A. parallelopipedus.*

The assemblages from habitats without shadowing are furthermore differentiated according to higher representation of more or less heliophilous species *B. lampros, A. dorsalis, O. signaticornis, H. affinis, H. distginguendus* and the combination of *P. griseus* and *A. dorsalis* or in places with sparse tree or shrubby vegetation by the more eurytopic species *L. ferrugineus* or *T. quadristriatus*. The southern slope of the Bratislava castle hill and two plots from Líštiny take an isolated position due to exclusive occurrence of *O. subsinuatus* and increased dominance of more eurytopic *C. fuscipes*. The clustering pattern (Fig. 2) shows that the assemblages without shadowing have much more unstable composition that those from alluvial or forest habitats.

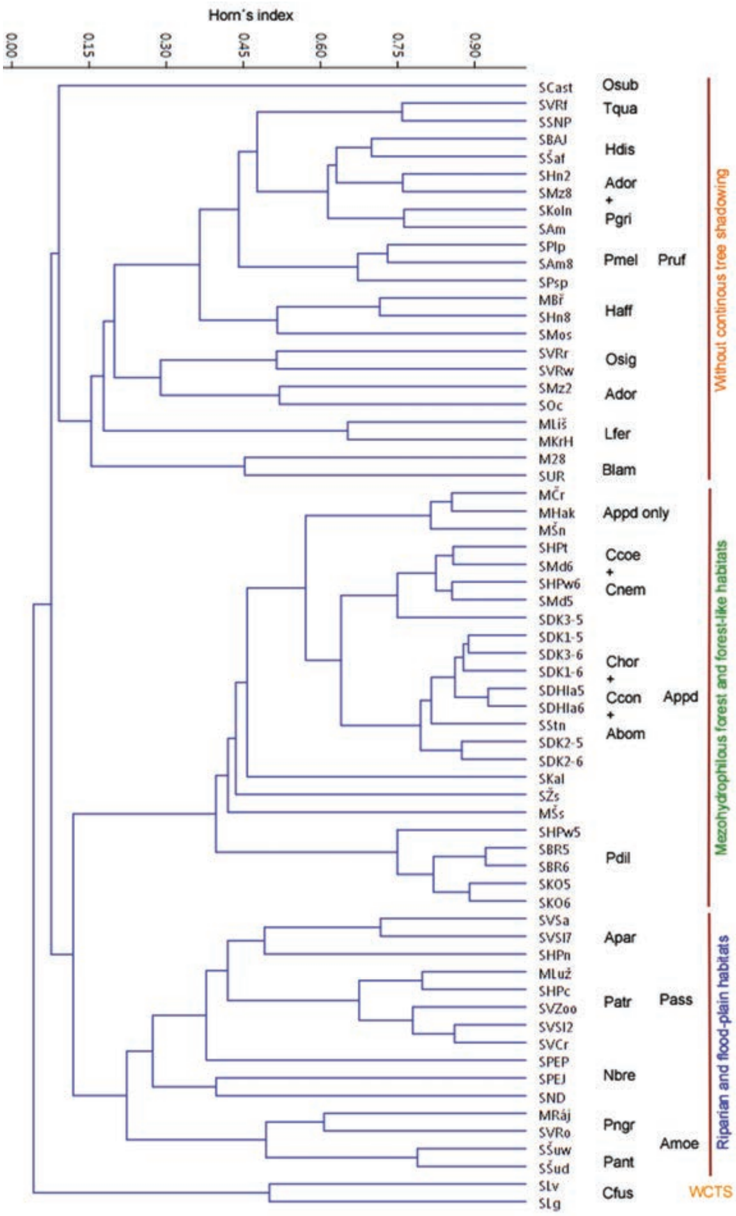

Figure 2. Hierarchical classification of Carabid assemblages in Bratislava and Brno
(for abbreviation of species names see Annex 1 and for the locality names see Annex 2).

The continuous transitions between assemblages from habitats with complete shadowing to those without shadowing in mesohygrophilous sites and between alluvial habitats are clearly shown by ordination diagrams. (Figs. 3 - 5). The principal coordinate analyses (Fig. 3) shows a stronger interference between the assemblages from the mesohygrophilous habitats with and without shadowing, whereas the direct ordination according the humidity and vegetation cover preference shows a stronger interference between the assemblages from the mezohygrophilous an alluvias habitats with shadowing (Fig. 4). In this case, four groups of assemblages can be distinguished. A very compact group of assemblages from mesohygrophilous forest or forest-like habitats is formed in the right lower corner. Two assemblages from forest habitats are shifted to left – that from southern slope of Špilberk in Brno and from Kalvária in

Bratislava. In Špilberk this shift is caused by balanced representation of two forest species *A. paralellopipedus* and *H. atratus* accompanied by several open landscape species. In Kalvária a still stronger shift is caused by high abundance of *H. tardus* and *A. saphyrea*. In the central lower part, a group of assemblages from sites with partial shadowing with trees or shrubs, where eurytopic species (*C. fuscipes, L. ferrugineus, P. melanarius*) or preferably forest species (*H. atratus, P. niger*, *C. intricatus*) are represented. In the left lower part, assemblages from the sites in the very city center or from sites with absence of wooden vegetation are concentrated (Fig. 4).

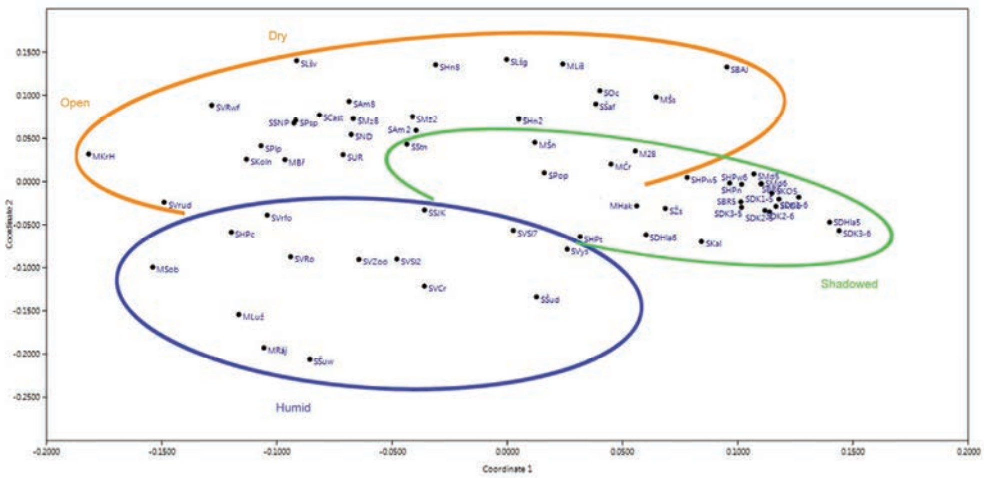

Figure 3. Principal coordinate ordination of Carabid assemblages in Bratislava and Brno according to humidity and vegetation cover preference (for abbreviation of species names see Annex 1 and for the locality names see Annex 2).

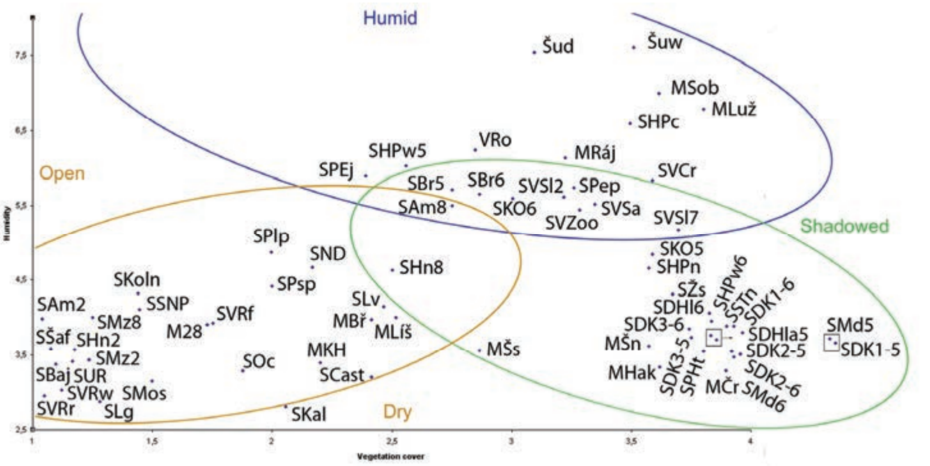

Figure 4. Direct ordination of Carabid assemblages in Bratislava and Brno according to humidity and vegetation cover preference (for abbreviation of species names see Annex 1 and for the locality names see Annex 2).

In the diagram of canonical correlation (Fig. 5) the assemblages from all three habitat types are separated in own quadrants and those from mesohygrophilous and floodplain forests are associated with coverage and to a limited degree also study plot size and altitude. However, the gradient between assemblages from floodplain and mesohygrophilous forest is more fluent.

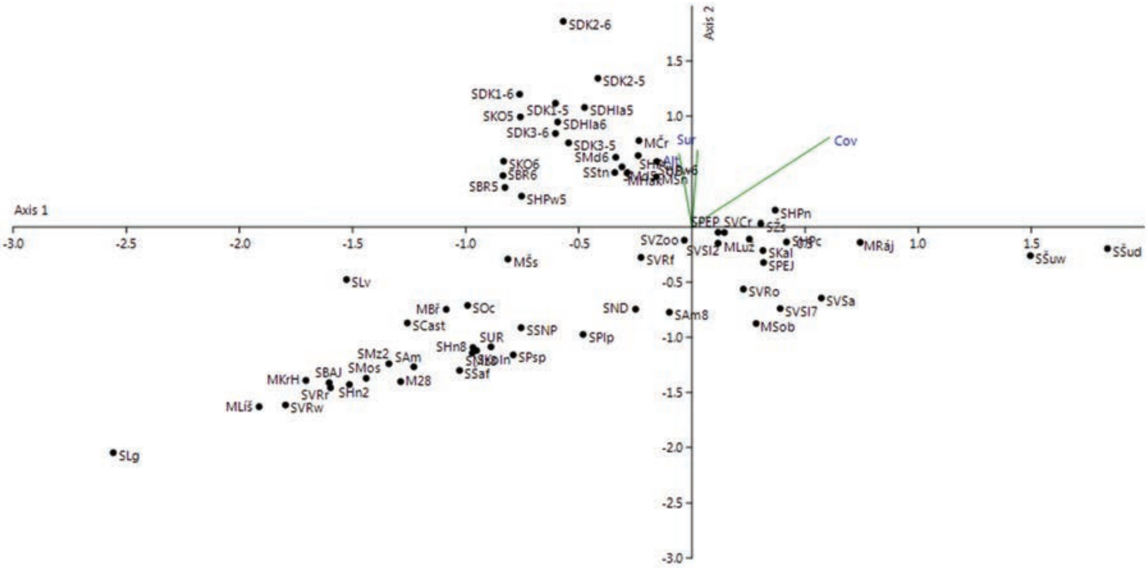

Figure 5. Canonical correlation of Carabid assemblages in Bratislava and Brno (Ar – surface of study plot, Alt – altitude, Cov – tree vegetation coverage, for abbreviation of the locality names see Annex 2).

In all ordination diagrams the dispersion of assemblages from the habitats without or with partial shadowing is larger and cluster analysis indicates a greater heterogeneity and randomness of representation of different species with similar ecological requirements.

DISCUSSION AND CONCLUSIONS

The forest stands preserving their integrity, independently on the composition of tree species and the often considerable representation of locust trees and other xenocoenous trees, offer suitable conditions for survival of most mesohygrophilous or hygrophilous forest species. These species are able to preserve or re-establish assemblages showing at least some basic features of the assemblages in natural or seminatural forest ecosystems in free landscape in Central Europe (ŠUSTEK, 1984a; 1984b, 2000). The tolerance of individuals of forest carabids is highly proportional to their quantitative representation in the natural ecosystems in corresponding conditions in free landscape in Central Europe (ŠUSTEK, 1976; 1983). Among the mesohygrophilous species the most tolerant is *A. parallelopipedus* followed by C. *coriaceus, C. hortensis, C. nemoralis* and *M. piceus,* while among the hygrophilous species in alluvia the most tolerant are *Agonum moestum, Patrobus atrorufus* and *Nebria brevicollis.*

The ability of some species of genus *Carabus* to survive in Bratislava was much higher (11 species) than in Brno (2 species), but in both cities it was much lower than in some big cities in Ukraine (PUTCHKOV et al., 2019), where even 21 species were recorded. In contrast, only two species were recorded in Berlin (DEICHSEL, 2006), one of which abundantly (*C. nemoralis*) A special case is occurrence of *C. intricatus* in both cities. It is made possible by the admirable ability of this species to overcome the vertical obstacles (ŠUSTEK, 1999b).

The composition of Carabid assemblages in the city center is predominantly regulated by several factors: absence or low density of tree or dense shrub vegetation on non built-up areas, isolation from the free landscape by different constructions, a limited area that does not allow establishment of independent prospering populations, strong dependence on spreading ability of species or more precisely ability to fly. Due to it, the Carabid assemblages in the city centers consist predominantly of the species inhabiting the arable land in city surrounding, but in some sites there is also considerably increased proportion of hygrophilous species characteristic of floodplain forests or riparian habitats. Similarly as in the forest-type urban ecosystem, the composition of the Carabid assemblages reflects the quantitative representation of individual species in the arable land. Thus the most frequent and abundant species in most parks and gardens in the city interior is *P. rufipes* showing an enormous expansivity, especially in warm evenings by turn of July and August (LINDROTH 1949; ŠUSTEK 1999a, 2014). It is followed by *A. dorsalis* and *B. lampros* or *B. properans.* However, unlike the forest type urban ecosystems, the composition of Carabid assemblages in very city center is much more variable and, due to certain degree, occasional (MAGURA et al., 2018). This variability (randomness) results from a large number of species of the genera *Ophonus* (in Central Europe 19 species, in the studied material 10 species), *Harpalus* (42/13 species) and *Amara* (52/12 species) with similar ecological requirements, but except for few almost anywhere abundant species (*O. brevicollis, H. latus, H. tardus, A. aenea, A. familiaris*) occurring locally and mostly in subdominant or subrecedent position (ŠUSTEK, 1994). For this reason, their chance to invade a site in the city centre depends on the momentary situation and local conditions. An example of their relatively high abundance is visible in just one site (Annex 5) *A. bifrons* in ruderal site at Vrakuňa, *H. rubripes* in grassy plot in Líštiny, *O. subsinuatus* in the Bratislava castle, but otherwise by a very dispersed occurrence of 1-2 individuals in all localities.

In spite of the fact that most Carabid species recorded in the very city center originate from the arable land in the city surrounding, some of such species, which reach high abundances in arable land, are rare in the city center. This is mainly valid for *P. cupreus* and *D. halensis* that are especially frequent in the fields. Similarly, the typical field species *C. auropunctatum*, recorded in more big cities in Ukraine (PUTCHKOV et al., 2019), was also found in Bratislava just in one meadow-like plot in the Bajkalská street. In general, the structure of the Carabid assemblages in center of Brno and Bratislava was most similar to that published recently by NIKOLENKO (2018) from Kharkov. In contrast, there was a considerable similiratity between the assemblages from alluvial sites in Bratislava and Brno and those from Berlin (DEICHSEL, 2006), which were also collected in habitates close to rivers.

A completely unique case was two small plots in the Kamenné námestie square in Bratislava at the Prior supermarket (now Tesco), where a surprisingly high number of *P. melanarius* and *P. niger* occurred under a dense stand of thuja. Both species are known to inhabit the floodplain forests and to change there suddenly their density according to momentary changing humidity conditions (ŠUSTEK, 1993). *P. niger* also quickly colonizes the reed stands shortly after longtermed flooding, where it co-occurs with so prominently hydrophilous species like *C. clathratus* (ŠUSTEK, 2010).

A significant feature was the recording of rare species in higly altered habitats, like *A. gracilipes* in Bratislava Americké námestie or *D. dentata* in the waste dump in Bratislava Vrakuňa (Annex 5), or *C. vaporariorum* and *C. cingulata* and specialized *C. clathratus* in seminatural forests and in the suburban zone (Annex 3 and 4).

In general it can be stated that even the intensively exploited and disturbed urban landscape is still able to preserve conditions for the long-term or at least temporary survival of a rich Carabid fauna.

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Zbyšek Šustek
Institute of Zoology, Slovak Academy of Sciences, Dúbravská cesta 9, 845 06 Bratislava, Slovakia.
E-mail: zbysek.sustek@savba

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Annex 1. Complete names of species, their abbreviations (A) and characteristics preference for humidity (H – 1 xerophilous, 8 – hygrophilous) and vegetation cover (V - 1 open landscape, 4 forests with continuous tree canopy).

Species	A	H	V	Species	A	H	V
Abax parallelopipedus (Paller et Mitterpacher, 1783)	*Appd*	3	4	*Europhilus piceus* (Linnaeus, 1758)	*Epic*	8	4
Abax parallelus (Duftschmidt, 1812)	*Apar*	4	4	*Harpalus affinis* (Schrank, 1781)	*Haff*	3	1
Acupalpus flavicollis (Sturm, 1825)	*Afla*	6	1	*Harpalus atratus* Latreille, 1804	*Hatr*	4	4
Acupalpus interstitialis Reitter, 1884	*Aint*	6	1	*Harpalus distinguendus* (Duftschmidt, 1812)	*Hdis*	3	1
Acupalpus meridianus (Linnaeus, 1767)	*Amer*	6	1	*Harpalus honestus* (Duftschmidt, 1812)	*Dhon*	4	1
Acupalpus mixtus (Herbst, 1784)	*Amix*	6	1	*Harpalus latus* (Linnaeus, 1758)	*Hlat*	4	1
Agonum gracilipes (Duftschmidt, 1812)	*Agra*	3	2	*Harpalus luteicornis* (Duftschmidt, 1812)	*Hlut*	5	1
Agonum moestum (Duftschmidt, 1812)	*Amoe*	8	4	*Harpalus picipennis* (Duftschmidt, 1812)	*Hpic*	3	1
Agonum muelleri (Herbst, 1784)	*Amue*	7	2	*Harpalus quadripunctatus* Dejean, 1812)	*Hqua*	5	4
Amara aenea (De Geer, 1774)	*Aaen*	3	1	*Harpalus rubripes* (Duftschmidt, 1812)	*Hrub*	2	1
Amara apricaria (Paykull, 1790)	*Apr*	3	1	*Harpalus serripes* (Quensel in Schönherr, 1806)	*Hser*	2	1
Amara aulica (Panzer, 1797)	*Aaul*	3	1	*Harpalus smaragdinus* (Duftschmidt, 1812)	*Hsma*	4	1
Amara bifrons (Gyllenhal, 1810)	*Abif*	3	1	*Harpalus tardus* (Panzer,1797)	*Htar*	2	1
Amara communis (Panzer, 1797)	*Acom*	3	1	*Harpalus vernalis* (Fabricius, 1801)	*Hver*	2	1
Amara consularis (Duftschmidt, 1812)	*Acon*	3	1	*Chlaenius nigricornis* (Fabricius, 1787)	*Chni*	8	5
Amara convexiuscula (Marsham, 1802)	*Acnv*	3	1	*Chlaenius vestitus* (Paykull, 1790)	*Chve*	8	8
Amara cursitans (Zimmermann, 1831)	*Acur*	3	1	*Laemosthenus terricolla* (Herbst, 1784)	*Lter*	4	2
Amara erratica (Duftschmidt, 1812	*Aerr*	3	1	*Lasiotrechus discus* (Fabricius, 1792)	*Ldis*	6	5
Amara familiaris (Duftschmidt, 1812)	*Afam*	3	1	*Leistus ferrugineus* (Linnaeus, 1758)	*Lfer*	4	3
Amara ovata (Fabricius, 1792)	*Aova*	3	1	*Leistus piceus* Fröhlich, 1799	*Lpic*	6	4
Amara saphyrea Dejean, 1828	*Asap*	3	1	*Leistus rufomarginatus* (Duftschmidt, 1812)	*Lruf*	5	4
Anchomenus dorsalis (Pontoppidan, 1763)	*Ador*	3	1	*Licinus cassideus* (Fabricius, 1792)	*Lcas*	1	1
Anisodactylus binotatus (Fabricius, 1792)	*Abin*	6	1	*Licinus depressus* (Paykull, 1790)	*Ldep*	2	1
Anisodactylus signatus (Panzer, 1797)	*Asig*	5	1	*Lorocera caerulescens* (Fabricius, 1775)	*Lcae*	4	2
Aptinus bombarda (Illiger, 1800)	*Abom*	3	4	*Microlestes maurus* (Sturm, 1827)	*Mmau*	2	1
Asaphidion flavipes (Linnaeus. 1758)	*Aflv*	6	4	*Microlestes plagiatus* (Duftschmidt, 1812)	*Mpla*	2	1
Badister bullatus (Schrank, 1798)	*Bbul*	5	2	*Molops elatus* (Fabricius, 1801)	*Mela*	5	4
Badister meridionalis (Puel,1925)	*Bmer*	6	2	*Molops piceus* (Panzer, 1793)	*Mpic*	4	4
Badister peltatus (Panzer, 1797)	*Bpel*	8	2	*Nebria brevicollis* (Fabricius, 1792)	*Nbre*	6	2
Badister sodalis (Duftschmidt, 1812)	*Bsod*	7	2	*Notiophilus biguttatus* (Fabricius, 1799	*Nbig*	4	2
Badister unipustulatus (Bonelli, 1813)	*Buni*	7	2	*Notiophilus palustris* (Duftschmidt, 1812)	*Npal*	4	2
Bembidion articulatum (Panzer, 1796)	*Bart*	8	5	*Notiophilus rufipes* Curtis, 1829	*Nruf*	4	2
Bembidion biguttatum (Fabricius, 1779)	*Bbig*	8	4	*Oodes gracilis* A. et G. B. Villa, 1833)	*Ogra*	8	2
Bembidion dentellum (Thunberg, 1787)	*Bden*	8	5	*Oodes helopioides* (Fabricius, 1792)	*Ohel*	8	2
Bembidion inoptatum (Schaum, 1857)	*Bino*	8	1	*Ophonus azureus* (Fabricius,1775)	*Oazu*	2	1
Bembidion lampros (Herbst, 1784)	*Blam*	3	1	*Ophonus brevicollis* Audinet-Serville, 1821	*Obre*	3	1
Bembidion minimum (Fabricius, 1792)	*Bmin*	8	5	*Ophonus cordatus* (Duftschmidt,1812)	*Ocor*	3	1
Bembidion nitidulum (Marsham, 1822)	*Bnit*	8	5	*Ophonus gammeli* Schauberger, 1832)	*Ogam*	3	1
Bembidion properans (Stephens, 1828)	*Bpro*	3	1	*Ophonus punctatulus* (Duftschmidt,1812)	*Opun*	2	1
Bembidion punctulatum Drapez, 1821	*Bpun*	8	5	*Ophonus puncticollis* (Paykull, 1793)	*Opcp*	2	1
Bembidion tetracolum (Say, 1823)	*Btet*	5	5	*Ophonus rupicola* Sturm, 1818	*Opcl*	2	1
Bembidion ustulatum (Linnaeus, 1758)	*Btet*	8	5	*Ophonus seladon* Schauberger, 1928	*Osel*	2	1
Bembidion varium (Olivier, 1795)	*Bvar*	8	5	*Ophonus signaticornis* (Duftschmidt,1812)	*Osig*	2	1
Bradycellus collaris (Paykull, 1798)	*Bcol*	3	1	*Ophonus subsinuatus* Rey 1886	*Osub*	2	1
Brachynus crepitans (Linnaeus, 1758)	*Bcre*	3	1	*Oxypselaphus obscurus* (Herbst, 1784)	*Oobs*	7	4
Brachynus explodens Duftschmidt, 1812	*Bexp*	3	1	*Panageus bipustulatus* (Fabricius, 1775)	*Pbip*	6	1
Broscus cephalotes (Linnaeus, 1758)	*Bcep*	3	1	*Paranchus alpipes* (Fabricius, 1796)	*Palb*	8	5
C.arabus clathratus Linnaeus, 1761)	*Ccla*	8	2	*Patrobus atrorufus* (Stroem, 1768)	*Patr*	7	4
Carabus.convexus Fabricius, 1775	*Ccon*	4	4	*Platyderus rufus* (Duftschmidt, 1812)	*Pruf*	3	4
Carabus coriaceus Linnaeus, 1758	*Ccor*	5	4	*Platynus assimilis* (Paykull, 1790)	*Pass*	7	4
Carabus glabratus Paykull, 1790	*Cgla*	5	4	*Platynus krynickyi* (Sperk, 1835)	*Pkry*	8	4
Carabus granulatus Linnaeus. 1758	*Cgra*	7	2	*Platynus livens* (Gyllenhal, 1810)	*Pliv*	8	4
Carabus hortensis Linnaeus, 1758	*Chor*	4	4	*Poecilus cupreus* (Linnaeus, 1758)	*Pcup*	4	1
Carabus intricatus Linnaeus, 1761	*Cint*	4	4	*Poecilus punctulatus* (Schaller, 1783)	*Punc*	2	1
Carabus nemoralis O. F. Mueller, 1764	*Cnem*	4	4	*Poecilus serriceus* (Fischer, 1824)	*Pser*	2	1
Carabus scheidleri Letzner, 1850	*Csch*	5	4	*Pseudoophonus griseus* (Panzer, 1797)	*Pgri*	3	1
Carabus ullrichi Germar, 1824	*Cull*	4	4	*Pseudoophonus rufipes* (De Geer, 1774)	*Pruf*	4	1
C.arabus violaceus Linnaeus, 1758	*Cvio*	5	4	*Pterostichus anthracinus* (Illiger, 1798)	*Pant*	8	4
Calathus erratus (C. R. Sahlberg, 1827)	*Cerr*	4	2	*Pterostichus burmeisteri* Heer, 1838)	*Pbur*	5	4
Calathus fuscipes (Goeze, 1777)	*Cfus*	4	2	*Pterostichus diligens* (Sturm, 1824)	*Pdil*	7	2
Calathus melanocephalus (Linnaeus, 1758)	*Cmel*	4	2	*Pterostichus macer* (Marsham, 1802)	*Pmac*	4	1
Calosoma auropunctatum (Herbst, 1784)	*Caur*	4	4	*Pterostichus melanarius* (Illiger, 1798)	*Pmel*	5	2

Annex 1. Continuation

Species	A	H	V	Species	A	H	V
Calosoma inquisitor Linnaeus, 1758	*Cinq*	4	4	*Pterostichus minor* (Gyllenhal, 1827)	*Pmiin*	8	5
Cicindela germanica Linnaeus, 1758	*Cger*	3	1	*Pterostichus niger* (Schaller, 1783)	*Pnig*	6	4
Clivina collaris (Herbst, 1784)	*Ccol*	6	2	*Pterostichus nigrita* (Fabricius, 1792)	*Pngr*	8	2
Clivina fossor (Linnaeus, 1758)	*Cfos*	6	4	*Pterostichus oblongopunctatus* (Fabricius, 1787)	*Pobl*	5	4
Cychrus attenuatus (Fabricius, 1792)	*Catt*	5	4	*Pterostichus ovoideus* (Sturm, 1824)	*Povo*	4	2
Cymindis axillaris (Fabricius, 1794)	*Caxi*	2	1	*Pterostichus pumilio* (Dejean, 1828)	*Ppum*	5	4
Cymindis cingulata (Dejean, 1825)	*Ccin*	2	1	*Pterostichus strenuus* (Panzer, 1797)	*Pstr*	7	2
Cymindis humeralis (Fourcroy, 1785)	*Chum*	3	4	*Pterostichus vernalis* (Panzer, 1796)	*Pver*	8	5
Cymindis vaporariorum (Linnaeus, 1758)	*Cvap*	2	1	*Stomis pumicatus* (Panzer, 1796)	*Spum*	6	2
Demetrias monostigma (Samuelle, 1819)	*Dmon*	8	1	*Syntomus pallipes* (Dejean, 1825)	*Spal*	5	1
Dolichus halensis (Schaller, 1783)	*Dhal*	4	1	*Syntomus truncatellus* (Linnaeus, 1761)	*Stru*	4	1
Dromius linearis (Olivier, 1795)	*Dlin*	4	1	*Synuchus vivalis* (Illiger, 1798)	*Sviv*	4	2
Dromius quadrimaculatus (Linnaeus, 1758)	*Dqua*	4	1	*Trechoblemus micros* Herbst, 1784)	*Tmic*	4	2
Drypta dentata (Rossi, 1790)	*Dden*	8	5	*Trechus pilisensis* Csiki, 1918	*Tpil*	5	4
Dyschirius globosus (Herbst, 1783)	*Dglo*	8	5	*Trechus pulchelus* Putzeys, 1846	*Tpul*	5	4
Elaphrus cupreus Duftschmidt, 1812	*Ecup*	8	2	*Trechus quadristriatus* (Schrank, 1781)	*Tqua*	4	1
Elaphrus uliginosus (Fabricius, 1792)	*Euli*	8	5	*Trichocellus placidus* (Gyllenhal, 1827)	*Tpla*	7	4
Europhilus fuliginosus (Panzer, 1809)	*Eful*	8	4	*Trichotichnus laevicollis* (Duftschmidt, 1812)	*Tlae*	5	4
Europhilus micans (Nicolaj, 1822)	*Emic*	7	4	*Zabrus tenebrionides* (Goeze, 1777)	*Zten*	3	1

Annex 2. Names, abbreviations and basic characteristics of the study plots in Bratislava (S) and Brno (M) (Ar – area in hectars, Alt – altitude in m, D – density of trre cover in %, V – vegetation type [R – riparian, A – flodplain forests, G – garden, O – plots without wooden plamt, P – urban parks], S – slope in º, E/S - exposition or shadowing by close high buildings [E – East, S – South, W – west, N – North], end year of collecting.

Locality	Abbrev.	Coordinates	Ar	Alt	D	V	S	E/S	Years
M Soběšice	MSob	N 49°14.272' E 16°36.394'	4,41	282	70	R	15	S	1973
S Vrakuňa oxbow	SVRo	N 48°09.605' E 17°13.257'	0,00	131	0	R	20	W	1982
M Lužánky	MLuž	N 49°12.342' E 16°36.594'	20,95	207	75	A	2	S	1977
M Ráječek	MRáj	N 49°09.898' E 16°38.764'	15,01	194	100	A	1	S	1973
S Jurský Šúr dry	SŠud	N 48°13.920' E 17°12.757'	1,20	130	100	A	1	E	1988
S Jurský Šúr wet	SŠuw	N 48°14.003' E 17°12.833'	0,80	130	100	A	1	E	1988
S Vydrica sanatory	SVSa	N 48°12.201' E 17°05.775'	0,60	258	100	A	5	S	1982
S Vydrica ZOO	SVZoo	N 48°09.512' E 17°04.541'	0,09	160	40	A	5	S	1982
S Vydrica Slovák	SVSl	N 48°09.259' E 17°04.539'	0,08	150	90	A	5	S	1982, 1987
S Vydrica crossing	SVCr	N 48°08.861' E 17°04.539'	0,06	142	30	A	5	S	1982
S Horský park creek	SHPc	N 48°09.594' E 17°05.296'	1,50	196	100	A	5	W	1982
S Vrakuňa forest	SVRf	N 48°09.617' E 17°13.303'	13,50	132	80	A	1	N	1982
S Petržalka SJK park	SPEJ	N 48°08.131' E 17°06.575'	20,61	137	60	A	1	E	1982
S Petržalka poplar stand	SPEP	N 48°08.176' E 17°07.195'	5,51	136	90	A	1	E	1982
M Čertova rokľa	MČr	N 49°13.652' E 16°37.536'	3,16	268	90	F	10	S	1978
M Hakenova	MHak	N 49°13.776' E 16°37.506'	4,20	273	90	F	10	S	1978
S Horský park top	SHPt	N 48°09.367' E 17°05.555'	23,80	255	100	F	20	S	1982
S Horský park north	SHPn	N 48°09.444' E 17°05.568'	23,80	220	100	F	20	N	1982
S Horský park west	SHPw	N 48°09.600´ E 17°05.217´	23,80	212	100	F	15	SE	1982
S Mlynská dolina	SMd	N 48°09.650´ E17°04.683´	4,12	190	100	F	45	W	2005, 2006
S Briežky	SBr	N 48°10.967´ E 17°06.666	7,50	340	100	F	10	SE	2005, 2006
S Koliba	SKO	N 48°10.550´ E 17°05.0833	6,09	380	100	F	2	SW	2005, 2006
S Devínska Kobyla 1	SDK1	N 48°11.083´ E 16°59.833´	69,00	340	100	F	15	S	2005, 2006
S Devínska Kobyla 2	SDK2	N 48°11.933´ E 16°59.583´	69,00	300	100	F	10	N	2005, 2006
S Devínska Kobyla 2	SDK3	N 48°11.233´ E 16°59.555´	69,00	452	100	F	2	S	2005, 2006
S Dúbravská Hlavica	SDHla	N 48°11.100´ E 17°00.750´	17,90	350	100	F	5	E	2005, 2006
S Kalvária	SKal	N 48°09.667' E 17°05.967'	4,98	225	100	F	40	S	1982
S Železná studnička	SŽs	N 48°11.754´ E 17°05.863´	3,50	199	100	F	35	E	1982
S Sitina	SStn	N 48°09.667' E 17°05.967'	5,03	244	95	F	5	E	1982
M Břenkova	MBř	N 49°12.763' E 16°37.281'	0,70	242	20	G	0	N	1980
M Líšeňská	MLíš	N 49°11.741' E 16°39.443'	1,30	255	20	G	5	N	1980
M Kraví Hora	MKrH	N 49°12.207' E 16°35.018'	3,70	292	20	G	2	S	1980
S Vrakuňa ruderal	SVRr	N 48°09.681' E 17°13.282'	0,03	132	0	O	5	S	1982
S Vrakuňa wheat field	SVRw	N 48°09.545' E 17°13.347'	0,50	132	0	O	1	N	1982

S Bajkalská str.	SBAJ	N 48°09.351' E 17°08.839'	2,78	135	0	O	1	W	1982
S Líštiny vineyeard	SLv	N 48°09.794' E 17°03.915'	0,39	227	15	O	1	E	1988
S Líštiny grassy plot	SLg	N 48°09.776' E 17°03.952'	0,11	224	0	O	1	E	1988
M Námestie 28. října sqr.	M28	N 49°12.155' E 16°36.779'	2,07	208	10	P	0	E	1978
M Špilberk south	MŠs	N 49°11.599' E 16°36.006'	1,53	271	15	P	35	S	1978
M Špilberk north	MŠn	N 49°11.734' E 16°36.006'	1,08	255	40	P	50	N	1978
S Castle	SCast	N 48°08.480' E 17°06.202'	0,25	148	30	P	40	S	1982
S Hlavné námestie sqr.	SHn	N 48°08.608' E 17°06.512'	0,16	140	10	P	1	N	1982, 1988
S Uršulínska str.	SUR	N 48°08.700' E 17°06.544'	0,03	140	5	P	1	NE	1982
S Notre Dam	SND	N 48°08.502' E 17°06.625'	0,04	139	20	P	1	NW	1982
S Nám. SNP sqr.	SSNP	N 48°08.760' E 17°06.569'	0,29	142	15	P	5	E	1982
S Kollárovo námestie sqr.	SKoln	N 48°08.983' E 17°06.763'	0,95	145	15	P	3	E	1982
S Prior large plot	SPlp	N 48°08.677' E 17°06.818'	0,00	139	60	P	1	NW	1982
S Prior small plot	SPs	N 48°08.689' E 17°06.815'	0,00	139	50	P	1	NW	1982
S Americké námestie sqr.	SAm	N 48°09.089' E 17°07.103'	0,23	140	20	P	1	S	1982, 1988
S Medická záhrada park	SMz	N 48°08.966' E 17°07.126'	3,27	140	20	P	1	N	1982, 1988
S Šafárikovo námestie sqr.	SŠaf	N 48°08.501' E 17°06.965'	0,20	138	10	P	1	S	1982
S Ondrejský cintorín cemetery	SOc	N 48°08.892' E 17°07.334'	6,58	139	40	P	1	N	1988
S Moskovská str.	SMos	N 48°09.122' E 17°07.227'	0,10	139	15	P	1	S	1988

Annex 3. Survey of species (arranged descendently according to presence) recorded in riparian and floodplain forest habitats in Brno and Bratislava (for site abreviations see tab. 1. P – presence in %. – sum of individuals. D – dominance in %.F – frequency. S.D. – standard deviation of number of individuals. V – coeficient of variance of number of individuals).

	MSob	**SVox**	**MLuž**	**MRáj**	**SŠuw**	**SŠud**	**SVys**	**SVyzo**	**SVySl2**	**SVySl7**	**SVyCr**	**SHPc**	**SVRf**	**SPEj**	**SPEp**	**P**	**S**	**D**	**F**	**S. D.**	**V**
P. assimilis		1	952	79	32	1	85	51	40	17	205	294		6	30	86.7	1793	18.6	119.5	466.5	3.9
P. atrorufus	27	113	689	378	67	14	84	67	14	1	79	381				80.0	1914	19.9	127.6	537.8	4.2
P. niger	141	5	15	20	27	13	14	22	10		18	10	1			80.0	296	3.1	19.7	82.0	4.2
P. strenuus	2	32	12	25	19	14			1	2		5	6	1	5	80.0	124	1.3	8.3	38.4	4.6
C. granulatus	13	2	3	14	173	315		3				3	1	1		66.7	528	5.5	35.2	177.9	5.1
P. anthracinus	1	57	4	8	122	113	24			1		11				60.0	341	3.5	22.7	108.3	4.8
P. melanarius		2	112	5			12	104	15		43	6	12			60.0	311	3.2	20.7	93.6	4.5
P. nigrita	22	38	27	32	44	13	86		4			27				60.0	293	3.0	19.5	90.7	4.6
A. parallelopipedus			12				11	35	33	12	93	6	76			53.3	278	2.9	18.5	78.9	4.3
L. caerulescens		2	11	18	6				3		2		1	2		53.3	45	0.5	3.0	20.3	6.8
N. brevicollis			1				6	25	24	4	53	162		113		53.3	388	4.0	25.9	113.8	4.4
O. obscurus		1	8	1	16	10					5	2			4	53.3	47	0.5	3.1	19.6	6.3
A. moestum	71	86		139	399	143	3						2			46.7	843	8.8	56.2	296.3	5.3
A. dorsalis		39	3							4	5		28	5	2	46.7	86	0.9	5.7	28.6	5.0
B. bullatus		8				1		1	1	2		1	33			46.7	47	0.5	3.1	19.7	6.3
E. micans		2		43	4	10	3		1					1		46.7	64	0.7	4.3	23.1	5.4
P. oblongopunctatus			1		1		257	6		71	18	13				46.7	367	3.8	24.5	126.2	5.2
S. pumicatus					2	2	3		4			2	9			40.0	22	0.2	1.5	12.5	8.5
A. flavipes		4	5										2	20	7	33.3	38	0.4	2.5	15.2	6.0
B. lampros		7	7		1								16	1		33.3	32	0.3	2.1	14.5	6.8
L. ferrugineus		2	17	1	1								3			33.3	24	0.2	1.6	13.8	8.6
P. ovoideus		1	7	4					1				1			33.3	14	0.1	0.9	12.9	13.8
S. pallipes		8	1										31	2	1	33.3	43	0.4	2.9	18.1	6.3
A. parallelus	1						5					10			4	26.7	20	0.2	1.3	9.6	7.2
B. sodalis		3		4	8	5										26.7	20	0.2	1.3	10.1	7.6
B. biguttatum		3	3	2	83											26.7	91	0.9	6.1	42.0	6.9
C. coriaceus								2			7	10			5	26.7	24	0.2	1.6	9.8	6.2
D. globosus		1		10	9	5										26.7	25	0.3	1.7	11.1	6.6
H. tardus							2					10	8		1	26.7	21	0.2	1.4	9.7	6.9
O. helopioides	12	3			14	51										26.7	80	0.8	5.3	30.0	5.6
O. brevicollis		8	1										19		2	26.7	30	0.3	2.0	12.9	6.4
P. rufipes		2	4										63		5	26.7	74	0.8	4.9	31.5	6.4
P. pumilio		3									1		27	3		26.7	34	0.4	2.3	14.5	6.4
T. quadristriatus		40		3								19	123			26.7	185	1.9	12.3	74.5	6.0
A. binotatus											1	1	1			20.0	3	0.0	0.2	7.1	35.3
B. peltatus					4	18				1						20.0	23	0.2	1.5	9.8	6.4
B. dentellum		9		1										4		20.0	14	0.1	0.9	8.2	8.8

B. ustulatum			50							2		12				20.0	64	0.7	4.3	23.8	5.6
B. explodens		2											54		1	20.0	57	0.6	3.8	26.0	6.8
C. hortensis							2	48			1					20.0	51	0.5	3.4	22.3	6.5
C. collaris		6							8			1				20.0	15	0.2	1.0	7.9	7.9
C. fossor		10								2			1			20.0	13	0.1	0.9	8.0	9.2
E. fuliginosus	37				2	7										20.0	46	0.5	3.1	17.3	5.6
H. luteicornis		1					1					1				20.0	3	0.0	0.2	7.6	37.9
P. bipustulatus		3											10		3	20.0	16	0.2	1.1	7.8	7.3
P. krynickyi		1			24	82										20.0	107	1.1	7.1	43.3	6.1
P. cupreus		1					3						2			20.0	6	0.1	0.4	7.2	18.1
P. minor		2		1		13										20.0	16	0.2	1.1	8.2	7.7
A. meridianus						1							1			13.3	2	0.0	0.1	5.0	37.4
A. mixtus		1			1											13.3	2	0.0	0.1	5.4	40.8
A. muelleri			1	1												13.3	2	0.0	0.1	6.0	45.3
A. aulica		44											8			13.3	52	0.5	3.5	20.7	6.0
A. familiaris									1			3				13.3	4	0.0	0.3	4.8	18.0
B. meridionalis					1	2										13.3	3	0.0	0.2	4.9	24.3
B. unipustulatus		1				12										13.3	13	0.1	0.9	6.2	7.2
B. articulatum		1	1													13.3	2	0.0	0.1	6.0	45.3
B. inoptatum				1								2				13.3	3	0.0	0.2	5.3	26.3

Annex 3. Continuation.

	MSob	**SVox**	**MLuž**	**MRáj**	**SŠuw**	**SŠud**	**SVys**	**SVyzo**	**SVySl2**	**SVySl7**	**SVyCr**	**SHPc**	**SVRf**	**SPEj**	**SPEp**	**P**	**S**	**D**	**F**	**S. D.**	**V**
B. nitidulum												5	2			13.3	7	0.1	0.5	4.7	10.1
B. crepitans		1											3			13.3	4	0.0	0.3	5.1	19.2
C. nemoralis							10	8								13.3	18	0.2	1.2	6.5	5.4
C. violaceus											2				2	13.3	4	0.0	0.3	4.8	17.8
C. fuscipes											4		45			13.3	49	0.5	3.3	21.8	6.7
C. melanocephalus		2											2			13.3	4	0.0	0.3	5.2	19.5
D. monostigma		1											1			13.3	2	0.0	0.1	5.4	40.8
E. cupreus				126			57									13.3	183	1.9	12.2	75.4	6.2
E. uliginosus					16	9										13.3	25	0.3	1.7	8.9	5.4
H. atratus											1		1			13.3	2	0.0	0.1	5.0	37.4
Ch. nigricornis		1											2			13.3	3	0.0	0.2	5.3	26.3
L. discus		4	1													13.3	5	0.1	0.3	5.8	17.3
N. biguttatus													1	1		13.3	2	0.0	0.1	5.0	37.4
N. rufipes														1	1	13.3	2	0.0	0.1	5.0	37.4
O. gracilis		2				1										13.3	3	0.0	0.2	5.4	26.9
P. albipes			3			2										13.3	5	0.1	0.3	5.2	15.6
P. livens					1	47										13.3	48	0.5	3.2	22.4	7.0
P. punctulatus		1											1			13.3	2	0.0	0.1	5.4	40.8
P. diligens	17					5										13.3	22	0.2	1.5	8.8	6.0
P. vernalis					8	15										13.3	23	0.2	1.5	8.3	5.4
A. interstitialis												3				6.7	3	0.0	0.2	2.5	12.5
A. aenea										3						6.7	3	0.0	0.2	2.5	12.5
A. apricaria													1			6.7	1	0.0	0.1	2.7	40.0
A.convexiuscula													1			6.7	1	0.0	0.1	2.7	40.0
A. saphyrea												2				6.7	2	0.0	0.1	2.5	19.0
B. minimum					1											6.7	1	0.0	0.1	2.7	40.0
B. properans													15			6.7	15	0.2	1.0	7.0	7.0
B. punctulatum					1											6.7	1	0.0	0.1	2.7	40.0
B. tetracolum					3											6.7	3	0.0	0.2	2.5	12.5
B. collaris													1			6.7	1	0.0	0.1	2.7	40.0
C. clathratus					14											6.7	14	0.1	0.9	6.5	7.0
C. ullrichi													1			6.7	1	0.0	0.1	2.7	40.0
C. erratus													2			6.7	2	0.0	0.1	2.5	19.0
C. attenuatus							1									6.7	1	0.0	0.1	2.7	40.0
C. axillaris							2									6.7	2	0.0	0.1	2.5	19.0
D. linearis		1														6.7	1	0.0	0.1	3.0	45.3

D. quadrimaculatus			4													6.7	4	0.0	0.3	2.9	11.0
E. piceus				1												6.7	1	0.0	0.1	3.0	45.3
H. honestus													1			6.7	1	0.0	0.1	2.7	40.0
H. latus													1			6.7	1	0.0	0.1	2.7	40.0
H. serripes		1														6.7	1	0.0	0.1	3.0	45.3
Ch. vestitus		3														6.7	3	0.0	0.2	2.9	14.4
L. terricolla													5			6.7	5	0.1	0.3	2.8	8.3
L. piceus							1									6.7	1	0.0	0.1	2.7	40.0
L. rufomarginatus												1				6.7	1	0.0	0.1	2.7	40.0
L. depressus													2			6.7	2	0.0	0.1	2.5	19.0
M. maurus														1		6.7	1	0.0	0.1	2.7	40.0
N. palustris					2											6.7	2	0.0	0.1	2.5	19.0
O. azureus													1			6.7	1	0.0	0.1	2.7	40.0
O. punctatulus			6													6.7	6	0.1	0.4	3.3	8.2
O. rupicola				1												6.7	1	0.0	0.1	3.0	45.3
O. seladon			1													6.7	1	0.0	0.1	3.0	45.3
P. rufus															4	6.7	4	0.0	0.3	2.6	9.7
P. burmeisteri							45									6.7	45	0.5	3.0	22.8	7.6
S. vivalis							1									6.7	1	0.0	0.1	2.7	40.0
T. pillisensis												25				6.7	25	0.3	1.7	12.2	7.3
Species	11	50	30	25	32	28	24	12	15	13	17	29	47	15	16		123				
Individuals	344	572	1962	918	1106	924	718	372	160	122	538	1028	628	162	77		9631				

Annex 4. Survey of species (arranged desccendently according to presence) recorded in the mesohygrophilous forest-like habitats in Brno and Bratislava (for site abbreviations see tab. 1, P – presence in %, – sum of individuals, D – dominance in %, F – frequency, S.D. – standard deviation of number of individuals, V – coefficient of variance of number of individuals).

	MČr	MHak	SHPt	SHPn	SHPw5	SHPw6	SMd5	SMd6	SBR5	SBR6	SKO5	SKO6	SDK1-5	SDK1-6	SDK2-5	SDK2-6	SDK3-5	SDK3-6	SDHla5	SDHla6	SKal	SŽs	SStn	MŠpn	MŠps	P	S	D	F	S. D.	V
A. parallelopipedus	120	67	104	9	10	12	20	63	25	38	9	6	87	61	183	200	51	54	107	118	135	45	392	15	20	100	1951	26.1	78.0	85.3	1.1
C. coriaceus			16	2	9	10	3	11	1	10	7	7	5	5	10	4	5	7	11	10	8	2	73			84	216	2.9	8.6	14.1	1.6
C. nemoralis			26	3	10	11	24	8	5	3	13	18	13	12	35	19	37	12	37	15	43	63	130			84	537	7.2	21.5	27.6	1.3
H. atratus		1	11	1	1	3	16	19	4	1	2	1	1	7	2	4	48	14			2	4	125		24	84	291	3.9	11.6	26.0	2.2
A. parallelus	33	4	9	37		1				1			1	1	36	21			19	15		40	8			56	226	3.0	9.0	13.7	1.5
C. hortensis									17	172	56	83	71	163	35	155	28	82	116	199		5	449			56	1631	21.8	65.2	102.6	1.6
C. glabratus									1	4	36	33	4	10	10	6			12	19		39	1			48	175	2.3	7.0	12.0	1.7
C. intricatus								3		2		6	2	2	4	2		3	1		3		9	1		48	38	0.5	1.5	2.2	1.5
P. rufipes	1		4			1				1			2	1	3	1	2	1				2	3			48	22	0.3	0.9	1.2	1.3
P. diligens					86		1		88	297	32	162	5			3	4	9	3	38						48	728	9.7	29.1	68.0	2.3
C. convexus								1					11	11	24	15	2	3	7	1			1			40	76	1.0	3.0	6.0	2.0
C. ullrichi													8	8	8	18	5	4	23	26		45	40			40	185	2.5	7.4	12.9	1.7
C. inquisitor					4		1			1		5	7		4		6		5				3			36	36	0.5	1.4	2.3	1.6
M. piceus		1			1	2	2	3				1	1		1							14				36	26	0.3	1.0	2.8	2.7
H. tardus				3	1		1						1			2	5	5			227					32	245	3.3	9.8	45.3	4.6
N. rufipes				2	1	2	2	3				1		1												28	12	0.2	0.5	0.9	1.8
A. aenea					1		1														9	23	11		2	24	47	0.6	1.9	5.2	2.8
A. ovata										1			1	1				2	1						5	24	11	0.1	0.4	1.1	2.5
A. bombarda														2	20	110	1		8	3						24	144	1.9	5.8	22.1	3.8
C. violaceus												1	4	21								3	3			20	32	0.4	1.3	4.3	3.3
O. brevicollis		1		1																	2	2	14			20	20	0.3	0.8	2.8	3.5
O. gammeli														4	1	8	5	2								20	20	0.3	0.8	2.0	2.5
P. burmeisteri										3		6				2			2			175				20	188	2.5	7.5	34.9	4.6
P. oblongopunctatus				20																	6	29	201	1		20	257	3.4	10.3	40.3	3.9
S. pumicatus	2	5																			1	2		3		20	13	0.2	0.5	1.2	2.4
T. quadristriatus		1		5																			1	1	1	20	9	0.1	0.4	1.0	2.9
C. granulatus										7		1						1	1							16	10	0.1	0.4	1.4	3.5
P. pumilio			1	2																	4		5			16	12	0.2	0.5	1.3	2.7
S. vivalis																1		1			6		4			16	12	0.2	0.5	1.4	3.0
A. familiaris																					26	5			10	12	41	0.5	1.6	5.5	3.4
A. saphyrea																	1				103	5				12	109	1.5	4.4	20.6	4.7
C. scheidleri																			7	4		6				12	17	0.2	0.7	1.9	2.8
N. brevicollis			5	7																		1				12	13	0.2	0.5	1.7	3.2
O. azureus													2		1		1									12	4	0.1	0.2	0.5	3.0
A. dorsalis																							1		1	8	2	0.0	0.1	0.3	3.5
B. lampros				1																	1					8	2	0.0	0.1	0.3	3.5
C. fuscipes													1		1											8	2	0.0	0.1	0.3	3.5
H. distinguendus		1												1												8	2	0.0	0.1	0.3	3.5
H. smaragdinus	2																								2	8	4	0.1	0.2	0.6	3.5
L. terricolla																			1	1						8	2	0.0	0.1	0.3	3.5
N. biguttatus		4																				3				8	7	0.1	0.3	1.0	3.5

Annex 4. Continuation.

	MČr	MHak	SHPt	SHPn	SHPw5	SHPw6	SMd5	SMd6	SBR5	SBR6	SKO5	SKO6	SDK1-5	SDK1-6	SDK2-5	SDK2-6	SDK3-5	SDK3-6	SDHla5	SDHla6	SKal	SŽs	SStn	MŠpn	MŠps	P	S	D	F	S. D.	V
O. punctatulus			4																				16			8	20	0.3	0.8	3.3	4.1
P. strenuus			1	1																						8	2	0.0	0.1	0.3	3.5
A. flavicollis																					1					4	1	0.0	0.0	0.2	5.0
A. interstitialis																					1					4	1	0.0	0.0	0.2	5.0
A. mixtus																					2					4	2	0.0	0.1	0.4	5.0
A. communis																						15				4	15	0.2	0.6	3.0	5.0
B. bullatus																									7	4	7	0.1	0.3	1.4	5.0
B. ustulatum				2																						4	2	0.0	0.1	0.4	5.0
B. varium																					1					4	1	0.0	0.0	0.2	5.0
C. erratus		2																								4	2	0.0	0.1	0.4	5.0
C. melanocephalus		1																								4	1	0.0	0.0	0.2	5.0
C. cingulata																							1			4	1	0.0	0.0	0.2	5.0
C. humeralis														1												4	1	0.0	0.0	0.2	5.0
C. vaporariorum													1													4	1	0.0	0.0	0.2	5.0
D. linearis																									1	4	1	0.0	0.0	0.2	5.0
H. latus												1														4	1	0.0	0.0	0.2	5.0
H. quadripunctatus																						1				4	1	0.0	0.0	0.2	5.0
H. vernalis																									1	4	1	0.0	0.0	0.2	5.0
L. ferrugineus		1																								4	1	0.0	0.0	0.2	5.0
L. caerulescens																									1	4	1	0.0	0.0	0.2	5.0
M. elatus																						1				4	1	0.0	0.0	0.2	5.0
O. subsinuatus																						2				4	2	0.0	0.1	0.4	5.0
P. bipustulatus								1																		4	1	0.0	0.0	0.2	5.0
P. rufus					1																					4	1	0.0	0.0	0.2	5.0
P. assimilis				8																						4	8	0.1	0.3	1.6	5.0
P. cupreus																						1				4	1	0.0	0.0	0.2	5.0
P. serriceus																							1			4	1	0.0	0.0	0.2	5.0
P. melanarius	2																									4	2	0.0	0.1	0.4	5.0
P. nigrita				2																						4	2	0.0	0.1	0.4	5.0
T. pilisensis				16																						4	16	0.2	0.6	3.2	5.0
T. pulchelus																					1					4	1	0.0	0.0	0.2	5.0
T. placidus																					1					4	1	0.0	0.0	0.2	5.0
T. laevicollis																						5				4	5	0.1	0.2	1.0	5.0
Species	6	12	10	18	11	8	10	9	7	14	7	15	20	18	17	17	15	15	17	12	21	27	23	5	12		55				
Individuals	160	89	181	122	125	42	71	112	141	541	155	332	228	312	378	571	201	200	361	449	583	538	1492	21	75		7480				

Annex 5. Survey of species (arranged descendently according to presence) recorded in Brno and Bratislava in habitats without continuous tree canopy (for site abbreviations see tab. 1. P – presence in %. S – sum of individuals. D – dominance in %. F – frequency. S.D. – standard deviation of number of individuals. V – coefficient of variance of number of individuals).

	MBř	MLíš	MKrH	SVrud	SVRw	SBAJ	SLšv	SLšg	M28	SCast	SHN2	SHN8	SUrš	SND	SSNP	SKoln	SPlp	SPsp	SAm2	SAm8	SMz2	SMz8	SŠaf	SOc	SMos	P	S	D	F	S. D.	V.
A.dorsalis		4	1	72	1			2			6			1	1	1	1		6		19	1		3		56.0	119	6.2	4.8	14.6	3.1
P. rufipes	30	8				140					38	3			2	14	54	23	197	1	8	6	20			56.0	544	28.3	21.8	47.1	2.2
B. lampros	3			50		16			7		1		4		1	2	2	43	1				1			48.0	131	6.8	5.2	12.9	2.5
H. affinis	22					13				1	43	1					1		4		7	1	3		5	44.0	101	5.2	4.0	9.6	2.4
P. melanarius	1	13		2							3			3	1		158	17		1		3	4			44.0	206	10.7	8.2	31.5	3.8
A. aenea		1		1		2		1			1		2				1		3		1		6			40.0	19	1.0	0.8	1.4	1.8
A. flavipes	9			1							5	1		3		2	4	5								32.0	30	1.6	1.2	2.3	1.9
A.familiaris				1		4			2	1				1									9		1	28.0	19	1.0	0.8	1.9	2.6
H. distinguendus		1		1		46					2		2								2		6			28.0	60	3.1	2.4	9.2	3.8
T. quadristriatus	3	7				1									1	1	1						1			28.0	15	0.8	0.6	1.5	2.5
B. properans				19	3	33					2				1						1					24.0	59	3.1	2.4	7.4	3.1
C. collaris													1	1		1	2	4	2							24.0	11	0.6	0.4	1.0	2.2
O. brevicollis		1				1		1						1								1	2			24.0	7	0.4	0.3	0.5	1.9
S. pallipes	2			3	1	2		1													1					24.0	10	0.5	0.4	0.8	2.0
C. fuscipes				2		7	14	16													10					20.0	49	2.5	2.0	4.6	2.3
C. melanocephalus						1		2									2	2			1					20.0	8	0.4	0.3	0.7	2.2
H. atratus	50									6		1												1	1	20.0	59	3.1	2.4	10.0	4.2
P. niger		2										2					21	24		1						20.0	50	2.6	2.0	6.2	3.1
B. bullatus	5			1	2					2																16.0	10	0.5	0.4	1.1	2.8
C. intricatus	4	3	1							14																16.0	22	1.1	0.9	2.9	3.3
H. latus	2					1	1	1																		16.0	5	0.3	0.2	0.5	2.5
M. maurus		4		5		7																	1			16.0	17	0.9	0.7	1.8	2.7
P. griseus																1	2	1	3							16.0	7	0.4	0.3	0.7	2.6
A. binotatus															1	1							1			12.0	3	0.2	0.1	0.3	2.8
B. nitidulum				1	1													1								12.0	3	0.2	0.1	0.3	2.8
C. erratus		2	1														1									12.0	4	0.2	0.2	0.5	3.0
D. halensis		2															2		2							12.0	6	0.3	0.2	0.7	2.8
H. tardus				5		5								1												12.0	11	0.6	0.4	1.4	3.2
L. caerulescens	6																				1				1	12.0	8	0.4	0.3	1.2	3.8
N. brevicollis														1			2		1							12.0	4	0.2	0.2	0.5	3.0
N. rufipes										1			1											1		12.0	3	0.2	0.1	0.3	2.8
O. signaticornis				22	22	11																				12.0	55	2.9	2.2	6.4	2.9
P. bipustulatus				1	5			1																		12.0	7	0.4	0.3	1.0	3.6
P. punctulatus				19	10	20																				12.0	49	2.5	2.0	5.6	2.9
S. truncatellus				1	1	8																				12.0	10	0.5	0.4	1.6	4.0
A. aulica		3		1																						8.0	4	0.2	0.2	0.6	3.9
A. cursitans							4	5																		8.0	9	0.5	0.4	1.3	3.5
A. saphyrea				1		1																				8.0	2	0.1	0.1	0.3	3.5
B. biguttatum																1			1							8.0	2	0.1	0.1	0.3	3.5
B. explodens											2		1													8.0	3	0.2	0.1	0.4	3.7
B. cephalotes				4	2																					8.0	6	0.3	0.2	0.9	3.7
C. violaceus		11					8																			8.0	19	1.0	0.8	2.7	3.5

Annex 5. Continuation.

	MBř	MLiš	MKrH	SVrud	SVRw	SBAJ	SLšv	SLšg	M28	SCast	SHN2	SHN8	SUrš	SND	SSNP	SKoln	SPlp	SPsp	SAm2	SAm8	SMz	SMz	SŠaf	SOc	SMos	P	S	D	F	S. D.	V.
C. germanica				2	11																					8.0	13	0.7	0.5	2.2	4.3
D. linearis										1			1													8.0	2	0.1	0.1	0.3	3.5
E. micans																			1	1						8.0	2	0.1	0.1	0.3	3.5
L. ferrugineus		88	1																							8.0	89	4.6	3.6	17.6	4.9
L. depressus		4	1																							8.0	5	0.3	0.2	0.8	4.1
O. azureus				1				3																		8.0	4	0.2	0.2	0.6	3.9
P. cupreus				7	20																					8.0	27	1.4	1.1	4.2	3.9
P. serriceus				1	4																					8.0	5	0.3	0.2	0.8	4.1
P. pumilio										4					1											8.0	5	0.3	0.2	0.8	4.1
A. parallelopipedus					1																					4.0	1	0.1	0.0	0.2	5.0
A. gracilipes																			1							4.0	1	0.1	0.0	0.2	5.0
A. apricaria		2																								4.0	2	0.1	0.1	0.4	5.0
A. bifrons				14																						4.0	14	0.7	0.6	2.8	5.0
A. consularis											1															4.0	1	0.1	0.0	0.2	5.0
A. erratica	4																									4.0	4	0.2	0.2	0.8	5.0
A. ovata								1																		4.0	1	0.1	0.0	0.2	5.0
A. signatus				4																						4.0	4	0.2	0.2	0.8	5.0
B. articulatum									2																	4.0	2	0.1	0.1	0.4	5.0
B. dentellum																	2									4.0	2	0.1	0.1	0.4	5.0
B. ustulatum																		2								4.0	2	0.1	0.1	0.4	5.0
B. crepitans				8																						4.0	8	0.4	0.3	1.6	5.0
C. hortensis							1																			4.0	1	0.1	0.0	0.2	5.0
C. auropunctatum						8																				4.0	8	0.4	0.3	1.6	5.0
C. fossor																	1									4.0	1	0.1	0.0	0.2	5.0
H. picipennis								1																		4.0	1	0.1	0.0	0.2	5.0
H. rubripes								29																		4.0	29	1.5	1.2	5.8	5.0
H. smaragdinus				1																						4.0	1	0.1	0.0	0.2	5.0
L. discus																	1									4.0	1	0.1	0.0	0.2	5.0
N. biguttatus		2																								4.0	2	0.1	0.1	0.4	5.0
O. cordatus	1																									4.0	1	0.1	0.0	0.2	5.0
O. puncticollis						1																				4.0	1	0.1	0.0	0.2	5.0
O. subsinuatus										23																4.0	23	1.2	0.9	4.6	5.0
O. obscurus																	1									4.0	1	0.1	0.0	0.2	5.0
P. macer																			1							4.0	1	0.1	0.0	0.2	5.0
S. pumicatus					4																					4.0	4	0.2	0.2	0.8	5.0
S. vivalis		3																								4.0	3	0.2	0.1	0.6	5.0
T. micros																1										4.0	1	0.1	0.0	0.2	5.0
Z.tenebrionides						4																				4.0	4	0.2	0.2	0.8	5.0
Species	14	19	5	29	15	21	5	13	3	9	11	5	7	8	8	10	19	10	12	4	10	5	11	3	4		80				
Individuals	142	161	5	251	88	332	28	64	11	53	104	8	12	12	9	25	259	122	222	4	51	12	54	5	8		1924				

ON THE ASSESSMENT OF THE EFFECTIVENESS OF THE CONSERVATION OF RED DATA INSECT SPECIES IN THE PROTECTED NATURAL TERRITORIES IN BELARUS AND VIETNAM

DERUNKOV Alexander, SETRAKOVA Ekaterina, PHAM Hong Thai

Abstract. The study was carried out to find the approaches to the assessment of the conservation effectiveness of Red Data insect species in the especially protected natural territories in Belarus (East Europe) and Vietnam (Southeast Asia). A review of the structure of a modern system of protected areas in both countries is provided. The structure is similar and includes the national parks, nature reserves, the special protected areas, and a few other categories of protected areas like, for example, scientific and experimental forest areas in Vietnam. The total number of the protected territories is many times higher in Belarus than in Vietnam – 1,285 versus 164, although the area of the protected territories in both countries is different, as well as a total area of the countries. The lection of the criteria to assess the conservation effectiveness of Red Data insect species in the especially protected natural territories is very difficult because their multiplicity and different interpretations. We tried to use the only criterion of presence of the Red Data species in the protected areas. The nature reserves, national parks and 5 the largest special protected territories (zakaznik) were analysed in this way in Belarus. In Belarus, the effectiveness of the protected areas according to this criterion is very high because: 1). More than 80 % of Red Data species are presented in the protected areas, 2). There are at least three Red Data species inhabited every territory and 3).There are species presented almost exclusively in the protected territories. There is a problem to use this criterion in Vietnam because of the poor knowledge of the regional biodiversity and the local faunas, existing of the large number of the endemics and undescribed species, as well as the rarity of many species. Some problems of the conservation of Red Data insect species in the especially protected natural territories are outlined.

Keywords: Insecta, Red Data species, especially protected natural territories, Belarus, Vietnam.

Rezumat. Asupra evaluării eficacității conservării datelor/listelor roșii de insecte speciale în teritoriile naturale protejate în special în Belarus și Vietnam. Studiul a fost realizat pentru a găsi abordările pentru evaluarea eficacității de conservare a speciilor de insecte Red Data în teritoriile naturale în special protejate din Belarus și Vietnam (Asia de Sud-Est). Este prezentată revizuirea structurii unui sistem modern de arii protejate din ambele țări. Structura este similară și include parcurile naționale, rezervațiile naturale, zonele protejate speciale și alte câteva categorii de arii protejate precum, de exemplu, zonele forestiere științifice și experimentale din Vietnam. Numărul total al teritoriilor protejate este de multe ori mai mare în Belarus decât în Vietnam – 1.285 față de 164, deși suprafața teritoriilor protejate din ambele țări este diferită, precum și o suprafață totală a țărilor. Selectarea criteriilor pentru evaluarea eficacității conservării speciilor de insecte Red Data în teritoriile naturale protejate este foarte dificilă, deoarece multiplicitatea lor și interpretările diferite. Am încercat să folosim singurul criteriu de prezență a speciilor Red Data în zonele protejate. Rezervele naturale, parcurile naționale și cele 5 cele mai mari teritorii speciale protejate (zakaznik) au fost analizate în acest fel în Belarus. În Belarus, eficacitatea zonelor protejate conform acestui criteriu este foarte mare, deoarece 1) peste 80% din speciile din Lista Roșie sunt prezentate în zonele protejate, 2) există cel puțin trei specii din Lista Roșie locuite în fiecare teritoriu și 3) acolo sunt specii prezentate aproape exclusiv pe teritoriile protejate. Există problema utilizării acestui criteriu în Vietnam, din cauza cunoștințelor slabe despre biodiversitatea regională și faunele locale, care există din numărul mare de endemice și specii nedescrise, precum și din raritatea multor specii. Sunt prezentate câteva probleme ale conservării speciilor de insecte Red Data în teritoriile naturale protejate în special.

Cuvinte cheie: Insecta, specii din Lista Roșie, în special teritorii naturale protejate, Belarus, Vietnam.

INTRODUCTION

The problem of representativeness and effectiveness of the protected areas becomes the mainstream not only in the South-East Asia region but also in the Europe where effectiveness of the nature protection in the protected areas is sufficiently high. It was shown in the South-East Asia that the individual distribution models of biodiversity characterize the majority of the animal taxa. Most "hotspots" of biodiversity do not match to the protected territories. For certain taxa it was shown that above 55 % of territory with about 75 % of taxon diversity does not protected (HUGHES, 2017). Different strategies of multifunctional utilization of the tropical forest landscape were assessed (LAW et al., 2017). It was shown on the example of the forest landscapes in Indonesia that reserving of 29-37 % of territory for the nature protection is enough for biodiversity protection in the forests.

Methodical approaches were developed to select ecologically valuable territories that could be used for landscape planning and for conservation in North Europe and were tested in East Finland (KANGAS et al., 2016). To develop the models of landscape planning, large ecological data arrays were used but developed models have substantial limitations.

Thus, today, research is focused on new approaches to the conservation of the biodiversity. Reassessment of the role of protected areas, finding of more effective ways for management and functioning of the protected areas, search of compromise between the conservation efforts and interest of the local communities occur today.

MATERIAL AND METHODS

We carried out a comparative analysis of the current system of the protected territories in Belarus and Vietnam relying on the official information from open sources. The number and structure of the especially protected natural territories were compared in both countries.

The selection of the criteria to assess the conservation effectiveness of Red Data insect species in the especially protected natural territories is very difficult because of their multiplicity and different interpretations. We tried to use only the criterion of the presence of the Red Data species in the protected areas. This criterion undoubtedly has many restrictions. Using of the indicator species often does not allow to compare them informatively with the other taxa; therefore we need the multispecies approach to determine the conservation priorities then the further development of the approaches oriented on the separate taxon (HUGHES, 2017). Often ecological models have been criticized for a naive approach to model development and a lack of strictness in evaluation; but a more ecological emphasis based on expert knowledge can facilitate the development of a more accurate and relevant analysis of biodiversity based on accurate data on a species level (SEARCY & SHAFFER, 2016). Using of the multispecies approach with consideration for the ecological factors may be very useful for the selection of the valuable habitats for conservation. Such approaches were developed for one beetle family – rove-beetles – and they were successfully tested in the riverine ecosystems in the Great Britain (EYRE et al., 2001). The problem of criteria choice for assessment of the effectiveness of the protected areas is very important. The plots with traditional farming systems in national parks are the most valuable natural habitats in the mountain districts in the Mediterranean region in Europe (CIMINI et al., 2013). Shrub and forest expansion may cause more substantial loss of the local biodiversity in comparison with forest plots degradation. Habitat mosaic in this region is critical for sustaining of the high level of the local biodiversity.

Nevertheless, the use of Red Data insect species is more understandable for the wide circle of scientific experts and for public. It is the simplest way to assess the value of the natural protected territory. Obviously, it is impossible to protect the rare species without protection of their habitats. But the rare and vulnerable species indicate the vulnerable habitats and help focus the attention of the nature conservation organizations on targeted habitats for their protection. This habitat-based approach was applied in the latest edition of the Red Book of the Republic of Belarus (2015).

To assess the presence of Red Data insect species in the protected territories in Belarus we selected the Berezinsky biosphere reserve, national parks and 5 of the most important "zakazniks". The significance of the zakazniks as protected territories was estimated on such features as the total square, diversity of the ecosystems, plants and animals in their territory (YURGENSON et al., 2017; ***. ESPECIALLY PROTECTED, 2019; ***. 8 LARGEST BOGS, 2019). The list of insect species included in Vietnamese Red Book was analysed on the distribution of the species, category of protection and on the presence in the protected territories.

RESULTS AND DISCUSSIONS

The good practice of organization of the protected territories was accumulated in both countries, although there are the specific characters in each country determined by the physiographic peculiarities of the region and by the fauna structure.

There are four categories of especially protected natural territories in the Republic of Belarus – natural reserve, national park, "zakaznik" and natural landmark. The territories are different in their status of protection and use, governed by a special system of laws and regulations. The natural reserve is considered to be most effective as a protected territory because the reserve is established with the goals of protection and study of etalon ecosystems and other valuable natural complexes and objects, animal and plant world, natural ecological systems and landscapes, arrangement of conditions providing the natural course of the nature processes. Any economic activity is prohibited in the natural reserve if this activity affects natural processes.

The national parks are established with the goal of protection of the etalon ecosystems and other valuable natural complexes and objects, their use in the course of nature protection, scientific, educational, touristic, recreational and health-improving activities. A few zones are marked out within the borders of the national park depending on their functional load.

The most important zone for the protection of biodiversity is a specially reserved zone, meant for the protection of the nature complexes and objects in the natural conditions, providing with conditions of their development, within whose limits all kinds of activity are prohibited, except for scientific investigations and nature conservation actions.

"Zakaznik" is a specially protected territory established with the goals of protection and study of the particular valuable natural complexes and objects, even the separate rare species of the plants and animals. The economic activity is allowed on the territory of zakaznik if this activity does not affect the protected complexes or objects. Depending on the type of protected object and protection goals, zakazniks can be landscape zakazniks, biological zakazniks, etc.

Natural landmarks are established with the goals to protect separate natural objects.

As of 1 January 2018, the system of the especially protected natural territories in the Republic of Belarus includes 1,285 objects (Fig. 1) including 1 natural reserve, 4 national parks, 99 zakazniks of the republican significance (35 landscape, 38 biological, 17 hydrological and 9 wetland zakazniks), 277 zakazniks of the local significance, 326 natural landmarks of republican significance and 578 natural landmarks of the local significance. The total area of the especially protected natural territories is 1,811.6 thousand hectares or 8.72 % of the territory of country (YURGENSON et al., 2012; ***. ESPECIALLY PROTECTED, 2019).

The system of the especially protected natural territories in Vietnam includes 164 territories (see Fig. 1). The basic structure of the protected territories in Vietnam is similar with Belarus. There are 32 National Parks, 90 Nature Reserves and 42 Cultural and Historical Sites. A few other categories of protected territories were established in Vietnam, such as Marine Protected Areas, Special Use Forests, Wetland Protected Areas etc. Species and habitat reserves were established for the protection of endemic or valuable flora and/or fauna. Scientific forests are specifically designated to protect sites used for scientific research. The total area of the especially protected natural territories in Vietnam is 2,499.4 thousand hectares or 7.58 % of the territory of the country (***. UNEP-WCMC, 2019).

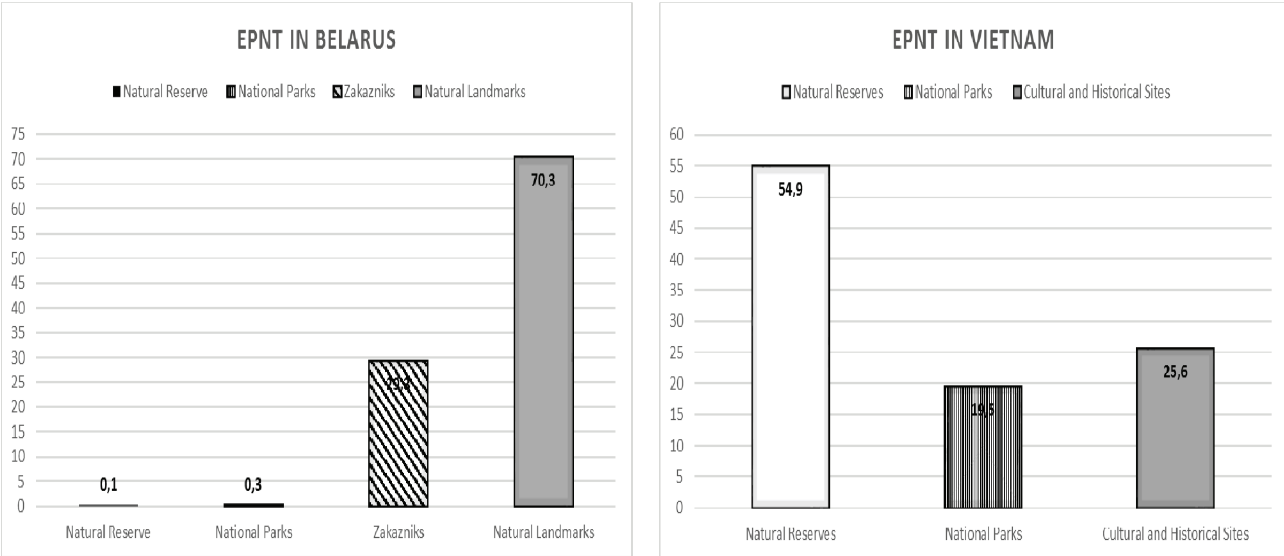

Figure 1. Structure of the especially protected natural territories (EPNT) in Belarus and Vietnam.

National parks in Vietnam were established for the protection of ecosystems containing high values for science, education, and tourism. Nature reserves were established to maintain ecological processes through the restoration of natural resources and biodiversity. Landscape protected areas or Cultural and Historical Sites protect natural and cultural sites with a high aesthetic value.

The system of the especially protected natural territories in both countries is similar but the proportion of the protected territories of different types is very different. The number of the natural reserves and national parks in Vietnam is much higher than in Belarus. Zakazniks play an important role in nature protection in Belarus. As of 1 January 2018 the total area of zakazniks was 13726 sq.km, or 6,6 % of the territory of Belarus. The percentage of the protected territories in both countries is similar, around 8 % of the total square of the country.

International and national criteria are used to establish the especially protected natural territory in Belarus. One of the important criteria is the presence and the number of the habitats of the plant and animal species from the Red Book of the Republic of Belarus. It is necessary that the certain number of the plant and animal species from the Red Book of the Republic of Belarus inhabited the potentially protected territory: at least 50 species for natural reserve, 30 species for national park, and 10 species for zakaznik.

A list of the threatened insect species of Belarus includes 87 species listed in Red Data Book and 133 species included in the annex to the Red Book as species requiring the special attention for additional study and preventive protection (***. THE RED BOOK, 2015). There are 1 mayfly species (Ephemeroptera), 8 dragonfly species (Odonata), 3 orthopterous insect species (Orthoptera), one bug species (Hemiptera), 31 beetle species (Coleoptera) 34 butterfly species (Lepidoptera) and 9 hymenopteran species (Hymenoptera) in the main list of Red Book species. Table 1 shows that the Red Data insect species are well presented in the protected territories in Belarus. In the most important territories, the percentage of the Red Data species exceeds 20 % and even 50 % in a few territories. There is a weak trend of decrease in the number of rare species in the northern territories, although we suppose that the main reason of the low number of the Red Data species in some territories generally is the poor knowledge of the local insect fauna. It is important to emphasize that the overlapping of species lists does not extend in the different protected territories. It means that they are important for the protection of the local pool of rare and threatened species.

The most important territories for the Red Data insect species are the national parks and zakazniks of the large square with a diversity of the habitats. The undisturbed conditions of the ecosystems during a long time are very important for the survival of the rare species, too. Despite the relatively good knowledge of the Red Data species distribution in the Belarusian territory, the actual distribution in the protected territories needs a substantial clarification.

The number of Red Data species is underestimated in many protected territories, especially zakazniks (KULAK, 2015, KOZULKO et al., 2019).

The evidence of this problem is controversial in the data about the number and abundance of the Red Data insect species in the protected territories in Belarus from the different literature sources (YURGENSON et al., 2012; YURGENSON et al., 2017; ***. ESPECIALLY PROTECTED, 2019). More than 20 % of Red Data insect species are found only outside the limits of the especially protected territories. There remains the possibility that some of these species will be found in the protected territories in the future after their careful investigation. For example, 8 new habitats of critically endangered butterfly species *Zerynthia polyxena* (Denis & Schiffermüller) were found after the last issue of Red Book of the Republic of Belarus (SETRAKOVA & MAKOVETSKAIA, 2019). Although the new habitats are out of the protected territories, the climate changes and related changes of the vegetation may lead to a wider distribution of this species, also in the protected territories, or may activate the establishing of new protected areas.

Table 1. The number of Red Data insect species found in the most important especially protected natural territories (EPNT) in Belarus.

No.	EPNT	Number of Red Data insect species	Percentage of the Red Data insect species found in the EPNT, %
1	Berezinsky Biosphere reserve	37	42.5
2	“Belovezhskaya pushcha” National park	44	50.6
3	“Pripiatsky” National park	45	51.7
4	“Braslav Lakes” National park	12	13.8
5	“Narochansky” National park	10	11.5
6	“Zvanets” zakaznik	25	28.7
7	“Srednyaya Pripiat” zakaznik	37	42.5
8	“Sporovsky” zakaznik	18	20.7
9	“Naliboksky” zakaznik	15	17.2
10	“Olmanskie bolota” zakaznik	23	26.

Most Red Data species are also known from the habitats outside the specially protected territories, but these populations are threatened. For example, the population of the species *Carabus clathratus* L., inhabiting wet fen habitats critically depends on conditions of the flood-plain ecosystems. The forest species *Carabus coriaceus* L. and *Carabus violaceus* L. are very sensitive to the disturbance of mature forest ecosystems. On another hand, some species are found only in the protected territories. For example, the species *Carabus intricatus* L. is known only from the National park “Belovezhskaya pushcha” in the south-west of Belarus.

A list of the threatened insect species of Vietnam includes 22 species listed in Red Data Book (***. RED DATA BOOK OF VIETNAM, 2007) and 13 species proposed for inclusion (Table 2). Among 35 Red Data species only two butterfly species of the genus *Teinopalpus* are listed in IUCN Red List. All 35 species are found in the protected areas.

Table 2. List of the insect species included in Vietnamese Red Data Book.

No.	Taxon	Vietnam Red Data Book (2007)	Distribution
	Phasmattodea: Phyllidae		
1	*Phyllium siccifolium* (L.) (**GB**)*	VU	Tropical South-East Asia
	Heteroptera: Belostomatidae		
2	*Lethocerus indicus* (L. et S.)	VU	China, India, Indonesia, Malaysia, Myanmar, Japan, New Guinea, New Zealand, Sri Lanka, Vietnam
	Coleoptera: Lucanidae		
3	*Dorcus curvidens curvidens* (Hope)	CR	Bhutan, China, India, Indonesia, Laos, Malaysia, Myanmar, Nepal, Philippines, Taiwan, Thailand, Vietnam
4	*Dorcus antaneus* Hope	EN	India:Sikkim, Himachal Pradesh, Nepal, Bhutan, Myanmar, China:Yunnan, Xizang, Guangxi, Guizhou, Hainan, Thailand, Laos, Vietnam, Taiwan, Malaysia, Borneo, Sumatra, Java, Myanmar
5	*Dorcus titanus titanus* West.	EN	Japan, Indonesia, the Philippines, Malaysia, Thailand, Vietnam, Laos, Myanmar, India, China, Taiwan and Korea
6	*Odontolabis cuvera fallaciosa* Boil.	VU	China, Laos, Thailand, Vietnam
	Coleoptera: Scarabaeidae		
7	*Trypoxylus dichotomus politus* Prell. (**GB**)*	EN	China, Japan, Laos, Malaysia, South Korea, Taiwan, Thailand, Vietnam
8	*Chalcosoma atlas* L.	CR	Palaearctic (Nepal), Oriental (Vietnam, Cambodia, Myanmar, Perak, Sumatra, Nias, Java, Borneo, Philippines, Sulawesi, India: Mizoram)

9	*Cheirotonus battareli* (P.)	EN	Known only from the North Vietnam: Sa Pa (Lao Cai), Van Ban (Yen Bai), Tay Con Linh (Ha Giang), Mau Son (Lang Son), Pia Oac (Cao Bang), Tam Dao (Vinh Phuc), Pu Mat (Nghe An).
10	*Cheirotonus jansoni* (P.)	EN	Palaearctic (China:Fujian, Guandong, Guangxi, Jiangsu, Jiangxi, Sichuan, Zhejiang), Oriental (Vietnam, Myanmar, Laos)
11	*Eupatorus gracilicornis* (A.)	VU	China, India, Myanmar, Thailand, Laos and Vietnam
12	*Jumnos ruckeri tonkinensis* Nagal	CR	Malaysia, Thailand, Vietnam, India
	Lepidoptera: Amathusidae		
13	*Stichophthalma uemurai uemurai* Nish.	VU	Vietnam
14	*Zeuxidia mansoni* Moore	DD	Myanmar, Thailand, Vietnam
	Lepidoptera: Nymphalidae		
15	*Kallima albofasciata* Moore	DD	Andaman Islans, Vietnam (?)
	Lepidoptera: Papilionidae		
16	*Byasa crassipes* (Ober.)	DD	North east India (Manipur), Myanmar, Thailand, Laos, Vietnam, and possibly southern China.
17	*Papilio (Achillides) elephenor* Dub.	DD	India, Laos (?), Vietnam
18	*Papilio noblei noblei* Nic.	VU	Myanmar, Thailand, Laos and Vietnam
19	*Teinopalpus aureus aureus* Mell. (**GB**)*	VU	China, Laos, Vietnam
20	*Teinopalpus imperialis imperialis* Hope (**GB**)*	VU	Nepal, India, Vietnam
21	*Troides helena cerberus* Felder (**GB**)*	VU	Nepal, India, Bangladesh, Myanmar, Malaysia, Singapore, Indonesia, Laos, Cambodia, Thailand, Vietnam, southern China. Indonesian archipelago, Sumatra
22	*Troides aeacus aeacus* Felder (**GB**)*	VU	From Nepal until Taiwan and Indonesia

Legend: Remark: VU (Vulnerable), EN (Endangered), CR (Critical Endangered), DD (Data Deficient), (**GB**)* Records in the GenBank.

It is possible to see that the geographic ranges of the Red Book species embrace not only the Vietnamese territory but also the territories of a few other countries. The level of protection is different in those countries. The distribution of the species as well as their threatened status needs clarification because of the deficiency of data.

Obviously, the list of threatened species is very incomplete. The Vietnamese insect fauna is very poorly studied. More than 100 new species are described every year. At the same time the number of endemic insect species and even genera increases. The most studied order of insects is the Order of butterflies. Over 1,100 butterfly species are known from Vietnam, about 7 % of them are considered endemic in Indo-China (Vietnam, Laos, Cambodia and east Thailand) (MONASTYRSKII, 2010).

In Vietnam, 177 tiger beetle species were found, 59 (33.3%) of which are endemic. The highest percentage of the endemics is in the genera *Neocollyris* and *Therates* – 28 species (15.8%) and 16 species (9.0%) respectively. In the genus *Neocollyris*, three subgenera are the most rich in endemics. There are 8 endemic species (4.5%) in the *Isocollyris* subgenus, 7 (4.0%) – in *Pachycollyris* and 5 (2.8%) – in *Leptocollyris* (WIESNER et al., 2017).

Many endemic species in Vietnam are local species (especially in the mountains). Therefore, it is impossible to conserve them properly by establishing a bundle of protected areas because of divergent economic interests, interests of local communes and nature protection.

The generally poor studied Vietnamese insect fauna is a problem for including separate species in the Red Book and for the use of species for assessment of the effectiveness of the protected areas. Many insect species are known in a single specimen in Vietnamese territory, therefore, it is very difficult to understand the degree of rarity and threat to these species in the natural ecosystems.

The insect fauna has been studied much better in Belarus than in Vietnam. Nevertheless, the same problem of poor knowledge of the local faunas exists in the protected territories in Belarus. Generally, it is possible to state that the existing system of especially protected natural territories is quite effective for protection of the Red Data insect species. The diversity of the Red Data species with the different ecological requirements in the protected territories shows that a selection of these territories was properly accomplished. The network of specially protected natural territories in Belarus improves and modifies every year. In 2014, the Belarusian Government adopted The National strategy for development of the system of specially protected natural areas until January 1, 2030, that must ensure the conservation of the natural ecosystems, biological and landscape diversity. Similar work is performed in Vietnam. According to the approved national planning system of Special Use Forests up to 2020, Vietnam will have 34 national parks (AN et al., 2018). The increasing number of national parks may improve the conservation and sustainable development of significant natural ecosystems and endangered and rare species in Special Use Forests (***. GOVERNMENT OF VIETNAM, 2014).

The problem of the effectiveness of the protected area network for biodiversity conservation repeatedly arose in the countries adjacent to Belarus. In Russia, the representativeness of vertebrate animals in the protected territories is about 90 %, while for mammals it is close to 100 % (KREVER et al., 2009). At the same time, it is impossible to do a similar assessment for insects. The representativeness of the insect species included in the Russian Red Book exceeds 70 % in the protected territories. The expansion of the existing protected area network is proposed as the main approach to enhance the effectiveness of the protected areas in biodiversity conservation in Russia.

A number of scientists long ago explored the problem of the “matrix” or a forest landscape not included in the protected areas, but important for the protection of the local diversity (LINDENMAYER & FRANKLIN, 2002). The problem is that nature reserves are considered as “habitats” and the other forests as “non-habitats”. Most forests in the temperate zone are managed or will be managed. The problem of the increased use of tropical forests by human society may lead to similar situations. Nature reserves cannot perform the functions of biodiversity conservation adequately without additional measures for its protection in the remaining territory, first of all providing for proper forest management.

Many threats to biodiversity in the Asia and Pacific regions require new policy and approaches to biodiversity protection (SQUIRES, 2013). The conservation of native habitats remains a priority. At the same time, a reasonable compromise must be sought between the needs of local communities in the production of organic products and hard restrictive measures for the use of nature ecosystems and local biodiversity.

It was indicated that Vietnam’s protected areas are inadequately managed (***. VIETNAM TROPICAL FORESTS, 2013). They point out that the challenges to effective protected area management in Vietnam include: 1). Inadequate financing; 2). Lack of enforcement authority by protected areas management boards; 3). Overlapping institutional mandates; 4). Lack of protected area management know-how, particularly in the case of Provincial People’s Committees; 5). Inadequate human resources; 6). Human pressure in the absence of enforcement capacity or effective community participation; 7). Fragmentation and the construction of large infrastructure within protected areas; and 8). Land grabbing. These problems lead to the loss of local and regional biodiversity.

There is a dangerous trend of unprecedented extinction of species in Vietnam in the first decades of the 21st century (***. WORLD BANK, 2005). In the 2000s the Vietnamese government has developed collaborative or “co”-management approaches in Special Use Forests (most of them are specially protected forests) under the guidance of the Convention on the Biodiversity Programme of Work on Protected Areas with funding from the Global Environment Fund and the European Union (KIM DUNG et al., 2017).

However, the modern development of the way to which Vietnamese laws and policies support co-management remains unclear. One of the important mechanisms to improve the situation is using “co-management” to provide the integration of nature conservation and sustainable development. There are the successful examples of harmonizing conflict between the assurance of local livelihoods, market demands and nature conservation in the Xuan Thuy national park (KIM DUNG, 2019).

In this case the local people became resource users and responsible for the sustainable use of the resources. At the same time, they became stakeholders in the protection of all components in the protected territory including environment and habitats for Red Data species.

CONCLUSIONS

The system of specially protected natural territories in both countries is similar, as is the percentage of the protected territories, and it amounts to around 8 % of the total square of each country. In Belarus, the effectiveness of the protected areas according to the criterion of presence of Red Data species in the protected areas is very high because 1). More than 80 % of the Red Data species are present in the protected areas, 2). There are at least three Red Data species in every territory and 3). Some species are present almost exclusively in the protected territories. There is a problem in using this criterion in Vietnam because of the poor knowledge of the regional biodiversity and the local faunas, the existence of a large number of the endemics and undescribed species, as well as the rarity of many species.

Both countries make efforts to improve the national system of specially protected natural territories. In order to improve the effectiveness of the conservation of Red Data insect species in the protected territories in Belarus it is very important to find new habitats of rare species, to understand their regional ecological requirements and biological features. In Vietnam, the main problem in the protection of the rare species is a conflict of interests of the local communities and conservationists.

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Derunkov Alexander
Scientific and Practical Center of the National Academy of Sciences of Belarus for Bioresources,
Akademicheskaya str., 27, 220072 Minsk, Belarus.
E-mail: alex_derunkov@tut.by

Setrakova Ekaterina
Scientific and Practical Center of the National Academy of Sciences of Belarus for Bioresources,
Akademicheskaya str., 27, 220072 Minsk, Belarus.
E-mail: ekaterina_setrakova@mail.ru

Pham Hong Thai
Vietnam National Museum of Nature, Vietnam Academy of Science and Technology,
Graduate School of Science and Technology, Vietnam Academy of Science and Technology,
18 Hoang Quoc Viet St, Hanoi, Vietnam.
E-mail: phamthai@vnmn.vast.vn

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RESEARCH ON THE DEVELOPMENT OF STEM AND BARK DANGERS BETWEEN THE PERIOD OF 2016-2018 IN THE RĂȘINARI SILVIC RANGE FOREST, SIBIU COUNTY

STANCĂ-MOISE Cristina

Abstract. The pests of the stem and bark of resinous species were also reported in the Rășinari Forestry. Monitoring the pests after confirming their presence in different areas of the forest fund, the observations related to the different stages of development and the study were made according to the characteristic of the damage. Adult observation was signaled during the flight, traveling from one place to another, in search of a hole to jump into the bark of tree trunks. During the period 2016-2018, in the Rășinari Forestry, weak insect attacks were observed, in particular: *Ips typographus*, *Hylobius abietis* and *Tortrix viridata*. The degree of infestation is poor, with prophylactic and effective combat.

Keywords: Rășinari Forestry, monitoring, pests, *Ips typographus*, *Hylobius abietis* and *Tortrix viridata.*

Rezumat. Cercetări asupra evolutiei dăunătorilor de tulpină şi scoarţă în perioada anilor 2016-2018, în cadrul Ocolului Silvic Rășinari, județul Sibiu. Dăunătorii tulpinii și cei de scoarţă ai speciilor de rășinoase au fost semnalați și în cadrul Ocolului Silvic Rășinari. Monitorizarea dăunatorilor după confirmarea prezenței lor în diferite zone ale fondului forestier, observaţiile legate de diferite stadii de dezvoltare și realizarea studiului s-au făcut după caracteristica vătămării. Observarea adulţilor a fost semnalată în timpul zborului, în deplasările de la un loc la altul, în căutarea roaderii unui orificiului pentru a intra în scoarţă de pe trunchiurile arborilor. În perioada anilor 2016-2018 în cadrul Ocolului Silvic Rășinari s-au observat, atacuri slabe de insecte, în special: *Ips typographus, Hylobius abietis* și *Tortrix viridata*. Gradul de infestare este slab, procedându-se la o combatere profilactică eficientă.

Cuvinte cheie: Ocolul Silvic Rășinari, monitorizare, dăunători, *Ips typographus*, *Hylobius abietis* și *Tortrix viridata.*

INTRODUCTION

From a geographic point of view, the territory on which the forests of Răşinari are situated is located in the mountain area (85%) and the hill (15%), in the middle basin of the Sadu river on the left slope of the Sadul Valley and the North-East of the Mountains Cibin, on the right side of the Steaza Valley. Forests are located at an altitude between 400 m (U.B. VI) and 1900 m (U.P.V), and the general exhibition is partially sunny (46%). The most common type of mountain resort is: 2332 - Bm spruce hillsides, Oxalis-Dentaria (33%), and the prevalent forest type is 1121-Molidis with green Bm mussels (22%). The direct neighborhoods of the forest are lands with public forest ownership of the state or private public property and agricultural land with different uses (arable, hayfields, pastures) (SCHNEIDER-BINDER, 1973).

The forest vegetation that does not belong to the Forestry of Răşinari is made up of clusters of trees or wooded pastures. For this form of vegetation, specialized studies (silvic-pastoral arrangements) have been prepared. The species that form grassland and wooded pastures are spruce, beech and birch. Geomorphological factors are important by influencing ecological factors, heat, light, humidity. Their variety determines the variety of forest resorts, and the altitude difference leads to vegetation distribution; so, in the hills we encounter beech-oaks and even anis, and on the slopes of the mountains we find spruce forests, beech forests and mixtures with oak and other species. The forest formations consisted of a structure of five basic species (spruce, fir, beech and oak) the highest share being 58% of the spruce, which shows that the spruce is in the area. The remaining basic formations were formed on beech and the oak. Oak species have a symbolic presence (SCHNEIDER-BINDER, 1973).

In the forests of the Răşinari commune there is a rich hydrological network whose main collectors are the Sadu River and Steaza Valley. Part of the stream and the gorges feed the Aries Lake. It can be said that the forest vegetation takes the necessary water for the development almost entirely from precipitations. The studied territory is in the moderate, boreal continental climate, the mountain climate, corresponding to the high area with cool winters, precipitation throughout the year, with the coldest temperature below 5°C and the warmest below 18°C.

In the Forest of Dumbrava Sibiului (BUCȘA & CURTEAN, 1996; BUCȘA, 1997, 2002, 2004), in the Forest Range Miercurea Sibiului (STANCĂ-MOISE & BLAJ, 2017a; STANCĂ-MOISE et al., 2017b), Răşinari Forestry ecosystem (ANTONIE, 2015) and in the Forest District Sibiu (STANCĂ-MOISE et al., 2018a; STANCĂ-MOISE & BLAJ, 2018b; STANCĂ-MOISE et al., 2018c), studies on affected forests were carried out (STANCĂ-MOISE, 2014; 2016).

MATERIALS AND METHOD

In limiting the populations of the *Ips typographus* pest within the Răşinari Forestry Plant in the three production units (Oncești UPV, Răşinari UPVI and UPUNI UPVI Forest Hills), the pheromone method of attracting and catching adults was used. Flight barriers that were placed on the sunny slopes were used at a distance of about 10-20 m from the tree and about 25 m away between two adjacent races. Pheasant lures with trappings were placed 2-3 times a week to remove captured adults who might otherwise have been decomposed and would have considerably reduced the effectiveness of the pheromone. The races were primed with the *Atratyp Plus* pheromone produced at the Raluca Ripan Institute of Chemistry in Cluj (Fig. 1), where the races were also made, the pheromone proving to be comparable in terms of the efficiency of catching beetles with those produced abroad (MIHALCIUC et al., 1998; MIHALCIUC et al., 2001; LUBOJACKÝ J. & HOLUSA, 2014).

In order to limit *Hylobius abietis* populations during the years 2016-2018, pheromone barriers were placed, consisting of a panel made of foil (DILLON et al., 2006), under which the adult collecting trough was mounted. The panel had the following dimensions 50/50 cm, and the collecting trough was 50-60 cm long, width 20-30 cm and height 15-20 cm. There was a constant water level (about half the volume) in this trough (DAY SR. & SALISBURY, 1999; HERITAGE S. & MOORE, 2001; DILLON et al., 2008).

Figure 1. Barrier pheromone races (orig. photo.)

In limiting the populations of the *Tortrix viridata* pest in the Rășinari Forest, ATRAVIR fertilizers were used, with the pheromone composition: Z11-tetradecen-1-yl acetate (sexual attractant). Pheromone balls placed in the center of vertical panels with adhesive were fixed to the shafts. The number of catches in the period 2016-2018 also allowed a prognosis on the evolution of population in 2019.

Catch points of the pests: *Ips typographus*, *Hylobius abietis* and *Tortrix viridata* in the Rășinari Forest were located in areas affected by wind or snow by knots and ruptures, packages in operation up to 3-4 years old with damaged trees, physiologically weakened stands, resins, damaged by wind, watered, polluted, affected forests where a significant proportion of defoliators were found. The placement of these races was done in the slopes, in the clearings and in the forest meshes, at a distance of 10-30 m from the edge of the forest. They were installed before the beginning of the insects' flight (end of March/early April). The collection points covered the entire surveyed surface, perimeter, altitude and exhibition area.

RESULTS AND DISCUSSIONS

Ipst typographus (Coleoptera: Curculionidae) (Great bark beetle of spruce). This pest was reported in the Forestry District of Rășinari between 2016-2018 (Tables 1, 2, 3) in the spruce forest, but also mixed with other whitewood species. The infestation rate in the year 2016 was 496 hectares, and 169 Atratyp Plus pheromone races were used to fight this pest. In 2017 the degree of satisfaction was 343 hectares, using 163 pheromone races to limit the population of this pest. There is a regression in the evolution of the pest in 2018, the infested area being 343 hectares, fighting against a number of 133 traps. The infested trees were aged between 5-120 years old and were attacked by larvae making their galleries, and the attack of this pest among the young trees was rarely identified.

Under the conditions of the forest ecosystem within the Silvic Forestry of Rășinari, 2 generations per year were reported, and the adults were detected by wintering in the stem of the infested trees. It is also found that there are cases when the pest grows in the egg, larvae or aft. The finding of the attack was made with the naked eye, based on the green-gray-pale appearance of the infested trees. Over time, the coloration changed to yellow, red and finally the trees dried out. The colour change began from the top of the tree to the base. When the attack was set up, the bark was exfoliated starting from the middle of the stalk and advancing up and down, 2-3 months after the appearance of the adults.

Table 1. The pest attack of *Ips typographus* within the Rășinari Forestry, 2016.

No. Criterion	UP Bazinet	Ua /Groups of u.a.	The surface of whitewood stands		Population Density Nr. holes / m2	Infected trees in the category		Nr. of trees needed for the category		TREES (pc.)			Necessary snares		Phero-monal lures
			Total	Infested		I	II	I	II	Snare (I+II)	Con-trol	Total (11+12)	Wing type traps, x5	Primed and treated trees + x3	
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**8**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
1	Oncești UP V	1-141	4320	446	until 8	50	50	17	50	67	22	89	112	22	134
2	Rășinari UP VI	17-124	1078	50	until 8	0	0	0	0	0	0	0	25	0	25
3	Pasture imp. UP VII	19-76	585	0	-	0	0	0	0	0	0	0	10	0	10
TOTAL			**5983**	**496**		**50**	**50**	**17**	**50**	**67**	**22**	**89**	**147**	**22**	**169**

Table 2. The pest attack of *Ips typographus* within the Rășinari Forestry, 2017.

No. Crt.	UP Bazinet	Ua /Groups of u.a.	The surface of whitewood stands		Population Density Nr. holes / m2	Infected trees in the category		Nr. of trees needed for the category		TREES (pc)			Necessary snares		Phero-monal lures
			Total	Infested		I	II	I	II	Snare (I+II)	Control	Total (11+12)	Wind type traps, x5	Primed and treated tres x3	
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**8**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
1	Oncești UP V	1-141	4320	271	until 8	66	66	14	66	80	27	107	90	27	117
2	Rășinari UP VI	17-124	1078	72	until 8	0	0	0	0	0	0	0	36	0	36
3	Pasture imp. UP VII	19-76	585	0	-	0	0	0	0	0	0	0	10	0	10
TOTAL			**5983**	**343**		**66**	**66**	**14**	**66**	**80**	**27**	**107**	**136**	**27**	**163**

Hylobius abietis (Coleoptera: Curculionidae) was monitored in the Forestry of Rășinari during the years 2016-2018 (Tables 4, 5, 6) in the places with cutting breeds and immediate afforestation where it caused crop injuries to barely planted softwoods, especially spruce, aged 2-5 years old. In 2016 the infested area was 32.3 ha, the intensity of the attack decreased in 2017 to 7.1 ha and in 2018 to 4.6 ha.

The attack was produced by adults affecting the bark of the seedlings, a result being the leakage of resin appeared in place of the injury. The notice of this pest within the Rășinari Forestry imposed measures to protect the forest fund and control the population of this pest, which shows a decrease of the surface attacked in 2018 and a forecast of less than 3 ha in 2019.

In the favourable years, adults are active from March to October when the population can reach a density of 100,000 individuals/ha (OLENICI & OLENICI, 2002, 2003, 2006; OLENICI et al., 2007). The growth of the beetle population for 2-3 years can lead to overlapping of generations and thus a multiplication of the adult population (OLENICI et al., 2005).

Table 3. The pest attack of *Ips typographus* within Rășinari Forestry 2018.

No. Crt.	UP Bazinet	Ua /Groups of u.a.	The surface of whitewood stands		Population Density Nr. holes / m2	Infected trees in the category		Nr. of trees needed for the category		TREES (pc)			Necessary snares		Phero-monal lures
			Total	Infested		I	II	I	II	Snare (I+II)	Control	Total (11+12)	Wind type traps, x5	Primed and treated tres x3	
1	2	3	4	5	6	7	8	8	10	11	12	13	14	15	16
1	Oncești UP V	1-141	4320	289	until 8	0	0	0	0	0	0	0	96	0	96
2	Rășinari UP VI	17-124	1078	54	until 8	0	0	0	0	0	0	0	27	0	27
3	Pasture imp. UP VII	19-76	585	0	-	0	0	0	0	0	0	0	10	0	10
TOTAL			**5983**	**343**		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**133**	**0**	**133**

For survival but also for reproduction, beetles from different generations feed themselves on the entire vegetation season, causing damage to the bark of the saplings. Ponta is deposited by females in the cracks of the crust, being attracted by the smell of freshly cut wood. Larvae are not important because they cause injuries in the roots of Olenici cages.

Table 4. Data statistics and the dynamics of active fuels in tree groups between 2015-2016, within the Rășinari Forestry.

FOREST					Pest, illness or the abiotic factor	Infested surface in the year of : ha		Infested surface in the year of : ha	
Naming	Ua/ Groups of ua/	Surface/ ha	Composition	Age (years)		2015	2016	2015	2016
Oncești UP V	1 -141	4320.4	min.30%MoBr	5 – 120	*Ips typographus*	17	446	S	fs
Rășinari UP VI	17 – 124	1077.5	min.30%MoBr	5 – 120	*Ips typographus*	2	50	S	fs
TOTAL		**5397.9**				**19**	**496**		
Rășinari UP VI	1 – 126	497.2	min.30%GoSt	5 – 150	*Tortrix viridana*	-	-	Latency	Latency
UP V, VI,VII		87.7	9Mo1Br(La)	1 – 4	*Hylobius abietis*	0.2	32.4	s	s

Table 5. Data statistics and the dynamics of active fuels in tree groups between 2016-2017, within the Rășinari Forestry.

FOREST					Pest, illness or the abiotic factor	Infested surface in the year of : ha		Infested surface in the year of : ha	
Naming	Ua/ groups of ua/	Surface ha	Composition	Age (years)		2016	2017	2016	2017
Oncești UP V	1 -141	4320.4	min.30%MoBr	5 – 120	*Ips typographus*	446	271	fs	fs
Rășinari UP VI	17 – 124	1077.5	min.30%MoBr	5 – 120	*Ips typographus*	50	72	fs	fs
TOTAL		**5397.9**				**496**	**343**		
Rășinari UP VI	1 – 126	497.2	min.30%GoSt	5 – 150	*Tortrix viridana*	-	-	latency	latency
UP V, VI,VII		87.7	9Mo1Br(La)	1 – 4	*Hylobius abietis*	32.4	7.1	s	s

Table 6. Data statistics and the dynamics of active fuels in tree groups between 2017-2018, within the Rășinari Forestry.

FOREST					**Pest, illness or the abiotic factor**	**Infested surface in the year of : ha**		**Infested surface in the year of : ha**	
Naming	**Ua/ Groups of ua/**	**Surface ha**	**Composition**	**Age (years)**		**2017**	**2018**	**2017**	**2018**
Oncești UP V	1 -141	4320.4	min.30%MoBr	5 – 120	*Ips typographus*	271	289	fs	fs
Rășinari UP VI	17 – 124	1077.5	min.30%MoBr	5 – 120	*Ips typographus*	72	54	fs	fs
TOTAL		**5397.9**				**343**	**343**		
Rășinari UP VI	1 – 126	497.2	min.30%GoSt	5 – 150	*Tortrix viridana*	-	-	latency	latency
UP V, VI,VII		87.7	9Mo1Br(La)	1 – 4	*Hylobius abietis*	7.1	4.6	s	s

Abbreviations: Mo - spruce; Br - Fir; La-larch; Go- sessile Oak; Sr - Oak tree; Fs - very weak attack (1-10%); S- weak attack (11-25%); M- middle attack (26- 50%).

Tortrix viridata is a pest that attacks oak, hornbeam, elm and birch but also fruit trees. The butterfly has a wingspan of 18-25 mm. The front wings are of light green uniform, larger than the hindmost grey ones. Females deposit eggs that are small, yellow-orange, two on the thin branches at the base of the petiole, the buds, and on the top of the crown (GOOSHBOR et al., 2016). In spring, early April, small, black-eyed larvae appear to be tied to silky yarns that attack the buds, and later young leaves. It has reached full development (18 mm in length), in June it shoots in twisted leaves, and after 2-3 weeks, at the end of June, begins the flight of adults, above the crowns. Larva attack reduces growth, predisposing trees (trees) to attack other pests. In the Rășinari Forest Area (Tables 4, 5, 6) the attack of this pest is considered to be latent.

CONCLUSIONS

During the years 2016-2018, within the Silvic Forestry of Rășinari, a collection of 495 pheromone flights served an area of 1182 ha of forest affected by the *Ips typographus* pest attack presented in Tables 1, 2, 3. Following the synthesis and the interpretation and analysis of the catches we found the following: the largest attacked forest area of 446 hectares was in the production unit from Oncești UPV, followed by Rășinari UP VI 50 ha, which can be said that the degree of infestation is a weak one. As a result of flocking, *Ips typographus* populations had a large amount of wood material favourable to feeding and reproduction.

Pheromone trapping levels remained relatively constant in 2018 compared to 2017 during the vegetation season, indicating moderate densities of bark beetle populations within the Silvic Forestry of Rășinari. The localized outbreaks were predominantly damaged due to the poor vegetation state of trees suddenly exposed to direct sunlight, which favoured the installation of bark beetles. As a result of the research we found that the capture was conditioned by the general flight evolution, by the climatic factors of each year and by the location of the trap. Differences noted from one point to another were due to the local conditions of each collection area.

In order to prevent the formation of outbreaks of *Ipidae* in the Silvic Forestry of Rășinari, hygienic measures are recommended, broken and demolished trees should be removed to avoid the occurrence of outbreaks.

The attack of *Hylobius abietis* bark pests during 2016-2018 within the Silvic Forestry of Rășinari was on an area of 44 ha, 32.3 ha attacked in 2017, 7.1 ha in 2018 and a 4.6 ha in 2019. Following monitoring to control the populations of bark pests *Hylobius abietis*, it was observed that infestations ranged from very weak to latent. To avoid the attack of this pest, we propose treating the seedlings with Mospilan before planting.

Tortrix viridata was monitored during the Rally between 2016 and 2018 but its presence was not reported, considering it was in a state of latency.

In the future, in the Rasinari Forestry, the populations of *Ips typographus*, *Hylobius abietis* and *Tortrix viridata* pests are kept under observation, and where their presence is reported, measures are taken to combat and control populations.

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Stancă-Moise Cristina
"Lucian Blaga" University of Sibiu, Faculty of Agricultural Sciences,
Food Industry and Environmental Protection, Sibiu, Romania.
E-mail: cristinamoise1@yahoo.com

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ADDITIONAL DATA FOR THE CATALOGUE OF BIRD COLLECTIONS OF THE OLTENIA MUSEUM CRAIOVA (ROMANIA)

RIDICHE Mirela Sabina

Abstract. The present paper is a tool of scientific valorisation of the data provided by the 34 bird specimens from the collection of the museum in the last years (2014-2019) and aims to complete the latest edition of the Ornithological Catalogue of the Oltenia Museum Craiova (O. M. C.). The bird specimens belong to 22 species of 21 taxonomic genera (*Tachybaptus, Microcarbo, Botaurus, Ardea, Phoenicopterus, Tadorna, Anas, Accipiter, Buteo, Perdix, Phasianus, Crex, Himantopus, Recurvirostra, Calidris, Scolopax, Limosa, Numenius, Larus, Alcedo, Oriolus*). The following data sequence will be presented for each bird specimen: place and date of collection, age group and sex, collector's name, preparation-preservation method and inventory number. The majority (17) of the recorded species are specific to the aquatic environment, most of them coming from the area of the Bistreţ Lake (the Floodplain of the Danube, in the south of Dolj County). Two of the species (*Phoenicopterus ruber* and *Numenius arquata*) are singular in the ornithological collection of the O. M. C. adding value to the ornithological patrimony of the museum.

Keywords: catalogue, bird collection, Oltenia Museum Craiova.

Rezumat. Date adiționale la Catalogul colecției de păsări a Muzeului Olteniei Craiova (România). Lucrarea de față este un instrument de valorificare științifică a datelor furnizate de 34 de exemplare de păsări instroduse în colecția muzeului în ultimii ani (2014-2019) și are scopul de a completa ultima ediție a catalogului ornitologic al Muzeului Olteniei Craiova (M. O. C.). Păsările la care ne referim aparțin la 22 specii din 21 genuri taxonomice (*Tachybaptus, Microcarbo, Botaurus, Ardea, Phoenicopterus, Tadorna, Anas, Accipiter, Buteo, Perdix, Phasianus, Crex, Himantopus, Recurvirostra, Calidris, Scolopax, Limosa, Numenius, Larus, Alcedo, Oriolus*). Pentru fiecare exemplar de pasăre este prezentată următoarea succesiune de date: locul şi data colectării, grupa de vârsta şi sexul, numele colectorului, modul de preparare-conservare şi numărul de inventar. Majoritatea (17) dintre speciile înregistrate sunt specifice mediului acvatic, cele mai multe exemplare provenind din zona lacului Bistreț (Lunca Dunării din sudul judetului Dolj). Două dintre specii (*Phoenicopterus ruber* și *Numenius arquata*) sunt singulare în colecția ornitologică a M. O. C., adăugând astfel un plus de valoare patrimoniului ornitologic al muzeului.

Cuvinte cheie: catalog, colecție de păsări, Muzeul Olteniei Craiova.

INTRODUCTION

The Ornithological Collection of the Oltenia Museum Craiova (O. M. C.) consists of 1,808 pieces represented by 1,773 birds (stuffed birds, skins, trophies, skeletons), 30 nests and 5 rings. This patrimony has been gathered over decades, starting with 1923 (the foundation of the Museum of Natural History in Craiova, transformed into a section of the Oltenia Museum in 1928), by donations (Dionisie Linţia, Constantina Sorescu, Dumitru Dumitrescu, etc.), acquisitions (Herman Fülop Collection, Valeria Breahmă Collection, Mircea Popescu Skin Collection) and field collections made by the museum specialists during different scientific researches.

Most of the ornithological material has been scientifically processed and published over the years in various papers and catalogues (GROSSU & POPESCU, 1975; BAZILESCU et al., 1980; PETRESCU & RIDICHE, 2009; RIDICHE 2004, 2006, 2011, 2017).

The present paper is a tool of scientific valorisation of the data provided by the 34 bird specimens from the collection of the museum in the last years (2014-2019) and aims to complete the latest edition of the Ornithological Catalogue of the museum (RIDICHE, 2011).

MATERIAL AND METHODS

For the classification system and the taxonomic list we used the Romanian Nomenclature of Birds (SZABÓ-SZELEY & BACZÓ, 2006), which also formed the basis of the last edition of the Ornithological Catalogue of the Oltenia Museum (RIDICHE, 2011), and for the update of some scientific names we accessed the database of BirdLife International (https://www.iucnredlist.org/species/).

Each bird specimen is presented with the following data sequence: place and date of collection, age and sex, collector's name, preparation and preservation method and inventory number. For an accurate knowledge of important bio-ecological characteristics of the bird species introduced in the collection, we included a table comprising brief data on their phenology and preferred habitat, as well as on the endangered species of birds in the European countries (HAGEMEIJER & BLAIR, 1997; MUNTEANU, 2005, 2012) – Table 1.

Used abbreviations and signs: Crt. Nr. – current number, Inv. Nr. – inventory number, Dj. – Dolj County, Ot. – Olt County, ♀ – female, ♂ – male, ○ – undetermined sex, ad. – adult, juv. – juvenile / immature, S. P. – stuffed piece. For the name of the collectors/donors, we also used abbreviations: B. L. – Bălă Lavinia; D. D. – Dumitrescu Dumitru; Ghe. A – Gheorghe Adrian; P. I. – Pătruțoiu Ion; R. M. – Ridiche Mirela; U. L. – Ungureanu Laurențiu; V. A. – Vișan Aneta; Z. E. – Zuican Emil.

RESULTS AND DISCUSSIONS

The birds in question belong to 22 species of 21 genera, 13 families and 11 taxonomic orders, as follows:

Order: **PODICIPEDIFORMES**
Family: **PODICIPEDIDAE**
Genus: ***Tachybaptus*** Reichenbach, 1853
Tachybaptus ruficollis (Pallas, 1764) **– Little Grebe**

Crt. Nr.	Place of collection	Date of collection	Sex, age group	Collector's name	Preservation	Inv. Nr.
1	Bistreţ – Dj.	December 10, 2016	Juv. ○	D. D.	S. P.	55689

Order: **PELECANIFORMES**
Family: **PHALACROCORACIDAE**
Genus: ***Phalacrocorax*** Brisson, 1760
Microcarbo pygmaeus (Pallas, 1773); Synonym: ***Phalacrocorax pygmaeus*** (Pallas, 1773) – **Pygmy Cormorant**

Crt. Nr.	Place of collection	Date of collection	Sex, age group	Collector's name	Preservation	Inv. Nr.
1	Bistreţ – Dj.	December 10, 2016	○, Imm.	D. D.	S. P.	55688

Order: **CICONIIFORMES**
Family: **ARDEIDAE**
Genus: ***Botaurus*** Stephens, 1819
Botaurus stellaris (Linnaeus, 1758) – **Bittern**

Crt. Nr.	Place of collection	Date of collection	Sex, age group	Collector's name	Preservation	Inv. Nr.
1	Bistreţ – Dj.	December 10, 2016	○, ad.	D. D.	S. P.	55696
2	Bistreţ – Dj.	December 10, 2016	○, ad.	D. D.	S. P.	55697
3	Bistreţ – Dj.	December 10, 2016	♂, ad.	D. D.	S. P.	55698

Genus: *Ardea* Linnaeus, 1758
Ardea alba Linnaeus, 1758; Synonyms: ***Casmerodius albus*** (Linnaeus, 1758), ***Egretta alba*** (Cramp and Simmons 1977) – **Great White Egret**

Crt. Nr.	Place of collection	Date of collection	Sex, age group	Collector's name	Preservation	Inv. Nr.
1	Bistreţ – Dj.	December 10, 2016	○, Imm.	D. D.	S. P.	55694
2	Bistreţ – Dj.	December 10, 2016	♀	D. D.	S. P.	55695

Order: **PHOENICOPTERIFORMES**
Family: **PHOENICOPTERIDAE**
Genus: ***Phoenicopterus*** Linnaeus, 1758
Phoenicopterus roseus Pallas, 1811 – **Greater Flamingo**

Crt. Nr.	Place of collection	Date of collection	Sex, age group	Collector's name	Preservation	Inv. Nr.
1	Bistreţ – Dj.	December 10, 2016	○, Imm.	D. D.	S. P.	55693

Order: **ANSERIFORMES**
Family: **ANATIDAE**
Genus: ***Tadorna*** von Oken, 1817
Tadorna tadorna (Linnaeus, 1758) – **Common Shelduck**

Crt. Nr.	Place of collection	Date of collection	Sex, age group	Collector's name	Preservation	Inv. Nr.
1	Bistreţ – Dj.	December 10, 2016	♂, ad.	D. D.	S. P.	55690
2	Bistreţ – Dj.	December 10, 2016	♂, ad.	D. D.	S. P.	55691
3	Bistreţ – Dj.	December 10, 2016	♂, ad.	D. D.	Skin	55692

Genus: ***Anas*** Linnaeus, 1758
Anas platyrhynchos Linnaeus, 1758 – **Mallard**

Crt. Nr.	Place of collection	Date of collection	Sex, age group	Collector's name	Preservation	Inv. Nr.
1	Mâinești - Ot.	December 12, 2015	♂, ad.	D. D.	S. P.	55667

Order: **ACCIPITRIFORMES**
Family: **ACCIPITRIDAE**
Genus: ***Accipiter*** Brisson, 1760
Accipiter gentilis (Linnaeus, 1758) – **Northern Goshawk**

Crt. Nr.	Place of collection	Date collection	Sex, age group	Collector's name	Preservation	Inv. Nr.
1	Breasta – Dj.	October, 2010	○, Imm.	AG.V.P.S.	S. P.	55396

Accipiter nisus (Linnaeus, 1758) – **Eurasian Sparrowhawk**

Crt. Nr.	Place of collection	Date of collection	Sex, age group	Collector's name	Preservation	Inv. Nr.
1	Beharca – Dj.	October 6, 2016	♀, ad.	B. L.	S. P.	55705

Genus: ***Buteo*** Lacépède, 1799

Buteo buteo (Linnaeus, 1758) – **Buzzard**

Crt. Nr.	Place of collection	Date of collection	Sex, age	Collector's name	Preservation	Inv. Nr.
1	Cârcea – Dj.	December 3, 2016	♀, ad.	B. L.	S. P.	55704

Order: **GALLIFORMES**

Family: **PHASIANIDAE**

Genus: ***Perdix*** Brisson, 1760

Perdix perdix (Linnaeus, 1758) – **Partridge**

Crt. Nr.	Place of collection	Date of collection	Sex, age group	Collector's name	Preservation	Inv. Nr.
1	Leu – Dj.	November 12, 2017	♀, ad	U. L.	S. P.	55395
2	Ot.	-	♂, ad.	D. D.	S. P.	55682

Genus: ***Phasianus*** Linnaeus, 1758

Phasianus colchicus Linnaeus, 1758 – **Pheasant**

Crt. Nr.	Place of collection	Date of collection	Sex, age group	Collector's name	Preservation	Inv. Nr.
1	Mâineşti - Ot.	December 12, 2015	♂, ad.	D. D.	S. P.	55665
2	Ot.	-	♀, ad	D. D.	S. P.	55681
3	Ot.	-	♂, ad.	D. D.	S. P.	55678
4	Ot.	-	♂, ad.	D. D.	S. P.	55679
5	Ot.	-	♂, ad.	D. D.	S. P.	55680

Order: **GRUIFORMES**

Family: **RALLIDAE**

Genus: ***Crex*** Bechstein, 1803

Crex crex (Linnaeus, 1758) – **Corncrake**

Crt. Nr.	Place of collection	Date of collection	Sex, age group	Collector's name	Preservation	Inv. Nr.
1	Malu Mare – Dj.	October 15, 2013	♀, ad.??	Z. E.	S. P.	55397

Order: **CHARADRIIFORMES**

Family: **RECURVIROSTRIDAE**

Genus: ***Himantopus*** Brisson, 1760

Himantopus himantopus (Linnaeus, 1758) – **Black-winged Stilt**

Crt. Nr.	Place of collection	Date of collection	Sex, age group	Collector's name	Preservation	Inv. Nr.
1	Măceșu de Jos – Dj.	August 17, 2016	○, Imm.	B. L.	S. P.	55706

Genus: ***Recurvirostra*** Linnaeus, 1758

Recurvirostra avosetta Linnaeus, 1758 – **Avocet**

Crt. Nr.	Place of collection	Date of collection	Sex, age group	Collector's name	Preservation	Inv. Nr.
1	Bistreţ – Dj.	December 10, 2016	♀, ad	D. D.	S. P.	55699
2	Bistreţ – Dj.	December 10, 2016	♀, ad	D. D.	Skin	55700

Family: **SCOLOPACIDAE**

Genus: ***Calidris*** Merrem, 1804

Calidris falcinellus (Pontoppidan, 1763); Synonym: ***Limicola falcinellus*** (Pontoppidan, 1763) – **Broad-billed Sandpiper**

Crt. Nr.	Place of collection	Date of collection	Sex, age group	Collector's name	Preservation	Inv. Nr.
1	Bistreţ – Dj.	December 10, 2016	♀, ad	D. D.	S. P.	55702

Genus: ***Scolopax*** Linnaeus, 1758

Scolopax rusticola Linnaeus, 1758 – **Eurasian Woodcock**

Crt. Nr.	Place of collection	Date of collection	Sex, age group	Collector's name	Preservation	Inv. Nr.
1	Dobreţu – Ot.	January, 2016	○, ad.	D. D.	S. P.	55666

Genus*:* ***Limosa*** Brisson, 1760

Limosa limosa (Linnaeus, 1758) – **Black-tailed Godwit**

Crt. Nr.	Place of collection	Date of collection	Sex, age group	Collector's name	Preservation	Inv. Nr.
1	Bistreţ – Dj.	September, 2013	○, ad.	V. A.	S. P.	55398

Genus: ***Numenius*** Brisson, 1760

Numenius arquata (Linnaeus, 1758) **– Eurasian Curlew**

Crt. Nr.	Place of collection	Date of collection	Sex,age group	Collector's name	Preservation	Inv. Nr.
1	Bistreţ – Dj.	December 10, 2016	○, ad.	D. D.	S. P.	55701

Family: **LARIDAE**

Genus: ***Larus*** Linnaeus, 1758

Larus cachinnans Pallas, 1811 – **Caspian Gull**

Crt. Nr.	Place of collection	Date of collection	Sex, age group	Collector's name	Preservation	Inv. Nr.
1	Urzicuța – Dj.	November 15, 2014	○	Ghe. A.	S. P.	55399

Order: **CORACIIFORMES**
Family: **ALCEDINIDAE**
Genus: ***Alcedo*** Linnaeus, 1758
Alcedo atthis (Linnaeus, 1758) – **Kingfisher**

Crt. Nr.	Place of collection	Date of collection	Sex, age group	Collector's name	Preservation	Inv. Nr.
1	Bistreț – Dj.	December 10, 2016	○, Imm.	D. D.	S. P.	55703

Order: **PASSERIFORMES**
Family: **ORIOLIDAE**
Genus: ***Oriolus*** Linnaeus, 1766
Oriolus oriolus (Linnaeus, 1758) – **Golden Oriole**

Crt. Nr.	Place of collection	Date of collection	Sex, age group	Collector's name	Preservation	Inv. Nr.
1	Fărcaș – Dj.	July, 2013	○, Imm.	R. M.	S. P.	55400
2	Călugărei-Urodel (Dj.)	September 17, 2016	○, Imm.	P. I.	S. P.	55707

In Table 1, for each recorded bird species, we noted the phenology, preferred habitat and threat status at a national and European level, as these data help us to better understand their faunistic value.

Table 1. The habitat, the phenological type, and the threat status of the species of birds, introduced into the patrimony of the Oltenia Museum.

Nr.	Species	Habitat		The phenological type	Threat / Preservation Status	
		Aquatic	Terrestrial		Romania	Europe
1	*Tachybaptus ruficollis*	t	-	SV, rW	-	S
2	*Microcarbo pygmaeus*	t	-	SV	V	V
3	*Botaurus stellaris*	t	-	SV, P, rW	-	(V)
4	*Ardea alba*	t	-	SV, P, rW	E	S
5	*Phoenicopterus roseus*	t	-	Er	-	L
6	*Tadorna tadorna*	t	-	SV, rW	V	S
7	*Anas platyrhynchos*	t	+	PM, WV	-	S
8	*Accipiter gentilis*	t	-	R	-	S
9	*Accipiter nisus*	+	t	R, P, WV	-	S
10	*Buteo buteo*	+	t	R, P, WV	-	S
11	*Perdix perdix*	-	t	R	-	V
12	*Phasianus colchicus*	-	t	R	-	S
13	*Crex crex*	t	+	SV	V	V
14	*Himantopus himantopus*	t	-	SV	E	S
15	*Recurvirostra avosetta*	t	-	SV	V	L
16	*Calidris falcinellus*	t	-	P	-	(V)
17	*Scolopax rusticola*	t	-	P, SV, rW	-	V
18	*Limosa limosa*	t	-	P	-	V
19	*Numenius arquata*	t	-	P	-	D
20	*Larus cachinnans*	t	-	P, SV	-	-
21	*Alcedo atthis*	t	-	R/PM, WV	-	D
22	*Oriolus oriolus*	-	t	SV	-	S

Legend: Habitat: t – typical (specific); + – complementary (secondary). The Phenological type: R – resident; PM – partially migratory; SV – summer visitors; WV – winter visitors; P – passage visitors, Er – erratic, r - rare. Threat status: E – endangered, V – vulnerable, D – declining, L – limited area, S – safe, () – provisional status.

Most of the recorded species (17) are specific to the aquatic environment, most of them being found dead or injured in area of Bistreț Lake (the Floodplain of the Danube, in the south of Dolj County).

In terms of conservation, in Romania, six of the species are listed as vulnerable species (*Microcarbo pygmaeus, Tadorna tadorna, Crex crex, Recurvirostra avosetta*) or endangered species (*Ardea alba, Himantopus himantopus*) in the Red Book of Vertebrates (MUNTEANU, 2005); at European level (according to HAGEMEIJER & BLAIR, 1997), almost half of the species present different degrees of threat (vulnerable - 6 species, declining - 2 species, limited area - 2 species), and the rest are safe. Two of the species (*Phoenicopterus ruber* and *Numenius arquata*) are singular in the ornithological collection of O.M.C., adding value to the ornithological patrimony of the museum.

CONCLUSIONS

Between 2014 and 2019, 34 ornithological pieces were introduced in the patrimony of the Oltenia Museum Craiova, representing 22 bird species belonging to 21 genera, 13 families and 11 taxonomic orders. Most of these are typical aquatic species, of which *Phoenicopterus ruber* and *Numenius arquata* are singular in the ornithological collection of the O. M. C., adding value to the ornithological patrimony of the museum. Six species (*Microcarbo* *pygmaeus, Ardea alba, Tadorna tadorna, Crex crex, Himantopus himantopus* and *Recurvirostra avosetta*) are listed in the Red Book of Vertebrates from Romania.

For each registered bird specimen, we presented the following data sequence: place and date of collection, age and sex, collector's name, preparation and preservation method and inventory number.

The paper aims at completing the latest edition of the Ornithological Catalogue of the Museum Oltenia Craiova.

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Ridiche Mirela Sabina

Museum of Oltenia Craiova – Natural Sciences Department, Str. Popa Șapcă, no. 8, Craiova, 200422, Romania.

E-mail: rimirela@yahoo.com

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AN EVALUATION OF THE WINTERING OF THE WHITE–TAILED EAGLE (AVES: *Haliaeetus albicilla*) POPULATION IN THE DANUBE DELTA BIOSPHERE RESERVE AND ITS SURROUNDINGS DURING 2016 – 2018 (ROMANIA)

ALEXE Vasile, DOROȘENCU Alexandru, MARINOV Mihai, KISS J. Botond, BOLBOACĂ Lucian-Eugen, TUDOR Marian, MURARIU Dumitru

Abstract. The number of White-tailed Eagles (*Haliaeetus albicilla* Linnaeus 1758) wintering in the Danube Delta Biosphere Reserve (D. D. B. R.) was investigated in the period 2016 - 2018. In the period between October through March of each year we recorded a total of 312 individuals. Of these, 67% were adult birds, 17% juveniles and 16 % immature. The wintering WtE densities were calculated for the year 2016 as having a value of 0.015 individuals/km², for 2017 to 0.022 i/km² and for 2018 to 0.015 i/km². In 2017 we recorded 132 individuals, out of which more than a half (55%) were recorded in the Șontea - Fortuna Complex, followed by the Gorgova - Uzlina Complex, with 31%. Razim - Sinoe, Dunavăț - Dranov, Matița - Merhei and Roșu - Puiu Complex each have no more than 6% of the recorded individuals. The WtE densities recorded during the synchronous counting of 2017 were 0.247 i/km² for Șontea - Fortuna, 0.139 i/km² for Gorgova - Uzlina, 0.026 i/km² for Matița - Merhei, 0.016 i/km² for Dunavăț - Dranov, 0,015 i/km² for Razim - Sinoe and 0,007 i/km² for Roșu - Puiu. The sedentary wintering individuals corroborated with the northern population of individuals wintering in the Danube Delta highlights the importance of Danube Delta ecosystems in the annual movements of the species.

Keywords: wintering, *Haliaeetus albicilla,* White-tailed Eagle, D. D. B. R.

Rezumat. Evaluarea efectivelor de codalb (Aves: *Haliaeetus albicilla*) care au iernat în Rezevația Biosferei Delta Dunării și zonele limitrofe în perioada 2016 – 2018 (România). În cursul cercetărilor de iarnă din perioada 2016 - 2018, în Rezervația Biosferei Delta Dunării (R. B. D. D.) și zona limitrofă, s-au urmărit numărul codalbilor (*Haliaeetus albicilla* Linnaeus 1758) care iernau în acest teritoriu. În lunile octombrie – martie s-au înregistrat în total 312 indivizi, din care 67% adulți, 17% juvenili și 16% subadulți. Densitatea codalbilor a fost calculată în 2016 la 0,015 indivizi/km², în 2017 la 0.022 indivizi/km² iar în 2018 la 0,015 indivizi/km². În 2017, au fost observați 132 de indivizi de codalb, din aceștia mai mult de jumătate s-au aflat în complexul Șontea - Fortuna cu 55%, urmat de complexul Gorgova - Uzlina cu 31%, iar restul complexelor în Razim - Sinoie, Dunavăț - Dranov, Matița - Merhei și Roșu - Puiu nu depășesc nici unul 6%. Distribuția densității codalbilor pe km² cu ocazia recensământului sincron din 2017 în complexul Șontea-Fortuna a fost 0.247 indivizi/km², urmat de Gorgova - Uzlina cu 0.139, Matița - Merhei cu 0.026, Dunavăț - Dranov cu 0.016, Razim - Sinoie cu 0.015 indivizi/km² și Roșu - Puiu cu 0.007 indivizi/km². Iernarea populației sedentare și aglomerările efectivelor nordice subliniază importanța ecosistemelor deltaice în deplasările perianuale ale speciei studiate.

Cuvinte cheie: iernare, *Haliaeetus albicilla,* codalb, R. B. D. D.

INTRODUCTION

According to the literature, in Europe White-Tailed Eagle is considered a partially migratory species (the northern population), while in Romania it is classified as a breeding species, as well as winter visitor and transit species.

There are two sub-populations in Europe. First, the northern one, and second a southern one, from the Danube countries: Germany, Austria, Slovakia, Hungary, Croatia, Serbia, Bulgaria, Romania, Ukraine. The individuals of this population are breeding mainly on the Danube Valley and the Danube Delta Biosphere Reserve (D. D. B. R.). The WtE population from these countries is around 650 pairs, out of which approximately 200 breeds across the Danube River course (PROBST & GABORIK, 2012). In the D. D. B. R. the largest number of WtE individuals can be seen during the winter, when the local population is increased by the northern migratory birds, from Scandinavia, Belarus, Poland, Russia, etc. Regarding this, we have data from birds ringed from abroad, and recovered in D. D. B. R. (CĂTUNEANU, 1999; KISS, 2000; unpublished data). Data regarding the wintering areas of WtE are known from literature (CIOCHIA, 1971; CĂTUNEANU, 1973; KISS, 1971, 1973; KLEMM, 1973; MARINOV, 1993, 1997; POCORA & ION, 2005, 2006; POCORA, 2007). The observations cited in the literature usually mention no more than 10-12 observed individuals at once. Rarely some mention groups of 15 - 20 individuals of WtE, in the areas where waterfowls congregate. The maximum number of WtE during one observation was of 22 individuals in flight above the Letea forest on 27.11.2014 (POCORA, 2007, 2010). On the other hand, during a synchronous count in DDBR on 12.01.2014, 163 individuals were recorded (PROBST et al., 2014). In Bulgaria, between 2006 and 2012 the number of wintering individuals had large fluctuations, between 17 and 34 individuals (TODOROV et al., 2015). In Holland, between 2003 and 2010, in an area with the same habitat as D. D. B. R., but smaller in size, 15 – 26 individuals were regularly seen every winter, most of them being immature (RIJN et al., 2010). Between 2002 and 2017, autumn migration observations were carried out in Măcin Mountains. Here, the medium number of passing WtE was of 9.8 individuals (FÜLÖP et al., 2018). The same author mentions in autumn of 2012, in Greci, Văcăreni and Cerna areas, between 2 and 7 individuals (FÜLÖP et al., 2012). In the winters of 2008 and 2009, 12 individuals were seen feeding in the Zebil Lake area (ALEXE et al., 2011).

MATERIAL AND METHODS

The WtE winter monitoring in D. D. B. R. was conducted between 2016 – 2018, in the month between October through March. Transect and fixed points methods were used (BIBBY et al., 2000). For the field trips we used different motorboats. The monitoring was carried out daily in the aforementioned period on three aquatic complexes: Șontea - Fortuna, Uzlina - Gorgova and Razim - Sinoe. Other areas from D. D. B. R. and surroundings were occasionally visited. For our analysis we took in consideration only the data gathered during one day of synchronous monitoring in each month. The total number of individuals, age, place, activity and risk factors were recorded on a standard form. All the data was introduced in an electronic database. These were used to generate maps of the wintering WtE distribution in D. D. B. R. and surroundings. The maps were generated in QGIS software. For the WtE densities we used the following formula (KENNETH et al., 1981): D = N/A, where D = WtE density, N = number of recorded individuals, A = monitoring surface (D. D. R. B.).

RESULTS AND DISCUSSION

Fig. 1 shows the WtE age repartition during wintering between 2016 -2018 in DDBR and its surroundings. During the 3 years of research, the total recorded number of WtE was of 312 individuals. 67 % of them were adults, 17% juvenile and 16 immature (Fig. 2).

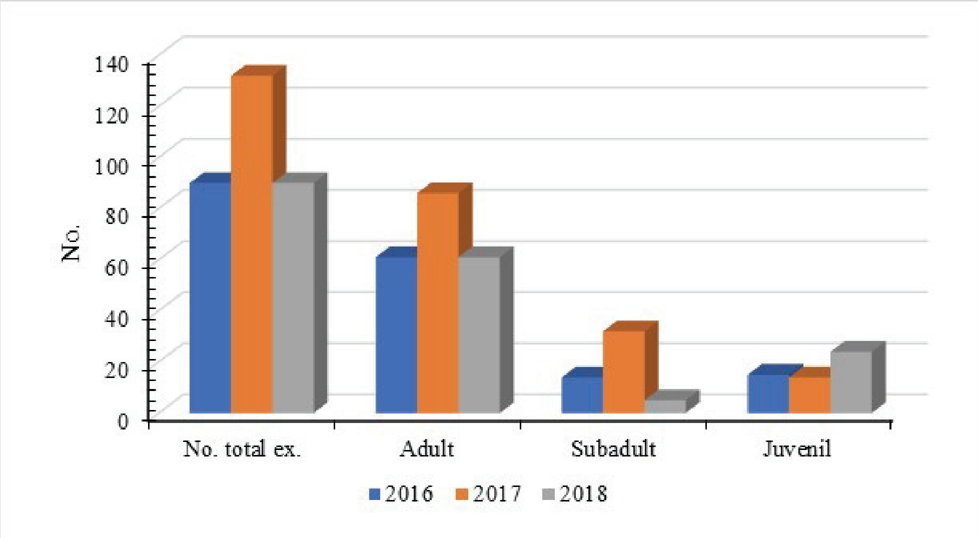

Figure 1. WtE - *Haliaeetus albicilla* age repartition investigated during 2016 – 2018 in D. D. B. R. and surroundings.

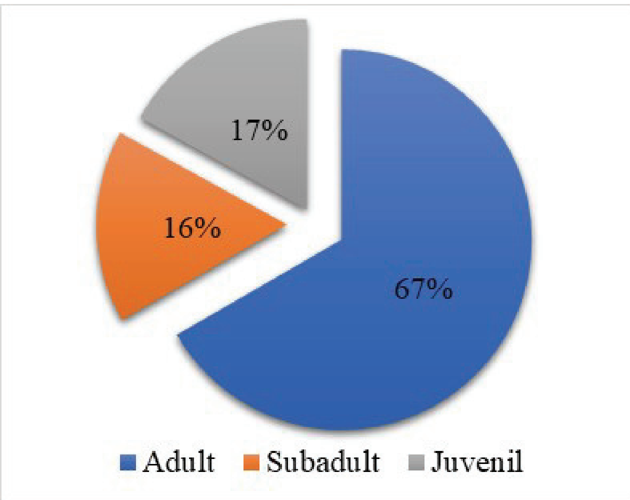

Figure 2. Wintering WtE - *Haliaeetus albicilla* age ratio during 2016 – 2018 in D. D. B. R. and surroundings.

The analysis regarding the age of WtE that wintered in D. D. B. R. and its surroundings shows that over half of the individuals were adults. The vagrant character of young WtEs is well known from literature, and was also documented by satellite tracking in a project initiated by I. N. C. D. D. D Tulcea (unp. data). Thus one can expect a higher proportion of young birds. However, we presume that the remarkable high longevity of the species lead to the change in age ratio, thus adult birds having the highest percent. In 2016 the density of WtE in D. D. B. R. was of 0.015 individuals/km². In 2017 the density reached 0.022 i/km², while in 2018 - 0.015 i/ km². Regarding aquatic complexes, during synchronous counting of 2017, when we recorded 132 individuals in total, more than a half (55 %) were recorded in Șontea-Fortuna complex, followed by Gorgova-Uzlina with 31%, while each of the Razim-Sinoie, Dunavăț-Dranov, Matița-Merhei și Roșu-Puiu complexes had under 6%. The highest density was recorded in the Șontea-Fortuna complex, with 0. 247 individuals/km², followed by Gorgova-Uzlina with 0.139 i/km², Matița-Merhei - 0.026 i/km², Dunavăț-Dranov - 0.016 i/km², Razim-Sinoie - 0.015 i/km² and Roșu-Puiu - 0.007 i/km².

Figs. 3 and 4 show that the concentrations of more than 4 individuals of WtE are localized in the areas with large water surfaces: Lumina, Văcaru, Lunga, Fortuna, Meșterul, Alb, Nebunu, Parcheș, Dranov, Sinoie-Sud Lakes, Murighiol Pond, Musura Gulf, Holbina, Sf. Gheorghe Branch, Dunărea Veche (Tulcea) and the Iancina Cape. One hypothesis is that during the winter these areas sustain large gatherings of waterfowls, which are part of the WtE prey.

The largest number of WtE recorded during a synchronous count was 38 individuals, on 23.11.2017.

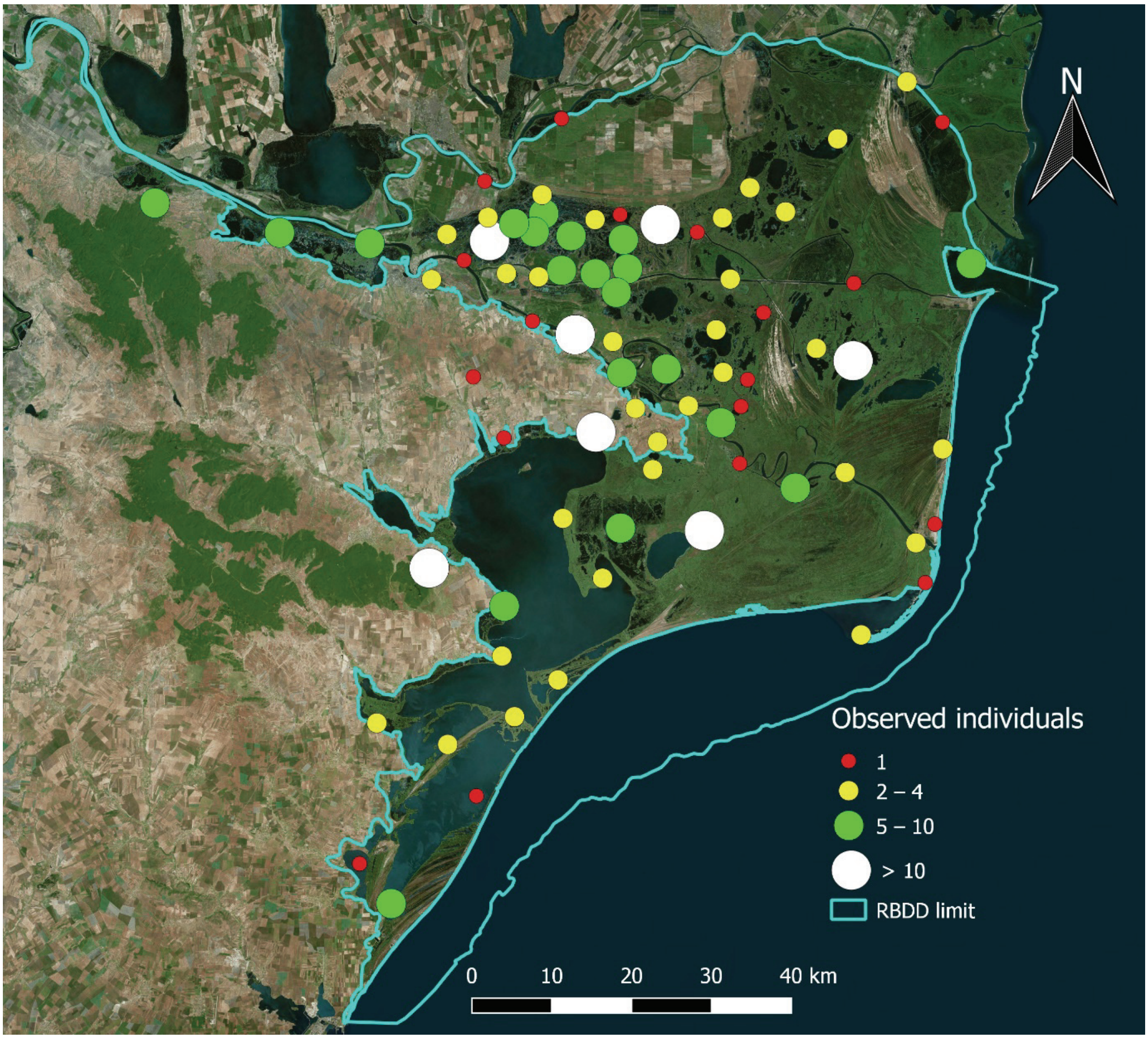

Figure 3. General distribution of White-Tailed Eagle – *Haliaeetus albicilla* during winter in D. D. B. R. and its surroundings (original).

The spatial dispersion during the winter of WtE can be influenced by environmental conditions and anthropogenic factors like forestry exploitations or fishing camps. We consider, however, that during the winter extreme cold and powerful winds are the most important factors influencing the species spatial distribution.

When ice forms on the lakes and the waterfowls migrate southwards, the WtE follows them, only to return in the spring with its potential prey.

The Fig. 4 shows the distribution and the number of WtE recorded when hunting. Here also the largest gathering is in Șontea-Fortuna.

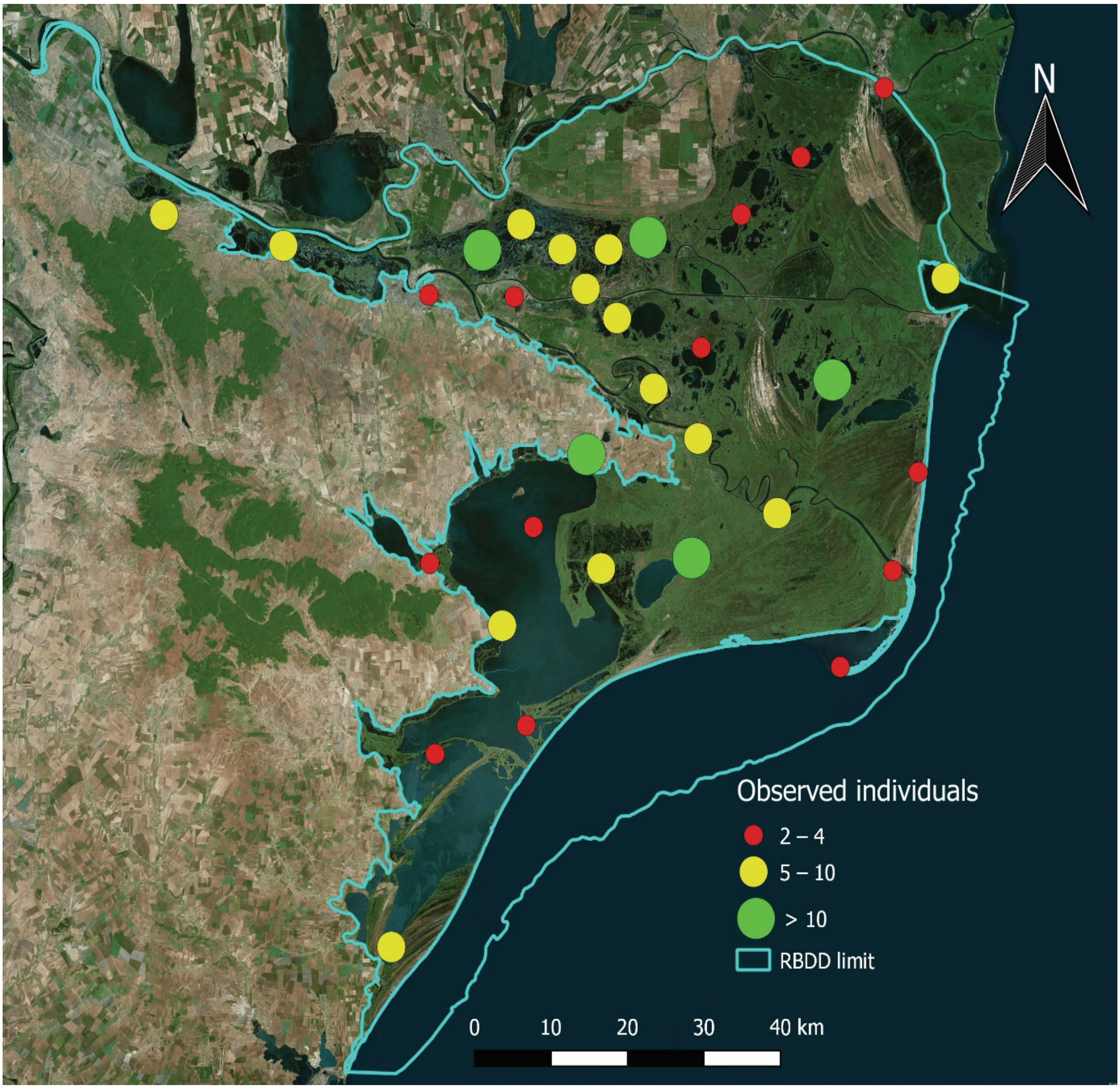

Figure 4. White-Tailed Eagle – *Haliaeetus albicilla* hunting areas during winter from D. D. B. R. and its surroundings (original).

The roosting places can be several kilometers away from hunting areas, but in general birds are searching for maximum efficiency in movements with minimum energy consumption. Fig. 5 shows the WtE roosting areas from D. D. B. R. and its surroundings (Letea Forest, Caraorman, Babadag - Enisala, Tichilești, Caraburun, Vadu and Păpădia and Rusca Forest Plantations). From the 8 identified roosting areas, 4 are within D. D. B. R., and 4 outside, in the continental area. These last 4 sites are situated between 1 and 5 km away from the D. D. B. R. limits. All these forests have tall mature trees that serve as roosting support for WtE only during winter. In all of the 8 sites there were regularly observed over 10 individuals. Isolated individuals can, of course, roost in other places in D. D. B. R., but we consider that these are the most important ones. The WtEs roost during night in these places, and in the morning search their prey both in the continental area, as well as in D. D. B. R. The largest number of recorded individuals during one visit in one of the roosting sites was 30, in Babadag – Enisala, on 19.12.2016.

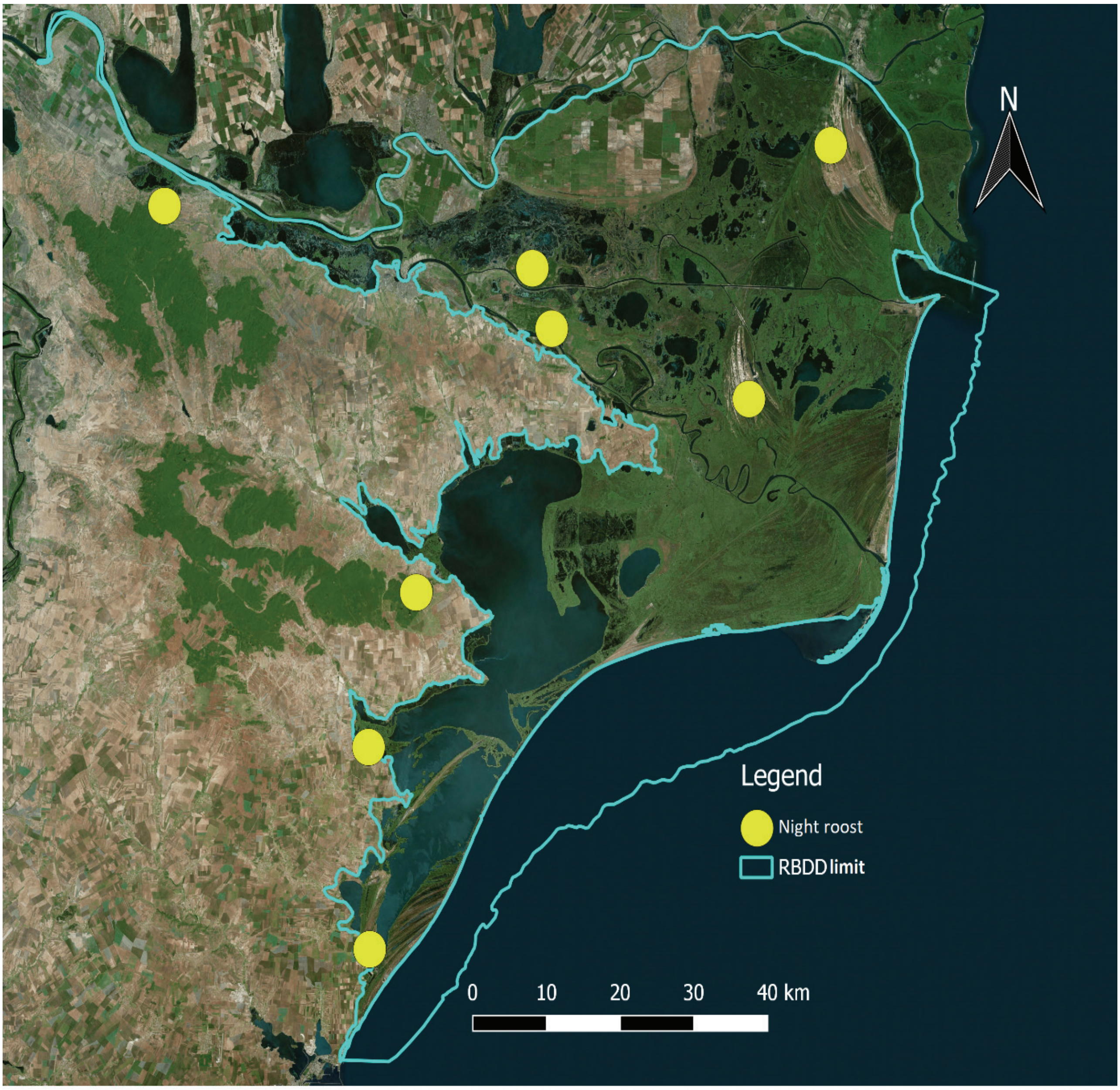

Figure 5. White-Tailed Eagle (*Haliaeetus albicilla*) roosting sites from D. D. B. R. and its surroundings (original).

The sedentary character of the Danube Delta WtE population and winter visitors from the northern population in the study areas can be explained by a rich food resource during cold season. The birds of prey follow flocks of waterfowls during their migration to those wetlands that are free from ice. Here, weakened, sick or injured birds, as well as their corpses, offers a rich food supply for the WtEs. Beside food availability, an important factor is the availability of good roosting places, with tall mature trees. Weather conditions, anthropogenic disturbances are some other actors that presumably influence both the prey (waterfowls) and the WtE distribution.

The WtE of populations wintering in D. D. B. R. has yearly fluctuations, thus these studies are a necessity in the context of the management of this species, as WtE is an indicator of the quality of biodiversity in Danube Delta Biosphere Reserve.

It is worth mentioning that, after the end of the winter season, part of the number of the White-tailed Eagle that were in D. D. B. R. and in the adjacent areas did not leave the winter quarter, heading north to track the water birds returning to nesting areas. At the beginning of the spring period, massive agglomerations around the Sarinasuf pond were reported. Thus, on April 6, 2019 we observed 44 individuals (20 adults and 24 immatures), while on April 7, 2019 30 individuals (15 adults and 15 immatures) (Fig. 6). White-tailed Eagles focused on a bay, where fish banks gathered on shallow and warmer water, a fact indicated by the presence of other fish-eating birds – large cormorants and common pelicans. WtEs fished according to their usual behaviour, diving from the air, but also to their feet, walking in the small water. After consuming their prey on the shores of the pond, the birds were scattered around the surrounding fields, in the absence of support trees, at distances of 600-800 m.

Due to the fact that this was the largest gathering of WtE from our own observations and in the literature (KISS, 1971; POCORA, 2010), we consider that migrating individuals heading northwards added to the D. D. B. R. wintering individuals, which stopped for a rich food supply.

Figure 6. White-tailed Eagle (*Haliaeetus albicilla*) observed on April 06, 2019 in the Sarinasuf pond (original).

CONCLUSIONS

D. D. B. R. is an important area for wintering WtE, both for local birds, as well as for winter visitors that follows waterfowl flocks during their migration.

In the winter, gatherings over 10 individuals of WtE are located in Somova - Parcheș, Șontea - Fortuna, Matița - Merhei, Isac - Uzlina and Razim - Sinoie aquatic complexes, where their favourite prey, waterfowls, are also concentrated.

The close vicinity of forests with large mature trees used as roosting places is a key element for WtE concentrations.

At the beginning of spring season, the WtE population in D. D. B. R. appears to grow, as migrating individuals heading northwards adds to the local wintering population.

The WtE monitoring is essential for the species management, as it is a quality indicator for the biodiversity in D. D. B. R.

According to our estimates, the wintering population of WtE in each winter could be between 200 and 350 individuals.

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Nucleu ”Delta Dunarii 2018”, proiectul PN6/2018: ”Cercetări privind bolile infecțioase și parazitozele cu caracter zoonotic la animale sălbatice şi domestice din Rezervația Biosferei Delta Dunării”; Programul Nucleu ”Delta Dunarii 2018”, proiectul PN14/2018: ”Evaluarea stării actuale a ecosistemelor acvatice de pe teritoriul Rezervației Biosferei Delta Dunării”; ”Cercetări în sprijinul dezvoltării capacităţii de monitorizare, evaluare şi valorificare a resurselor naturale oferite de zonele umede de importanţă internaţională din România şi de zona costieră a Mării Negre”; ”Inventariere şi monitorizare reţele electrice dunărene”, în cadrul proiectului DANUBEparksCONNECTED - Bridging the Danube Protected Areas towards a Danube Habitat Corridor (DANUBEparksCONNECTED - Rețeaua de Arii Protejate Dunărene, un Coridor de Habitate al Dunării).

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Alexe Vasile
Danube Delta National Institute for Research and Development, Street Babadag 165, Tulcea 820112, Romania.
University of Bucharest, Faculty of Biology, Splaiul Independenței, 91-95, Bucharest, R-050095, Romania.
E-mails: vasile.alexe@ddni.ro, alexe_vasile@yahoo.com

Doroșencu Alexandru, Marinov Mihai, Kiss Janos Botond, Bolboacă Lucian-Eugen, Tudor Marian
Danube Delta National Institute for Research and Development, Street Babadag 165, Tulcea 820112, Romania.
E-mails: alexandru.dorosencu@ddni.ro, mihai.marinov@ddni.ro, jbkiss03@yahoo.com, lucian.bolboaca@ddni.ro, marian.tudor@ddni.ro

Murariu Dumitru
Department of Ecology, Taxonomy and Environment Protection, Romanian Academy's Institute for Biology, 060031 Bucharest, Romania.
E-mail: dmurariu@antipa.ro

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SOME OBSERVATIONS REGARDING THE EURASIAN PIGMY OWL (*Glaucidium passerinum* LINNAEUS, 1758) FROM THE FĂGĂRAŞ, IEZER-PĂPUŞA AND LEAOTA MOUNTAINS (SOUTHERN CARPATHIANS, ROMANIA)

MESTECĂNEANU Adrian, MESTECĂNEANU Florin

Abstract. Some results of a study on the Eurasian Pygmy Owl (*Glaucidium passerinum* Linnaeus, 1758) performed during 2015-2019 in the Făgăraş, Iezer-Păpuşa and Leaota Mountains from Southern Carpathians (Romania) are presented in the paper. Local particularities of the occurrence and biology of the species in the area were followed and the distribution on habitats and sea level altitude, as well as the influence of the monthly and diurnal periods and of the weather conditions on its vocal activity in the breeding time were analysed. Because it is mentioned in Annex I of the Birds Directive, the species needs protection, in an area affected by intense forestry exploitations.

Keywords: Pigmy Owl, playback, habitats, weather conditions, protection.

Rezumat. Unele observaţii privind ciuvica (*Glaucidium passerinum* Linnaeus, 1758) din Munţii Făgăraş, Iezer-Păpuşa şi Leaota (Carpaţii Meridionali, România). În lucrare sunt prezentate câteva rezultate ale unui studiu referitor la ciuvică (*Glaucidium passerinum* Linnaeus, 1758), realizat în perioada 2015-2019 în munţii Făgăraş, Iezer-Păpuşa şi Leaota din Carpaţii Meridionali (România). Au fost urmărite, îndeosebi, particularităţi locale ale răspândirii şi biologiei speciei în zonă, analizându-se distribuţia sa pe habitate şi altitudine, precum şi influenţa perioadelor lunare şi diurne şi a condiţiilor meteo asupra activităţii sale vocale din perioada de împerechere. Aparţinând Anexei I a Directivei Păsări, specia necesită protecţie, într-o zonă care se confruntă cu intense exploatări forestiere.

Cuvinte cheie: ciuvică, playback, habitate, condiţii meteo, protecţie.

INTRODUCTION

Because of its secretive life and commonly hard conditions of surveillance, caused by weather and relief, the Eurasian Pigmy Owl (*Glaucidium passerinum* Linnaeus, 1758) from Romania was rarely a focus for ornithologists. While the species was monitored on a regular basis in the Eastern Carpathians (https://milvus.ro/), except for a few information (DARÓCZI, 2014), no results were published. Instead, some observations about the species can be found on the on-line ornithological national databases (http://pasaridinromania.sor.ro/ornitodata, http://www.openbirdmaps.ro/, https://rombird.ro/). Also, several issues mention it in the mountains from Romania (PAŞCOVSCHI, 1959; RADU, 1967; VASILIU & ŞOVA, 1968; MĂTIEŞ, 1979; KLEMM & KOHL, 1988; POP et al., 2008; MUNTEANU, 2009, 2012). From Făgăraş - Iezer - Păpuşa - Leaota area, there are some indications on its presence, too (LINŢIA, 1954; BĂCESCU, 1961; CIOCHIA, 1992; GEORGESCU & GEORGESCU, 1996; MUNTEANU et al., 2002).

The main aim of the study was to find some local particularities of its distribution in the area as well as of its biology.

MATERIAL AND METHODS

The Pigmy Owl is the smallest species of owl from Europe. It breeds in coniferous or mixed forests in the boreal zone or in the mountains of the Central Europe, where it prefers the mature spruce or the fir forests. It has a crepuscular activity and it eats birds and voles and nests in a hole in a tree. It is a chiefly resident species (SVENSSON et al., 2009), although, at least in the North of Europe (Central Sweden) some individuals, mostly juveniles, migrate long distances (few hundred of kilometres) mainly between September 15 and October 15 (POLAKOWSKI et al., 2008). Also, it inhabits cultivated forests containing artificial clearings, completely deforested sections and scattered uncut island-stands, but its prime habitat is represented by richly structured, lighter and more open stands of climax coniferous forests dominated by common spruce (MIKKOLA & SAKL, 1997). In Romania, it lives in the huge forests of spruce, up to their upper border, in a cold and wet environment; maybe in mixed forests (MUNTEANU, 2009). It prefers the mountain forests of Norway spruce and fir (DARÓCZI, 2014) and the heterogeneous and tall spruce forests, with fillings. Its presence was noted in a few points, mainly in the Oriental Carpathians and on the Northern slopes of the Southern Carpathians, as well as in the Banat Mountains (MUNTEANU, 2012). During the winter, some specimens execute small altitudinal movements (BIELZ, 1887).

The area of study included the southern versants of the Făgăraş Mountains and the Iezer-Păpuşa and Leaota Mountains (Fig. 1), all placed in the eastern part of the Southern Carpathians (also, know as Transylvanian Alps).

The relief is constituted by ridges that leave from the main crest on north-south direction, in the Făgăraş Mountains, on south-east direction, in the Iezer-Păpuşa Mountains, and radial, from the high peaks, in the Leaota Mountains. The main summits are: Moldoveanu (2,544 m), Negoiu (2,535 m), Viştea Mare (2,527 m), Lespezi (2,517 m) from the Făgăraş Mountains, Roşu (2,469 m) from the Iezer-Păpuşa Mountains, and Leaota (2,133 m) from the Leaota Mountains.

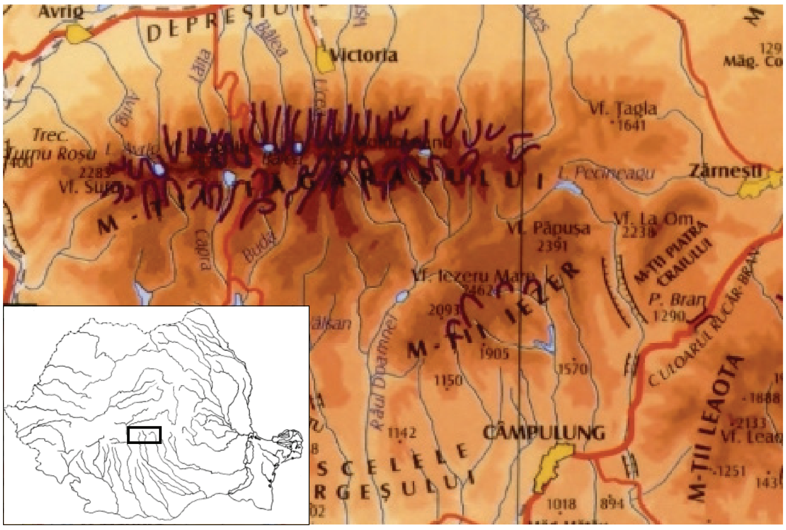

Figure 1. The map of the area (modified, by http://elearning.masterprof.ro/).

The hydrographical system of the investigated area is rich. The Topolog River, tributary of the Olt River and the Argeş River, with its branch – Râul Doamnei, spring from the southern slopes of the Făgăraş Mountains, and Bratia, Râul Târgului, some streams of Râul Doamnei and Argeşel, which flow together toward the Argeş River, spring from the Iezer-Păpuşa Mountains. On the other side, Dâmboviţa River collects most of its water from Leaota Mountains.

The climate is temperate continental with mountain features. The average temperature is -2 ^{0}C on the highest peak of the Făgăraş Mountains, where, in January, the lowest average value (-9 ^{0}C) is recorded. Nebulosity manifests most of the time (over 200 cloudy days/year). The level of precipitations exceeds 1,200 mm/year on the heights and even 1,400 mm/year on the tallest peaks. The snow cover is present on the crests between 150 and 200 days/year and the wind blows strongly mainly at the end of the winter and at the beginning of spring (BARCO & NEDELCU, 1974).

The vegetation is diverse, depending on the relief. At the lower level (up to ca. 1,200 m) there are forests of beech (*Fagus sylvatica* L.) and other wood species, at the middle level (up to 1,450 m) there are mixed forests of beech and Norway spruce (*Picea abies* (L.) Karst.) or Silver fir (*Abies alba* Mill.) and at the upper level (up to 1,850 m) there are forests of Norway spruce. The sub-alpine level (up to 2,200 m) is dominated by Dwarf mountain pine (*Pinus mugo* Turra) and Common juniper (*Juniperus communis*) and, in the alpine level (over 2,200 m), *Festuca supina* Schur., *Carex curvula* All., *Agrostis rupestris* All., *Oreochloa disticha* (Wulfen) Link, *Nardus stricta* L. are the most frequent species (DONIŢĂ et al., 2005; ALEXIU, 2008).

As methodology, we used the method of playback (DARÓCZI, 2014, modified). To test the method, the points of playback were randomly chosen in all types of forests from the area and in various weather conditions. Some of them were chosen in places with bad detectability and other in places with good visibility (deforested areas near the woods, exposed ridges or valleys, upper limit of the spruce forest, etc.). So, there were 41 days of field trips and 111 points of observations. 52.25% of the points of observation had adequate conditions for observations (adequate meteorological conditions, without abundant rainfall or snowfall or wind over 3 on the Beaufort scale of intensity, favourable habitat, which means relative or mature mixed or coniferous forests, lack of the stream noise, medium and good position as detectability) and 47.75% of the points of observation had good conditions for observations (the same elements like previously, but only good position as detectability, when the points from the closed forests were eliminated) (Table 1). The distance between the points of playback was more than 700 m. The period of monitoring was October-April, although an intense vocal activity of the birds can occur in September, too, and the points were passed once. The diurnal time of monitoring was between 8:00 and 17:00 (GMT+2). Normally, 5 minutes (alternatively, 1 minute calling, 1 minute listening) were reserved on every point of playback and, to reduce the stress on the birds, the calling generally ceased when the individuals were heard. The alarm behaviour of other birds was observed to find the individuals. In every point of playback, information about the species, the habitat, GPS coordinates, cote, date, hour, weather conditions were noted. As temperature of the air, the interval of monitoring was between -15 and 14 ^{0}C, and the types of clouds were used according to the speciality classification (http://www.cas.manchester.ac.uk/). For nebulosity, the sky was divided in ten parts and the coverage of clouds was visually estimated.

As tools, we used binoculars, camera, maps, GPS gadget, field journals, calling device, winter equipment (inclusively for deep snow) and a non-lethal kit of protection against aggressive animals.

RESULTS AND DISCUSSIONS

In 58.54% of the days of field trips and in 27.03% of the points of observations, individuals were registered. Among the latest, in 90% one individual was observed and in 10%, 2 individuals (on 28.I.2018, 25.III.2018, 9.XII.2018). On the whole, 33 individuals were registered. They were observed only in 50.00% of the points with adequate conditions for observations and only in 52.83% of the points with good conditions for observations (Table 1). 1 individual (1.89%) was recorded in a point with inadequate conditions for observations (interior of compact mature forest of spruce).

It is interesting to mention that the individuals were not observed in the points of playback situated in young forests and in relative young forests, near the noisy streams, and in the compact forests, because of the bad conditions of sound propagation (exception – 1 individual registered in a mature forest of spruce, as we saw earlier). Also, the individuals were absent from the observations on windy weather (over 3 on Beaufort scale) and in situations of abundant snowfall (Table 2).

Table 1. Some synthetic parameters of the observations of Eurasian Pygmy Owl (*Glaucidium passerinum*).

Parameter	Value	% of total	% of subtotal
No. days of field trips	41	100.00	-
No. days with observed individuals	24	58.54	-
No. days without observed individuals	17	41.46	-
No. points of observations	111	100.00	-
No. points with observed individuals	30	27.03	-
No. points with 1 observed individual	27	24.32	90.00
No. points with 2 observed individuals	3	2.70	10.00
No. points without observed individuals	81	72.97	-
No. individuals	33	100.00	-
No. points with adequate conditions for observations	58	52.25	-
No. points with inadequate conditions for observations	53	47.75	-
No. points with adequate conditions for observations without observations	29	26.13	50.00
No. points with adequate conditions for observations with observations	29	26.13	50.00
No. points with inadequate conditions for observations without observations	52	46.85	98.11
No. points with inadequate conditions for observations with observations	1	0.90	1.89
No. points with good conditions for observations	53	47.75	-

Table 2. The situation of the points with inadequate conditions for the Eurasian Pygmy Owl (*Glaucidium passerinum*) observations.

Inadequate conditions	No. points	% of all points of observations	% of all inadequate points	Remarks
Young forests and relative young forests	19	17.12	35.85	
Wind >I:3	12	10.81	22.64	2 points in young
Abundant snowfall	3	2.70	5.66	1 point in young
Noise of streams	8	7.21	15.09	
Reduced detectability caused by forest	23	20.72	43.40	
Bad conditions caused both weather and unfavourable habitat	31	27.93	58.49	

90.91% of the individuals were observed in the Argeş hydrographical basin and 72.73% in the Făgăraş Mountains, but the distribution does not reflect the preferences of the species for these forms of relief as much as our availability to visit them (Fig. 2, Table 3).

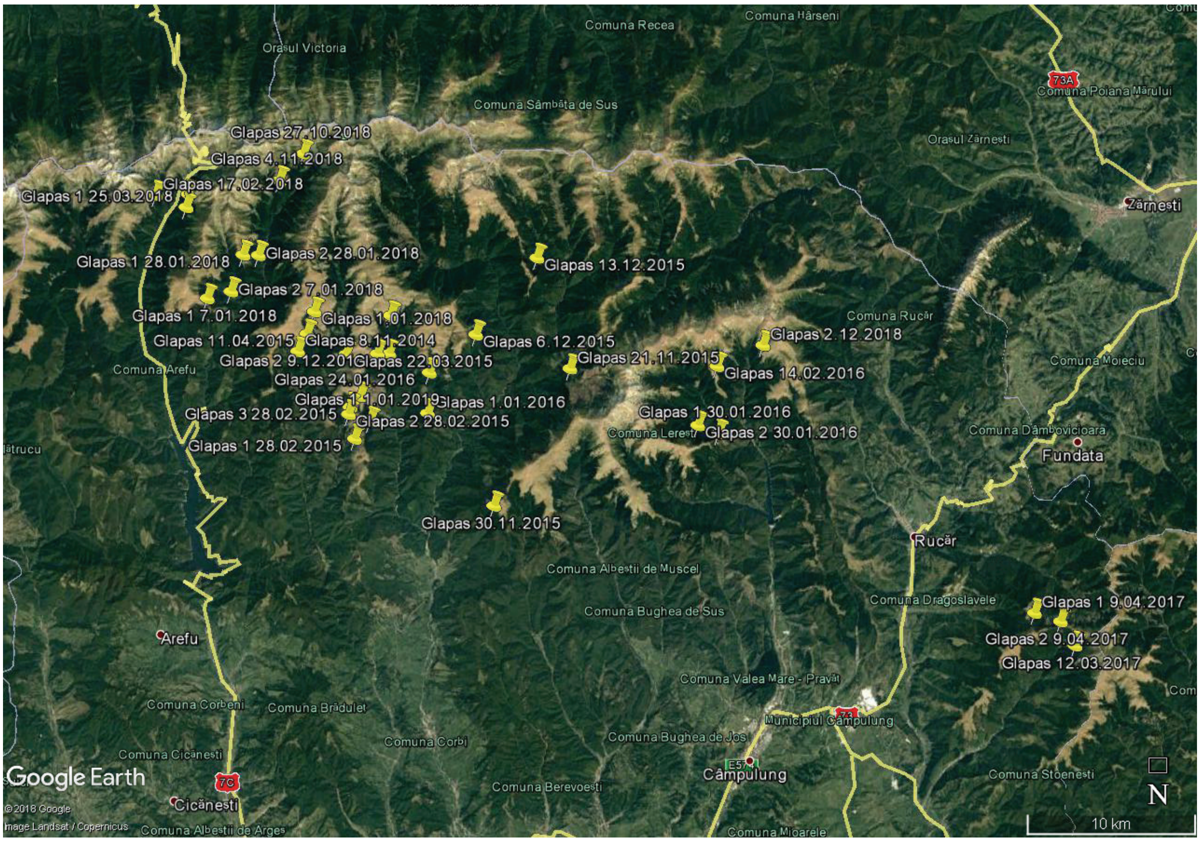

Figure 2. The map of distribution of the registered individuals of Eurasian Pygmy Owl (*Glaucidium passerinum*) (original).

Table 3. The distribution of the individuals of Eurasian Pygmy Owl (*Glaucidium passerinum*) by the main forms of relief.

The main forms of relief		No. individuals	%
Hydrographical basins	Olt Basin	0	0.00
	Argeş Basin	30	90.91
	Dâmboviţa Basin	3	9.09
Groups of mountains	Făgăraş	24	72.73
	Iezer-Păpuşa	6	18.18
	Leaota	3	9.09

From the point of view of the habitats occupied by individuals at the initial place of observation, the majority (33.39%) preferred the mature spruce forests and, a good part, the mature mixed forests with clearings (24.24%) or the mature spruce forests with clearings (24.24%). The fewest of them (3.03%) were registered in the mature mixed forests and in the relative mature spruce forests with clearings (Table 4). According to other authors, the species favours richly structured habitats with mature trees, clearings, dense groups of young spruce, etc., the nest being often placed in coniferous trees, especially in spruces, but also in birch and beech (KÖNIG & WEICK, 2008). In Western Rhodope Mountains (Southern Bulgaria), the species prefers old Spruce and Spruce - Scots Pine (*Pinus sylvestris* L.) forests and much more rarely, the mixed ones. It was found in few cases in much younger forests, between 50 and 80 years (SHURULINKOV et al., 2012). In the Swiss Jura Mountains, the Pygmy Owl was found in spruce as well as fir (50%) forests, and the most of the occupied cavities were in trees surrounded by natural regeneration (HENRIOUX et al., 2003). In old-growth forests of the southern French Prealps, optimal habitats were old-growth fir-dominated mixed forests including patches of dead spruces and edges with open habitat gaps (BARBARO et al., 2016). In Norway, the studies indicate an affinity for mature forests (STRØM & SONERUD, 2001) and in Greece, the habitat of the species was dominated by Norwegian Spruce forests (GASTERATOS et al., 2015). In Slovakia, the highest frequency of nests was found in spruce forests, in fir-beech forests and in beech-spruce-fir forests (PAČENOVSKÝ & ŠOTNÁR, 2010).

Table 4. The distribution of the individuals of Eurasian Pygmy Owl (*Glaucidium passerinum*) at the initial place of observation by the occupied habitats (n=33).

Occupied habitats by individuals	No. individuals	%
Mature mixed forests	1	3.03
Mature mixed forests with clearings	8	24.24
Relative mature spruce forests with clearings	1	3.03
Mature spruce forests	13	39.39
Mature spruce forests with clearings	8	24.24
Relative mature spruce forests	2	6.06

As it was expected, due to the placement of the playback points, most of the individuals (42.42%) were moved during the observations at the border of the spruce forest with the alpine level. A significant part remained in the mature spruce forest, while others appeared at the margin of the mature spruce forest with the clearing (Table 5).

Table 5. The distribution of the individuals of Eurasian Pygmy Owl (*Glaucidium passerinum*) at the final place of observation by the used habitat (n=33).

Habitat	No. individuals	%
Margin of mixed forest with clearing	1	3.03
Margin of spruce forest with alpine level	14	42.42
Margin of mature spruce forest with clearing	7	21.21
Mature spruce forest	9	27.27
Relative mature spruce forest	2	6.06

About the initial sea level altitude of the observed individuals (Table 6), most of them (45.45%) were recorded between 1,500 and 1,599 m, which correspond to the inferior floor of the Norway spruce forests. Only a few individuals were observed between 1,300-1,399 m and between 1,700-1,799 m. The mean was 1,567.48 m (Table 7). In the Western Rhodope Mountains, situated ca. 450 km to the South (in Bulgaria), the altitudes of the localities varied between 1,412 m and 1,930 m, on average 1,712 m (n=34), with the most between 1,700 and 1,800 m and between 1,800 and 1,900 m (SHURULINKOV et al., 2012). In Slovakia, in the High Tatra Mountains, the species bred from 420 m up to 1,600 m (where is the tree line) and occupied not only coniferous forests in high mountains, but also coniferous and broad-leaved forests (PAČENOVSKÝ & SHURULINKOV, 2008). In Greece, the altitude ranged from 1,200 to 1,600 m (GASTERATOS et al., 2015) while, in Slovakia, high prevalence of nests (72.5%) has been situated in elevations of 600-1,100 m, with an average of 840 m a. s. l. (PAČENOVSKÝ & ŠOTNÁR, 2010).

The maximum sea level altitude reached by individuals during the observations was another envisaged aspect. Most of the individuals were recorded between 1,700 and 1,799 m and only 2 (6.06%) ascended between 1,800-1,899 m (Table 8). The mean is 1,615.36 m and the maximum of 1,858 m coincides with the upper border of the Norway spruce forest (Table 9).

For comparison, the parameters of the playback points were presented in the same table. In other parts of the territory, the Pygmy Owl was occurred above 200 m, in Germany (MIKKOLA, 2012), and up to 2,150 m, in Alps (KÖNIG & WEICK, 2008).

Table 6. The distribution on intervals of altitude (m) of the recorded individuals of Eurasian Pygmy Owl (*Glaucidium passerinum*) (n=33).

Initial sea level altitude of the observed individuals	**1,300-1,399**	**1,400-1,499**	**1,500-1,599**	**1,600-1,699**	**1,700-1,799**	**1,800-1,899**
No. individuals	1	7	15	8	2	0
Weight (%)	3.03	21.21	45.45	24.24	6.06	0.00

Table 7. The main parameters of the initial sea level altitude (m) of the observed individuals of Eurasian Pygmy Owl (*Glaucidium passerinum*).

Parameter	**Value**
Mean	1,567.48
Standard Deviation	95.15
Minimum	1,313
Maximum	1,732
Confidence Level (95.0%)	33.74

Table 8. The distribution on intervals of altitude (m) of the maximum cote attained by the recorded individuals of Eurasian Pygmy Owl (*Glaucidium passerinum*) during the observations and of the sea level altitude of the playback points for the observed individuals, in brackets (n=33).

Intervals of sea level altitude	**1,300-1,399**	**1,400-1,499**	**1,500-1,599**	**1,600-1,699**	**1,700-1,799**	**1,800-1,899**
No. individuals (playback points)	1 (1)	6 (7)	7 (4)	11 (8)	5 (11)	2 (2)
Weight (%)	3.03 (3.03)	18.18 (21.21)	21.21 (12.12)	33.33 (24.24)	18.18 (33.33)	6.06 (6.06)

Table 9. The main parameters of the maximum sea level altitude (m) of the observed individuals of Eurasian Pygmy Owl (*Glaucidium passerinum*) and of the sea level altitude of the playback points for the observed individuals, in brackets.

Parameter	**Value**
Mean	1,615.36 (1,631.69)
Standard Deviation	123.81 (133.16)
Minimum	1,313 (1,390)
Maximum	1,858 (1,870)
Confidence Level (95.0%)	43.90 (47.21)

While most of the field days were in March (21.95%), the majority of the days with observations were recorded in January (29.17%) that means a rate of success of 87.50%. Surprisingly, in March the rate was the lowest (33.33%), while, in October and March, this seems to be medium (50.00%). February (with 75.00%) was also a good month in this respect and April (with 66.67%), a relatively good month. If we consider the field days with adequate conditions for observations, the distribution shows the month of January as having the biggest weight (24.24%), it being followed by March (with 21.21%). Instead, the rate of success of the observations was maximum (100.00%) in October and February, but the result must see under reserve because of the low number of sample (1, respectively 3). The following month is January (with 87.50%) and again March has the lowest percent (42.86%), (Table 10). It should be kept in mind that, in Romania, the eggs are laid at the end of March, up to the second decade of April (CIOCHIA, 1992). Also, the males start to call sometimes from September, depending on the weather, and, after the pair formation, the intensity of the calling can slowly decrease. Therefore, two periods of intense vocalizations were recognized: September-November and February-April (DARÓCZI, 2014).

Table 10. The monthly distribution of the days of observations for Eurasian Pygmy Owl (*Glaucidium passerinum*).

Month	**X**	**XI**	**XII**	**I**	**II**	**III**	**IV**
Field days	2	8	7	8	4	9	3
Weight (%)	4.88	19.51	17.07	19.51	9.76	21.95	7.32
Field days with observations	1	4	4	7	3	3	2
Weight (%)	4.17	16.67	16.67	29.17	12.50	12.50	8.33
Rate of success of the observations (%)	50.00	50.00	57.14	87.50	75.00	33.33	66.67
Field days with adequate conditions for observations	1	5	6	8	3	7	3
Weight (%)	3.03	15.15	18.18	24.24	9.09	21.21	9.09
Field days with observations	1	3	4	7	3	3	2
Weight (%)	4.35	13.04	17.39	30.43	13.04	13.04	8.70
Rate of success of the observations (%)	100.00	60.00	66.67	87.50	100.00	42.86	66.67

Regarding the monthly sharing of the points of observations, we see a different situation from that of the days of observation (Table 11). While most of the points of playback were disposed in March (25.23%), December (20.72%) and November (19.82%), the rate of success of observations was the biggest in January (58.82%) and October (50.00%). Taking into account only the points of playback with adequate conditions for observations, the rate of success of the observations changes again: it is maximal (100%) in October, but the value must be seen with circumspection because of the insufficient number of points of playback; it has important weights in January and February (76.92%, respectively 71.43%), before the eggs laying period. In March, at the beginning of the breeding period, the rate was the lowest (25.00%) and in April it became relatively high (60.00%). According to other authors, as we previously mentioned, the most vocal activity of the birds is between February and April, as well as in September-October, daytime singing decreases rather abruptly when the female starts laying and the pair formation have a break in midwinter (KÖNIG & WEICK, 2008).

Table 11. The monthly distribution of the points of observations for Eurasian Pygmy Owl (*Glaucidium passerinum*).

Month	**X**	**XI**	**XII**	**I**	**II**	**III**	**IV**	**The earliest data**	**The latest data**
Points of playback	2	22	23	17	12	28	7	4.X.2015	11.IV.2015
Weight (%)	1.80	19.82	20.72	15.32	10.81	25.23	6.31		
Points of playback with observed individuals	1	4	4	10	5	3	3	27.X.2018	11.IV.2015
Weight (%)	3.33	13.33	13.33	33.33	16.67	10	10		
Points of playback without observed individuals	1	18	19	7	7	25	4	4.X.2015	11.IV.2015
Weight (%)	1.23	22.22	23.46	8.64	8.64	30.86	4.94		
Rate of success of the observations (%)	50	18.18	17.39	58.82	41.67	10.71	42.86		
Points of playback with adequate conditions for observations (PPACO)	1	7	13	13	7	12	5	27.X.2018	11.IV.2015
Weight (%)	1.72	12.07	22.41	22.41	12.07	20.69	8.62		
PPACO with observed individuals	1	3	4	10	5	3	3	27.X.2018	11.IV.2015
Weight (%)	3.45	10.34	13.79	34.48	17.24	10.34	10.34		
PPACO without observed individuals	0	4	9	3	2	9	2	20.XI.2016	11.IV.2015
Weight (%)	0	13.79	31.03	10.34	6.90	31.03	6.90		
Rate of success of the observations (%)	100	42.86	30.77	76.92	71.43	25	60		

The earliest calling individual was registered at 9:50 and the latest one at 15:15 (GMT+2). On intervals of time of 2 hours, the majority of individuals (51.52%) and most of the points of playback with observed individuals (46.67%) were registered between 10:00 and 11:59, when 3 points of playback had 2 individuals each. The rate of success of the observations in the points with adequate conditions for observations was the highest (65.00%) between 10:00 and 11:59, too (Table 12). It is known that the birds are very active at dusk and dawn (KÖNIG & WEICK, 2008), or, more exactly, starting 20 minutes before the sunrise and ending 30 minute after the setting (DARÓCZI, 2014), but few of our observations from the beginning and the ending of the diurnal period do not confirm this; perhaps, these episodes there were before 8:00 and after 18:00. In the Rhodope Mountains, vocalization was detected during the entire day from 30 minutes before sunrise until 22:00 (SHURULINKOV, 2007). Also, it was stated that on calm evenings between February and early May, depending on climatic conditions, the male sings at different places in the territory (KÖNIG & WEICK, 2008).

Table 12. The hourly distribution of the observations of Eurasian Pygmy Owl (*Glaucidium passerinum*).

Time of observation of individuals (GMT+2)	**8:00-9:59**	**10:00-11:59**	**12:00-13:59**	**14:00-15:59**	**16:00-17:59**
No. individuals	1	17	9	6	0
Weight (%)	3.03	51.52	27.27	18.18	0.00
Points with observed individuals	1	14	9	6	0
Weight (%)	3.33	46.67	30.00	20.00	0.00
No. points with adequate conditions for observations	3	20	21	13	1
No. points with adequate conditions for observations with observed individuals	1	13	9	6	0
Rate of success of the observations (%)	33.33	65.00	42.86	46.15	0.00

As for the air temperature at the moment of observations, the interval of temperature when was recorded individuals were between -15 and 10 ^{0}C. Most of the individuals (75.76%) and of the points with observed individuals (73.33%) were registered between -5 and 4 ^{0}C. The highest rate of success in the points with adequate conditions for observations was between -15 and -6 ^{0}C, but the number of samples was relatively low. If we split the intervals of temperature at below and above 0 ^{0}C, we see an almost similar situation in the two cases, this time with a better rate of success of the observations between 0 and 14 ^{0}C, actually between 0 and 10 ^{0}C (Table 13). 2 points of playback each with 2 individuals were registered between - 5 and -1 ^{0}C and 1 point of playback with 2 observed individuals, between 0 and 4 ^{0}C.

Table 13. The distribution of the observations of Eurasian Pygmy Owl (*Glaucidium passerinum*) on intervals of temperature.

Temperature (^{0}C)	**-15 to -6**	**-5 to 4**	**5 to 14**	**-15 to -1**	**0 to 14**
No. individuals	3	25	5	15	18
Weight (%)	9.09	75.76	15.15	45.45	54.55
Points with observed individuals	3	22	5	13	17
Weight (%)	10.00	73.33	16.67	43.33	56.67
No. points with adequate conditions for observations	5	44	9	25	33
No. points with adequate conditions for observations with observed individuals	3	21	5	12	17
Rate of success of the observations (%)	60.00	47.73	55.56	48.00	51.52

In terms of nebulosity, an influence was also seen on the vocal activity of the birds (Table 14). So, the most individuals (39.39%) and most points with observed individuals (40.00%) were registered on the 7-10 interval of nebulosity, the rate of success of the observations was the highest (57.14%) for the 0-2 interval of nebulosity. The lowest one (42.86%) was noticed in circumstances with medium covered sky with clouds. However, two points each with 2 individuals were registered on 3-6 nebulosity and 1 point with 2 individuals was registered on 7-10 nebulosity.

Table 14. The distribution of the observations of Eurasian Pygmy Owl (*Glaucidium passerinum*) on intervals of nebulosity.

Nebulosity	**0-2**	**3-6**	**7-10**
No. individuals	8	12	13
Weight (%)	24.24	36.36	39.39
Points with observed individuals	8	10	12
Weight (%)	26.67	33.33	40.00
No. points with adequate conditions for observations	14	21	23
No. points with adequate conditions for observations with observed individuals	8	9	12
Rate of success of the observations (%)	57.14	42.86	52.17

Related to the type of clouds, most of the individuals (57.58%) and most of the points with registered individuals (56.67%) were observed in the presence of exclusive or predominant lower clouds. The rate of success of the observations in the points with adequate conditions for observations was the highest (64.00%) for similar clouds, too (Table 15). The lower clouds can be met on any type of weather, both fair weather (i. e. *Cumulus*) and bad weather (i. e. *Stratus*) and therefore the type of clouds has to be seen in link with the rank of sky covering. It is worth to mention that 2 points of playback each with 2 individuals were registered on lower clouds and 1 point with 2 individuals was registered on higher clouds.

Table 15. The distribution of the observations of Eurasian Pygmy Owl (*Glaucidium passerinum*) by the type of clouds.

Type of clouds	**Clear sky**	**Lower clouds**	**Medium clouds**	**Higher clouds**
No. individuals	4	19	1	9
Weight (%)	12.12	57.58	3.03	27.27
Points with observed individuals	4	17	1	8
Weight (%)	13.33	56.67	3.33	26.67
No. points with adequate conditions for observations	10	25	3	20
No. points with adequate conditions for observations with observed individuals	4	16	1	8
Rate of success of the observations (%)	40.00	64.00	33.33	40.00

Wind intensity plays an important role on the calling because it obstructs the detectability of the singing male if it blows strongly (Table 16). Most of the individuals (36.36%) and the most of the points with observed individuals (40.00%) were registered on intensity of 2. The highest rate of success of the observations (73.33%) was also recorded on 2 wind intensity, but an important value (56.25%) was obtained for fully calm weather. In wind of intensity of 3, this decreased up to 25.00% and in wind stronger than that, individuals were not recorded. Two points of playback each with 2 recorded individuals were registered on 0 intensity of wind and 1 point with 2 individuals was registered on 3 intensity of wind.

By the presence/absence of the snow cover of the soil, most of the individuals (78.79%) and most of the points with observed individuals (76.67%) were registered in the first situation. The rate of success in the points with adequate conditions for observations was higher for the soil covered with snow (57.89%), too (Table 17). We must remember that the period of observations was October – April, but birds can be vocally active also in other months of the year, when the soil is normally without the snow cover. All 3 points, every with 2 observed individuals, were recorded in conditions with snow cover.

Table 16. The distribution of the observations of Eurasian Pygmy Owl (*Glaucidium passerinum*) by the wind intensity (Beaufort scale).

Wind intensity	**0**	**1**	**2**	**3**
No. individuals	11	8	12	2
Weight (%)	33.33	24.24	36.36	6.06
Points with observed individuals	9	8	12	1
Weight (%)	30.00	26.67	40.00	3.33
No. points with adequate conditions for observations	16	23	15	4
No. points with adequate conditions for observations with observed individuals	9	8	11	1
Rate of success of the observations (%)	56.25	34.78	73.33	25.00

Table 17. The distribution of the observations of Eurasian Pygmy Owl (*Glaucidium passerinum*) by the presence/absence of the snow cover on the soil.

Snow cover	**No**	**Yes**
No. individuals	7	26
Weight (%)	21.21	78.79
Points with observed individuals	7	23
Weight (%)	23.33	76.67
No. points with adequate conditions for observations	20	38
No. points with adequate conditions for observations with observed individuals	7	22
Rate of success of the observations (%)	35.00	57.89

About the precipitations registered at the moment of the observations, only one individual (3.03% of all) was observed on November 21, 2015 (at 12:10), in circumstances with weak rainfall. The rest of the observations (96.97% of the individuals and 96.67% of the points with observed individuals) were recorded at time without precipitations, when the rate of success of the observations in the points with adequate conditions for observations was of 49.12%.

CONCLUSIONS

Some major findings can be extracted:

1. In the Făgăraş, Iezer-Păpuşa and Leaota Mountains, most of the individuals of Pygmy Owl preferred the mature spruce forests and, a good part, the mature spruce or mixed forests with clearings, while the fewest of them were registered in the mature mixed forests and in the relative mature spruce forests with clearings. During the observations, most of the individuals moved to the border of the spruce forest with the alpine level, a significant part remained in the mature spruce forest, while others appeared at the margin of the mature spruce forest with the clearing;
2. Most individuals were initially recorded between 1,500 and 1,599 m (the mean –1,567.48 m), which correspond to the inferior floor of the Norway spruce forests and only a few of them were observed between 1,300-1,399 m and between 1,700-1,799 m. At the end of the observations, most of the individuals moved between 1,700 and 1,799 m (the mean – 1,615.36 m; the maximum – 1,858 m, which represent the upper border of the Norway spruce forest);
3. For the October-April period, the rate of success of the field days with observations turned out to be the highest in October and February, high in January and the lowest in March, while the rate of success of the observations in the points of playback with adequate conditions for observations was the highest in October, high in January and February, and the lowest in March, which partially contradicts, at least for the heights of the Southern Carpathians, the periods of monitoring recommended by the Romanian manuals;
4. Between 8:00 and 17:00 (GMT+2), the diurnal period when monitoring was performed, the rate of success of the observations at points with adequate conditions for observations was the highest between 10:00 and 11:59, low between 8:00 and 9:59, and 0 between 16:00 and 17:59;
5. Depending on weather elements, the rate of success in points with adequate conditions for observations was: the highest between -15 and -6 ^{0}C temperature of the air and the lowest between -5 and 4 ^{0}C (however, for positive temperatures, the rate of success was bigger than for the negative temperatures, for -15 to 10 ^{0}C, the interval of air temperature when the individuals were recorded); the highest for the 0-2 interval of nebulosity and the lowest for medium covered sky with clouds; the highest in the presence of exclusive or predominant lower clouds and the lowest on sky covered with clouds at medium level; the highest for wind of 2 intensity and relatively high for the complete calm weather (on wind higher of 3, there were not observed individuals). Also, the rate of success in the points with adequate conditions for observations was higher for the soil covered with snow than for the snow-free soil. Very rarely, males were active during the weak rainfall and, during periods without precipitations, the rate of success of the observations in the points with adequate conditions for observations was almost 50%.

We hope the results will help the managers of the area to protect this species, currently included in the Annex I of the Birds Directive, and also the habitats occupied by it, because, like other species of owls, the Pygmy Owl can be considered a good indicator of the biodiversity and ecosystem health and used to identify the areas of conservation or at-risk (ROMULO, 2012). This is all the more necessary as presently the area faces with intense forestry exploitations.

The large body of forests, preferred by the species, should be excluded from logging and a suitable strategy should be elaborated at national level by the Forestry Department and the interested organisations.

Also, we express our belief that the results can be helpful to improve and adapt monitoring methods to local conditions.

Finally, we think that this work will be a preliminary study about the Pygmy Owls from the Făgăraş, Iezer-Păpuşa and Leaota Mountains and the researches will continue to confirm or infirm the results and to provide other on-site information on the species.

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Mestecăneanu Adrian
The Argeş CountyMuseum, Armand Călinescu, 44, 110047, Piteşti, Argeş, Romania.
E-mail: mestecaneanua@yahoo.com

Mestecăneanu Florin
Dârmăneşti, 117360, 283, Argeş, Romania.
E-mail: mestecaneanua@yahoo.com

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THE FOOD PROFILE OF THE GREAT SPOTTED WOODPECKER (*Dendrocopos major*) IN THE TIKJDA FOREST OF NORTH AFRICA

BOUGHELIT Nadia, MARNICHE Faiza, BOUKHEMZA Mohamed, MERIBAI Youcef, MOUHEB Walid, KHETTAR Amazigh

Abstract. The study of the diet of the Great Spotted Woodpecker (*Dendrocopos major*) was undertaken the Tikjda forest which lies north of Bouira (Algeria). We identified, thanks to Barber pots, food availability of up to 1094 individuals during 3 months of study in 2018, the highest number of which is recorded in Hymenoptera order with 63.62%. Similarly, we have collected 52 droppings of *Dendrocopos major* in the same period. The analysis of droppings allowed us to enumerate a set of 8066 food items. These items belong to 100 different prey taxa grouped in 6 classes, 21 orders and 55 families. The insect class is the most represented with 7820 individuals. One finds the greatest number of individuals in Hymenoptera and in particular in ants with 7576 individuals (93.93%). *Messor picturatus* with 5185 individuals is 64.28% of the total number of individuals in this family, followed by *Camponotus micans* with a rate of 13.66% (1102 individuals). The other classes are poorly represented ranging from 0.07% to 1.35%.

Keywords: Tikjda (Algiers), Great Spotted Woodpecker, *Dendrocopos major*, food availability, diet, Formicidae.

Rezumat. Profilul alimentar al ciocănitoarei pestrițe mari (*Dendrocopos major*), în pădurea Tikjda din Africa de Nord. Studiul dietei la ciocănitoarea pestriță mare (*Dendrocopos major*) a avut loc în pădurea Tikjda, situată la nord de Bouira (Algeria). Am determinat cu ajutorul vaselor Barber un spectru trofic ajungând la 1094 de exemplare pe parcursul a 3 luni de studiu din anul 2018, dintre care predominant fiind ordinul Hymenoptera cu 63,62%. Totodată, am colectat 52 de excremente de *Dendrocopos major* în aceeași perioadă. Analiza excrementelor ne-a permis să numărăm un set de 8066 elemente (ingluvii). Acestea aparțin la 100 de taxoni diferiti de pradă, grupați în 6 clase, 21 de ordine și 53 de familii. Clasa de insecte este cea mai reprezentată, cu 7820 de indivizi. Cel mai mare număr de taxoni se încadrează în ordinul Hymenoptera, dintre care Formicidae, cu 7576 indivizi (93,93%). *Messor picturatus*, cu 5185 de exemplare, reprezintă 64,28% din numărul total din această familie, urmată de *Camponotus micans* cu o rată de 13,66% (1102 indivizi). Celelalte clase sunt slab reprezentate, variind de la 0,07% la 1,35%.

Cuvinte cheie: Tikjda (Algeria), ciocănitoare pestriță mare, *Dendrocopos major*, disponibilitate alimentară, dieta, Formicidae.

INTRODUCTION

According to agriculture professionals, predation is defined as an essential ecological process in controlling populations and evolution of prey (RAMADE, 1984). The Picidae family includes some 200 worldwide distributed species, having the size of a blackbird (*Turdus merula*), and weighing between 70 and 100 g. Furthermore, the Great Spotted Woodpecker is, indeed the European woodpecker species with the widest distribution, as documented mainly for insectivorous birds (ants, larvae, beetles, caterpillars, flies), and more occasionally for gastropods, earthworms, seeds, conifer cones, fruits, buds, sap (BAVOUX & LEMARCHAND, 2015). Since forestry biodiversity is a very wide topic, our study was devoted on investigating the diet of the Insectivore Picidae Great spotted woodpecker (*Dendrocopos major*) around the forest of Tikjda (Bouiracity, Algeria) (Fig. 1). This region is well-known by its marked richness and originality of flora and fauna, and forestry environments, mainly plant formations which are more or less conserved and are located on top of mountain massifs. The great spotted woodpecker is a species of woodpecker, most widely and commonly found in Asia (up to Japan), Asia Minor, North West Africa and Europe (GEROUDET, 1980), since the great spotted woodpecker (*Dendrocopos major numidus*) found in Algeria and Tunisia has black and red chest, and the red of the lower abdomen part extends to the abdomen (GORMAN, 2014), and due to its unremitting activity, it plays an important role in forestry ecology. Moreover, this bird species also promotes the colonization of dead trees by fungi and xylophagous insects (Coleoptera), indicative of forest richness, and whose effect leads to wood breakdown (OOSNECK-DALIGAULT, 2015). Woodpeckers (Picidae) are the world scientific topic for several studies, such as those of MEYLAN (1931), HENRY (1998), BOCCA (1999) and ISENMANN et al. (2005). Interestingly, the great spotted woodpecker lives in the forests of Algeria, especially those of oak trees (*Quercus* spp.), but not those composed of Aleppo pine, and also in the maritime pines near to Oubeira Lake (ISENMANN & MOALI, 2000). Similarly, GACEM (1997) has found this species in olive groves of the Mâatkas region in the Tizi-Ouzou city (North Algeria). Unexpectedly, the works of BENDJOUDI & DOUMANDJI (1997) have investigated the diet of the great spotted woodpecker living in Mitidja plain (North Algeria). Despite the generalization of this study, overall and punctual data are provided in general books, like those of HEIM & MAYAUD (1962), ETCHECOPAR & HUE (1964), LEDANT et al. (1981), ISENMANN & MOALI (2000) and MAOUCHE-HENINE (2016). So far, very limited works have been conducted on the relationship between the trophic availability present in the field and the prey actually eaten by Great Spotted Woodpecker in the study region. Hence, this contribution comes on the one hand, to enhance the data that have been already collected, and at the other hand to determine the diet profile of the Great Spotted Woodpecker species in the Tikdjda region (northern Algeria) characterized by a humid climate in cool winter.

Figure 1. The Great Spotted Woodpecker *Dendrocopos major* (Linnaeus. 1758) in the Tikjda Forest (Bouira)
(original picture by Aimene Boulaouad, 2018).

MATERIAL AND METHODS

Study site

The study was performed in the Tikjda region, located at the foot of the Akouker Massif, one major region of the Bouira city (northern Algeria), the southern slope of Djurdjura in the Great Kabylie region, and the administrative headquarters of the Djurdjura National Park and UNESCO Biosphere. This experimental area is located at 1478 m of altitude and geographic coordination 36°15'53" N, 4°04'26" E, and the Tikjda massif includes red sandstone (Triassic) (FLANDRIN, 1952). Amazingly, the study site is mainly exposed to snow accumulation for the Mediterranean region (comparable to the Mercantour region) resulting from the ferruginous minerality of the subsoil, and the proximity of the Mediterranean Sea (Fig. 2).

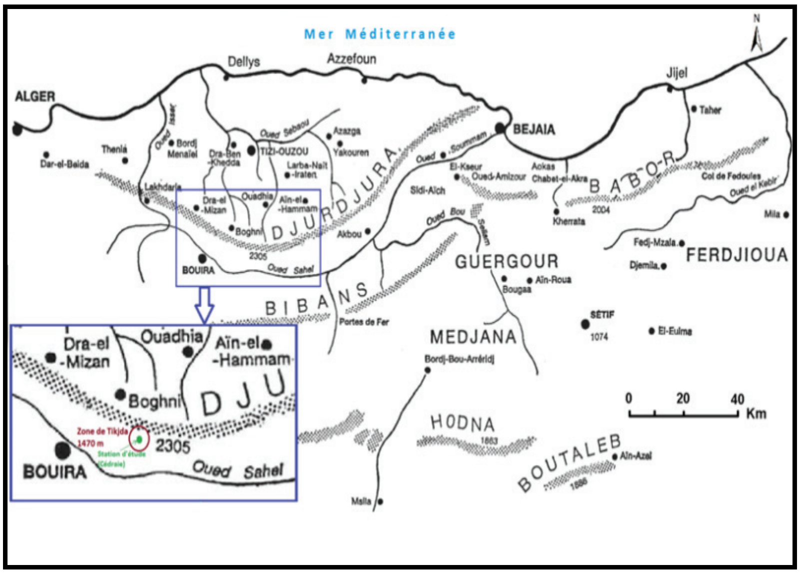

Figure 2. Geographical location of the three sampled station (PND. 2012, modified).

Also, the site is located in the humid bioclimatic level in cool winters. This study area is rich in endemic flora and fauna, and hence the different plant formations of Djurdjura have been described by several authors (LAPIE, 1909; MAIRE, 1926; QUEZEL, 1957; BARBERO et al., 1990). In this regard, MENARD & VALLET (1988) have identified five types of vegetation in the Tikjda area, namely Cedar forest (*Cedrus atlantica*), evergreen oak (*Quercus rotundifolia* L.), Matorral of cedar and holm oak forests, shrubby and lawn formations with Chamaephyte.

Wildlife availability, diet study and dropping analyses

The sampling of the prey species of *Dendrocopos major* and its droppings in the study site took lplace during the period of juvenile feeding, i.e the period between early April and late June. Here, eight Barber pots were placed in the habitats of the Great Spotted Woodpecker, which are separated from each other by a space of about 4 cm. Each pot was filled with water and vinegar at a third of its depth, and then the mixture was sprinkled with a pinch of domestic detergent as a powder in order to slow down the breakdown of the prey. Lastly, the flasks were covered by a stone so that the attention of those passing by would not be called. During the whole 72 hours, the pot contents were collected by a small mesh strainer and the traps were then put in place. The contents of all the pots were transferred into a Petri dish, and transported to the laboratory for being sorted using a binocular loupe (10x / 20). The prey species collected in the Barber pots were largely confirmed by PhD. Marniche Faiza (Zoology laboratory, National Veterinary School of El Alia, Algiers, Algeria), in addition to the supporting dichotomous keys and books, including taxonomic order of Myriapods (PERRIER & DELPHY, 1932), Orthoptera (CHOPARD, 1943), Coleoptera (DUCHATENET, 1986; MCGAVIN,2005), Heteroptera (VILLIERS, 1977), Hymenoptera (BERNARD, 1968; CAGNIANT, 1968, 1969, 1970) and consulted sites for identification of the species (www.antarea.com.; www.antweb.com; www.myrmecofourmis.com.; www.keibtier). The study of the diet of the great spotted woodpecker requires an actual field exploration. In this context, we have performed 11 regular spacewalks during a monthly cycle, from April to June, 2018 throughout all the study areas, along with all their droppings (slopes, dense forests and walkways). During these spacewalks, we have collected 52 of *D. major* droppings found under the Cedar trees, and then samples were labelled with the date and place of collection, and safely kept until the day of the analysis (Fig. 3).

a **b** **c**

Figure 3. Collection of field samples (Original).
Pots Berber; **b.** droppings of Great Spotted Woodpecker; **c.** measurement.

The analysis of great spotted woodpecker droppings was performed at the laboratory of zoology of the higher national veterinary school of El-Alia (Algiers, Algeria). First of all, the contents of each dropping was mixed in ethanol 70°, and then poured into Petri dishes. All of the fragments contained in triturated droppings (heads, elytra, mandibles, thoraxes, abdominal segments, pronotum (dorsal) and sometimes complete body) were dehusked and sorted by using forceps and a binocular microscope (total magnification: 10×20). These fragments were thereafter arranged in groups in another Petri dish for being measured.

Measurement of prey taxa fragments and data analysis

When the prey taxa fragments are sorted, determined and counted, they can be measured by using strips of graph paper to estimate the prey size of the prey taxon consumed by great spotted woodpecker. The size estimation of the designed prey was extrapolated from a fragment. Overall, the heads corresponds to 1/6, thorax 1/3, elytra ½ of the total length of the insect body (BENABBAS, 2014). This estimation is justified and completed by the reference guides (GRENHALGH & OVEDEN, 2009; TACHET et al., 2000) (Fig. 3). The results of Barber pots were efficiently used to evaluate the species abundance and the diversity in the study site. These data were analysed using Paleontological Statistics software package version 2.17 (HAMMER et al., 2001), and consequently the prey species consumed by this woodpecker is evidenced by some ecological indices as follow: the centesimal frequency (Fc %) (DAJOZ, 1975) the frequency of occurrence (Fo %) (DAJOZ, 1982); COSTELLO (1990); the interval of size classes of preys are estimated according to Stürge (SCHERRER, 1984); the diversity indices of Shannon and Equitability indices (E) (RAMADE, 1984); the length of the diet niche (B) (PIELOU, 1969), the biomass (B %) (VIVIEN, 1973) and the indices of Ivlev (FARHI et al., 2003).

Figure 4. Some fragments consumed by the Great Spotted Woodpecker at the edge of the Tikjda forest (Bouira) under a binocular loupe 20x (Original).

a. Head *Messor* sp.; b. Head *Tapinoma* sp.; c. Head *Pheidole* sp.; d. Head *Camponotus* sp.; e. Head Halctidae sp.; f. Head *Forficula* sp.; g. Head *Eupelix* sp.; h. Head *Sisyphus* sp.; i. Thorax *Crematogaster* sp.; j. Thorax *Messor* sp.; k. Thorax *Pheidole* sp.; l. Thorax *Tetramorium* sp.; m. Elytre of *Onthophagus* sp.; n. Elytre *Curculionidae*; o. Elytre *Apionidae*; p. Complete ants *Lasius* sp.

RESULTS

Wildlife availabilities

The analysis of samples through the Barber pots during the three months of study leads to count a set of 1094 species items, belonging to 73 different taxa grouped into six classes, namely Arachnids, including 153 prey taxa, Myriapods, Iules and Crustaceans (2 prey taxa each), Chilopoda (1 prey taxa), and Insects (831 taxa) (Appendix 1, Table 2). The insect is the highly represented class with 831 individuals (Fc% = 71.96 %), since the higher individual number was noticed in Hymenoptera (696 taxa), and mainly in Formicidae including 657 individuals (Fc% = 60.05 %) followed by Apidae, Halictidae and Apoidea having one individual each. In the same class, the Coleoptera occupies the second position with 58 individuals (Fc % = 5.30%) and Diptera the third position with 28 individuals (2.56%), in addition to Orthoptera including 20 individuals (Fc% = 1.83%). The second class is that of Arachnids, the most important class, containing 153 individuals (Fc% = 13.99%), while the third class is that of Opiliones with 99 individuals (9.05%), and the last classes are those of Crustaceans, Diplopods, Myriapods and Chilopods with 2 and 1 individuals, respectively and a frequency of 0.18% and 0.09% (Table 1). Formicidae hves been reported by several authors. Elsewhere close to El-Kseur region (north Algeria), SALMI et al. (2002) have reported the relative importance of the trapped ants in the Barber pots, like *Aphaenogaster testaceo-pilosa* (A.R. % = 14.9 %), *Tapinoma nigerrimum* (A.R. %= 7.1 %), *Cataglyphis bicolor* (A.R.%= 6.8 %) and *Messor barbara* (A.R.% = 6.3 %).

Table 1. The number of species trapped in Barber pots in the three-month study in the vicinity of forests Tikjda (Djudjura National Park).

Orders	April	May	June	ni	Fc (%)
Opiliones	29	12	58	99	9.05
Aranea	64	29	60	153	13.99
Acari	0	2	2	4	0.37
Myriapoda	0	1	1	2	0.18
Scolopendrida	0	1	0	1	0.09
Julida	0	0	2	2	0.18
Zygentoma	1	0	4	5	0.46
Dictyoptera	2	2	2	6	0.55
Orthoptera	7	11	2	20	1.83
Dermaptera	5	2	1	8	0.73
Hemipera	2	2	1	5	0.46
Homoptera	1	1	0	2	0.18
Coleoptera	30	13	15	58	5.30
Hymenoptera	**189**	**346**	**161**	**696**	**63.62**
Diptera	5	13	10	28	2.56
Lepidoptera	0	1	2	3	0.27
Malacostraca	1	1	0	2	0.18
Total (N)	**336**	**437**	**321**	**1094**	**100.00**

On top of that, the diversity indices of Shannon during the three study months are weak, and ranged from 0.93 bits to 1.49 bits (Table 3).

Table 3. Indices of ecological species trapped in Barber pots in the three months of study around the forests of Tikjda (Djudjura National Park).

Month	April	May	June
Taxa S	12	15	14
Individuals	336	437	321
Dominance D	0.37	0.64	0.32
Simpson1-D	0.63	0.37	0.65
Shannon H'(bits)	1.39	0.93	1.49
Evenness (e^H/S)	0.33	0.17	0.32
Equitability (E)	0.39	0.24	0.39

This index shows a strong emphasis of the rare species (FAURIE et al., 2003). In this study, Simpson's diversity index was found to be between 0.63 and 0.68, respectively for April and June. Unlike the diversity indices of Shannon, the Simpson index provides higher importance to abundant species than those of rare species, although it is less sensible to species diversity (MAGURRAN, 1988) except during May, when the species become less abundant in the study site. Maximum diversity is revealed by the value 1.49, since the minimum diversity is presented by the value 0.93. Moreover, the recorded index of equitability varies from 0.24 to 0.39, and hence this value seems to tend toward 0 which seems to appear as an imbalance between the numbers of species trapped by Barber pots. This imbalance is due to the dominance of the order Hymenoptera with the species *Messor picturatus* within the ant population.

Diet study

All insect fragments identified at the level of 52 droppings recovered from the Great Spotted Woodpecker were represented as spectra for food category groups. Figure 5 shows that the 6 classes have an average centesimal frequency ranging from 0.07% to 96.95%. Indeed, the analysis of the food diet of this species demonstrated the predominance of insects with 7820 individuals (Fc% = 96.95%). The Diplopoda, the Malacostraca, arachnids, centipedes and gastropods supplement the diet with converging frequencies Fc – 1.37%, 0.92%, 0.60%, 0.11% and 0.07% (Fig. 5).

The high impact on insects is due to the abundance of this group, generally much higher than that of other class categories (Table 2, Appendix 1).

The Picidae have been considered almost exclusively insectivore birds in some works (ZAKARIA et al. 1999; SAZIMA et al. 2001).

Here, the insect dominance in *Dendrocopos major* is most actually related to the fact that the individuals of this class are the most abundant animal in the environment. The works of MIRANDA & BÜRGI (2005) conducted in Switzerland have shown that the Great Spotted Woodpecker has a clear preference for insects and their larvae living not only in the woods, but also spiders, caterpillars, seeds and nuts rich in fat.

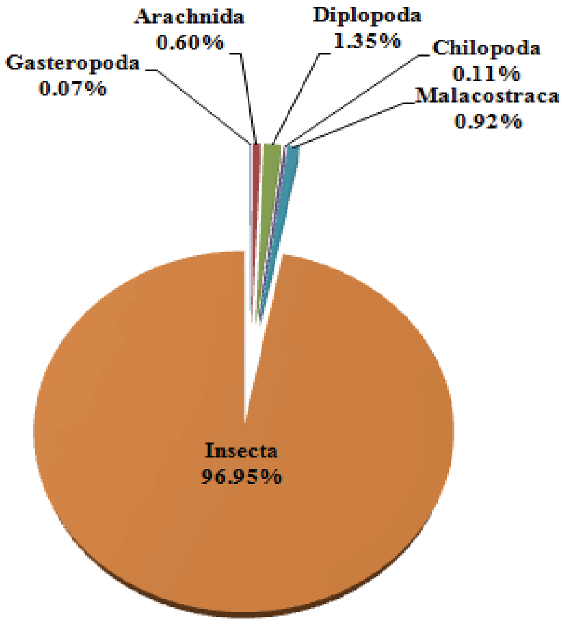

Figure 5. Different classes found in the droppings of the Great Spotted Woodpecker in the Tikjda Forest (Bouira).

Centesimal frequencies of species-prey, *Dendrocopos major* grouped according to the Formicidae species

The Formicidae family is ranked first in terms of prey species consumed by Great Spotted Woodpecker, and hence the 7576 prey-species identified in 52 droppings are mainly ants exhibiting a high rate (93.93%) (Table 4).

Table 4. Centesimal frequencies of the species of Ants within the Formicidae in the menu of the Great Spotted Woodpecker.

Species	ni	Fc (%)
Camponotus micans	1102	14.55
Camponotus creuntatus	149	1.97
Camponotus erigens	74	0.98
Camponotus barbaricus xanthomelas	3	0.04
Crematogaster scutellaris	374	4.94
Cataglyphis viatica	12	0.16
Pheidole pallidula	77	1.02
Tapinoma magnum	27	0.36
Tetramorium biskrens	69	0.91
Plagiolepis barbara	49	0.65
Aphaenogastertestaceo-pilosa	455	6.01
Messor picturatus	5185	68.44
N	**7576**	**100.00**

Within this same family, there is a dominant species (*Messor picturatus)* whose individual numbers found in droppings are estimated at 5185, and also reveals 64.28% of the prey species consumed by *D. major*, in addition respectively, to *Camponotus micans* (13.66%), *Aphaenogaster testaceo pilosa* (5.64%), *Crematogaster scutellaris* (4.94%) and *Camponotus creuntatus* (1.97%), *Pheidole pallidula* (0.95%) and *Camponotus erigens* (0.92%). The other species, namely *Camponotus barbaricus xanthomelas*, *Cataglyphis viatica, Tapinoma magnum* and *Plagiolepis barbara* present rates varying between 0.04 % and 0.91% of Formicidae found in the trophic diet of *D. major*, suggesting therefore that this species is predominantly myrmecophagous (Fig. 4). Also, the Great Spotted Woodpecker may be considered as a very useful predator limiting species populations of pest ants, like *Tapinoma magnum* which raise, protect and promote the multiplication of aphids and mealy bugs or *Crematogaster scutellaris* that perforate the bark of cork oaks and pines (BERNARD, 1968).

Centesimal frequencies (FC %) and the occurrence frequency (FO %)

The trophic diet of Great Spotted Woodpecker in the Tikjda forest includes 100 prey taxa, and is mainly composed of insects. As indicated in Table. 2, the higher value of the centesimal frequency was noticed for *Messor picturatus* (64.28 %), followed by *Camponotus micans* in second position (13.66 %), since the following positions are occupied by *Aphaenogaster testaceo pilosa* (5.64 %), *Crematogaster scutellaris* (4.64 %), *Camponotus creuntatus* (1.85%) and *Pheidole pallidula* (0.95 %). The remaining prey taxa are found very weak in droppings of *Dendrocopos major*. The occurrence frequency is defined as the ratio expressed as the percentage of the dropping numbers where the prey taxa are related to the total analysed droppings. Hence, the different prey taxa groups are grouped into three categories (privileged, secondary and accidental) of six prey taxa each (SORBE, 1972), and also the diet of *D. major* is presented by three occurrence classes (Table. 5).

Table 5. Classification of *Dendrocopos major* prey taxa by occurrence classes in the Tikjda Forest (Bouira).

Occurrence Classes	Preferred	Secondary	Accidental
Number of prey taxa	09	18	73
Parentage (%)	09.00	18.00	73.00

The privileged prey taxa class includes two orders, the Formicidae family, sub-families of Coleoptera order, and the sub-family Harpalinae which was found in the 52 analysed droppings. The second prey taxa class includes 18 species (18.00 %), 5 orders, 9 families, and lastly, the accidental species (73.00%) include 12 orders and 40 families (Table2). Noteworthy, the three occurrence classes are not similar, and thus this is proved by applying the Kruskaland Wallis ($\chi 2$ ddl=1, obs. = 13.29) test. The Costello graph can be performed focusing on the centesimal and occurrence frequencies of the most common prey taxa for the Great Spotted Woodpecker, and on those presented by the privileged species (Fig. 6).

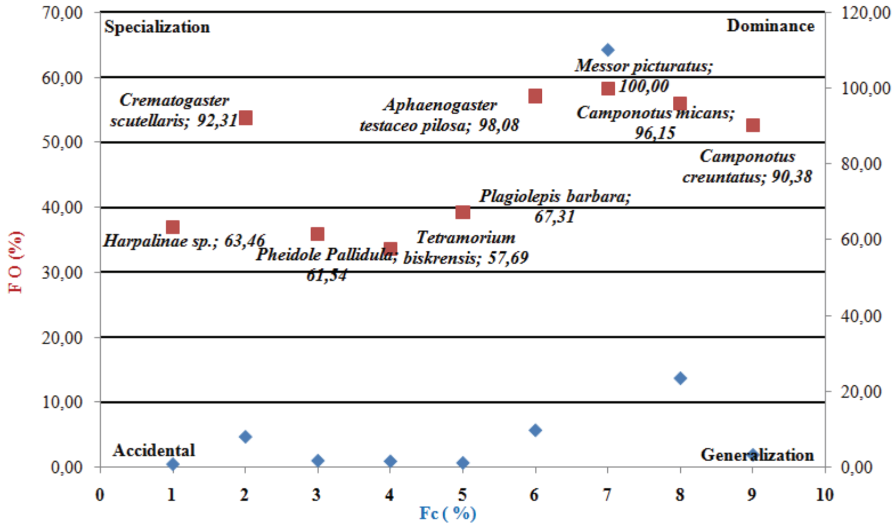

Figure 6. Potential prey taxa of Great Spotted Woodpecker in the Tikjda Forest (Bouira).

These various species are considered to be the potential prey taxa of *Dendrocopos major* in the Tikjda forest. On the other hand, the ant *Messor picturatus* (64.28 %, 100 %) is the only potential prey taxon of the Great Spotted Woodpecker. Additionally, other prey taxa are considered important in the species diet, including *Aphaenogaster testaceo-pilosa* (5.64%, 98.08%), *Camponotus micans* (13.66%, 96.15%), *Crematogaster scutellaris* (4.64%, 92.31%), *Camponotus creuntatus* (1.85%, 90.38 %), *Plagiolepis barbara* (0.61%, 67.31%), *Harpalinae* sp. (0.41%, 63.46 %), *Pheidole pallidula* (0,95 %, 61.54 %) and or *Tetramorium biskrensis* (0.86 %, 57.69 %). Despite their weak abundance (in occurrence and in number) in the analysed droppings, some species exhibit are quite significant in the diet of the spotted woodpecker, such as *Armadillidium* sp. (0.33%, 48.08 %), *Anisolabis mauritanicus* (0.17%, 23.08 %), *Ectobius* sp. (0.14 %, 19.23 %), *Dysdera* sp. (0.20 %, 17.31%), *Pentatomidae* sp. (0.04%, 5.77 %), *Theba pisana* (0.02%, 3.85 %) and *Eobania* sp. (0.01%, 1.92 %) (Appendix1, Table 2).

Shannon's index of diversity, equidistribution and width of the food niche

The diversity of diet of *D. major* is, overall, about 2.20 bits, while the maximum value H'max. reaches 4.46 bits. This indicates that the diet of this insectivore is less diversified, in terms of prey taxa, but it is compensated by the important number of prey consumed by the Picidae with an average of 159.72 items per droppings. The equidistribution index (E) gives the value 0.33and 9.03 for diet niche, indicating thus that the numbers of prey taxa consumed by Great Spotted Woodpecker tend to be in disequilibrium with each other, due to reason of diet preferences of *D. major* whose trophic profile is composed of 64.28 % of ant *Messor picturatus,* since the other species are low presented, and this subsequently proves that the species selects these preys to feed oneself. The abundance of Formicidae in the trophic diet of *D. major* can be justified by the wealth and accessibility of this family (exclusively social insects) in the environment.

Classification of prey taxa consumed by Great Spotted Woodpecker as a function of their sizes

The sizes of prey taxa consumed by *D. major* vary from 0.9 mm for *Acari* sp. and from 1 to 41 mm for *Cylindroiulus* sp. The average size of prey taxa per droppings is 10.39 ± 0.05 mm, in addition that eleven classes of the species were identified following the Sturge's Rule (NC = 1 + (3.3 Log10 N). The results of the centesimal frequencies of size classes of prey taxa consumed by Great Spotted Woodpeckerare displayed if Fig.7, from which we noticed that the first size class expressed in mm [6.62 – 9.48[includes high individual numbers with a frequency of 66.28%. Furthermore, *Messor picturatusis* identified as the dominant species in this class, followed by the class [12.34-15.20[(Fc % = 20.07%) including only 1619 individuals, in addition to the families; Oniscidae, Glomeridae, Polydesmie, Lithobiidae and Porcelionidae. The third class [3.76-6.62[having frequency of 5,43% includes only 438 individuals, and is represented by *Camponotus micans*, *Aphaenogaster testaceo-pilosa* et *Crematogaster scutellaris,* since the other classes are, [15.20-18.06[including 251 individuals (F% = 3.11%) and represented by Geotrupidae, Scarabaeidae and Cetonidae, class of [0.9-3.76[including 129 individuals (Fc %= 1.60%) and represented by Acari, Linyphiidae, *Atheta* sp, *Tapinoma magnum* and *Pheidole pallidula*, and the last classes are those of the interval [29.2-23.78[including 11 individuals exhibiting only a cumulated frequency as 0.14 %, such as the families, namely Blattidae, Blatellidae, Gryllidae, Forficulidae and Carcinophoriudae.

As a result, the species *D. major* shows a clear preference for the small sized preys, and this is largely compensated by the number of individuals of an anthill, and hence a nest of *Pheidole pallidula* may be counted up to 100.0000 individuals (BERNARD, 1968).

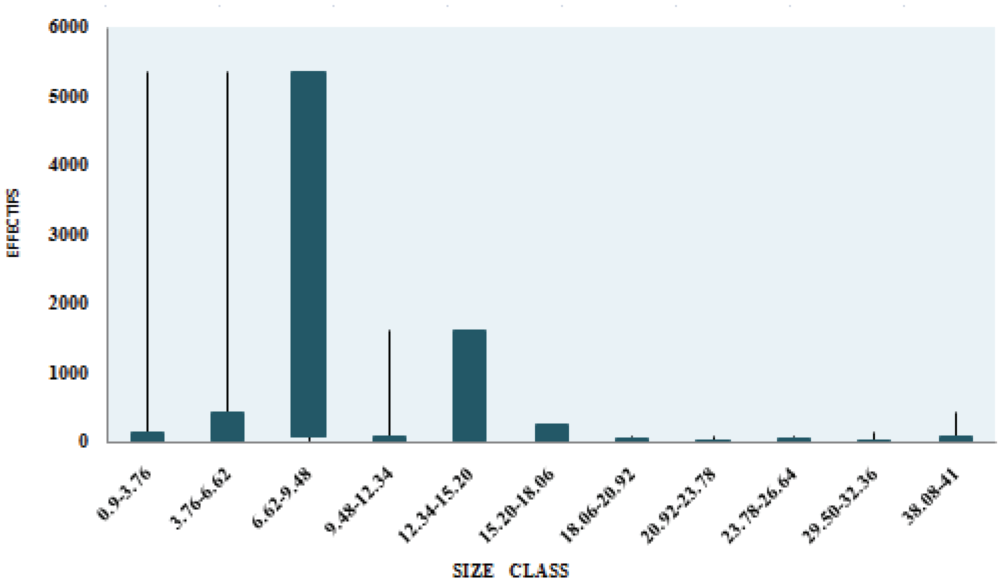

Figure 7. Effective of estimated size classes the Great Spotted Woodpecker's prey during 3 month of study.

Prey taxa biomass of *Dendrocopos major* in Tikjda forest (Bouira, North Algeria) and index of Ivlev Li

In term of biomass, among the highly consumed order by Great Spotted Woodpecker is that of Hymenoptera whose Formicidae family dominates with the species *Camponotus micans* (44.20 %), followed by the species *Messor picturatus* (34.66 %), *Camponotus creuntatus* (5.98 %), and *Aphaenogaster testaceo pilosa* (4.56 %). Regarding the other families, their biomass oscillates ranged from 0.07 % to 0.33 % are weakly represented (Table 6).

Table 6. Biomass *Dendrocopos major* taxa of prey in the forest of Tikjda (Bouira).

Ordres	Families	Prey taxa	pi	B (%)
Hymenoptera	Formicidae	*Camponotus micans*	13.22	44.20
		Camponotus creuntatus	1.79	5.98
		Camponotus erigens	0.89	2.97
		Camponotus barbaricus xanthomelas	0.04	0.12
		Crematogaster scutellaris	0.75	2.50
		Cataglyphis bicolor	0.14	0.48
		Pheidole pallidula	0.08	0.26
		Tapinoma magnum	0.02	0.07
		Tetramorium biskrens	0.14	0.46
		Plagiolepis barbara	0.15	0.49
		Aphaenogaster testaceo-pilosa	1.37	4.56
		Messor barbara	10.37	34.66
	Apidae	Apidae sp.	0.02	0.08
		Apis sp.	0.08	0.27
	Apoidea	Apoidea sp1	0.60	2.01
		Apoidea sp2	0.15	0.50
	Ichneumonidae	Ichneumonidae sp.	0.10	0.33
	Chalcidae	Chalcidae sp.	0.02	0.07
		N	**29.92**	**100.00**

To establish the relationship between the availability and the diet of Great Spotted Woodpecker, we have used the Ivlev's index, promoting to compare the abundance of available preys in the environment and the selection of consumed preys by *D. major*. On other words, this index is applied to highlight the prey- species preferential to Great Spotted Woodpecker in Tikjda forest. In Table 7, the values of Ivlev index in *D. major* at the site of cedar forests of Tikjda vary from 0.31 for *Tapinoma magnum* to 0.72 for *Aphaenogaster testaceo- pilosa*. Also, the species whose Ivlev

Li value is negative are less consumed though, they are widely found in the environment including *Tapinoma magnum* (Li = - 0.13) or Ichneumonidae sp. (Li = - 0.98), since the species whose Ivlev Li value is positive, they appeared to be highly sought by the predator, ie species is weakly abundant species in the environment, but it has high frequencies in the trophic profile, eg the species, *Pheidole pallidula, Armadillidium* sp., *Messor picturatus* or Tenebrionidae sp. These four species are well represented in D. major's trophic menu. This is probably due to their average size (3 to 12 mm) and their anthills that house thousands of individuals (CAGNIANT, 1997).

Table 7. IVLEV index of prey of *Dendrocopos major* in Tikjda cedar (Bouira) (FR: the abundance of an item i in the diet of the Great Spotted Woodpecker FD: the abundance of an item i in the medium considered: Li: IVLEV Li).

Categories	Species	FD	FR	Li
Aranea	*Dysdera* sp.	152	16	-1
Malacostraca	*Armadillidium* sp.	2	27	0
Hymenoptera	*Messor picturatus*	390	5185	0
	Tapinoma magnium	7	27	0
	Aphaenogaster testaceo- pilosa	10	455	1
	Pheidole pallidula	8	77	0
	Cataglyphis viatica	99	12	-1
	Ichneumonidae sp.	14	1	-1
	Apoidea sp.	1	3	0
Coleoptera	*Carabus morbillosus*	2	2	-1
	Onthophagus taurus	1	1	-1
	Onthophagus sp.	2	1	-1
	Ocypus olens	6	8	-1
	Tenebrionidae sp.	1	12	0

The species found in the soil-terrain, and present in the trophic diet of *D. major* arecounted as 63 species (Li = -1), and among them, all species of the classes, Arachnids, Collemboles and Crustaceans, as well as the species of the orders; Hemiptera, Diptera, Orthoptera, Cockroaches and Coleoptera. In Formicidae, we noticed the following species; *Cataglyphis viatica, Tapinoma magnum, Messor structor, Monomorium salomonis* or again *Monomorium* sp. Also, the species found in the trophic diet, but not in the study environment and exhibiting Ivlev Li value equals to +1 are counted as 96 species. These results are in line with those previously reported on other Picidae by BENABBAS (2014), who proved that within the species well-noted in the trophic diet of Wryneck Wren, the ants were found to be widely abundant in the diet as in the environment, and this is the case of *Pheidole pallidula* (Ii. = + 0.79), *Tapinoma nigerrimum* (Ii. = + 0.98) and *Tetramorium biskrens* (Ii. = + 0.72). The value of Ivlev Li index of the species namely, *Crematogaster scutellaris, Camponotus barbaricus xanthomelas* and *Plagiolepis barbara* is +1 (Li = +1)(Table 7). Moreover, the species spotted woodpecker proved to be selective in its search for food, i.e. it chooses the place of its nest as a function to its feeding habitats. The work of TOUIHRI et al. (2015) carried out in Tunisia proved that the nesting and feeding sites are overall associated for the species *P. vaillantii,* and similarly to those carried out in Great-Bretain for the species *Picus viridis* (ALDER & MARSDEN, 2010). Conclusively, the Great Spotted Woodpeckeris a very helpful predator limiting the populations of insect species; in particular ants, and thus *Dendrocopos major* can be used as a model to study the myrmecofauna of an environment.

DISCUSSION AND CONCLUSION

Up to now, no research work has been conducted on the ecological trophic of *Dendrocopos major* in north-Africa and particularly in Algeria. Therefore, the present work was designed to study the trophic profile during breeding period. In this study, the diet of Great Spotted Woodpecker has been studied through the analysis of 52 faeces collected in period of three months (early April, May and late June, 2018), by which 8066 food items were counted, and they are belonged to 100 prey taxa distributed into six classes; Gastropods, Arachnids, Crustaceans, Myriapods, Diplopods and Insectes. This dominance of insects in the trophic profile of *D. major* is, surely related to the fact that the preys of this class are highly abundant in the environment. In Tikjda forest, the nesting spotted woodpeckers are real opportunists, and whose trophic profile are mainly composed of Hymenoptera, especially Formicidae and Coleoptera, in particular Carabidae, as well as they select less of other taxonomic groups, such as Diptera. Additionally, Coleoptera and Hymenoptera are omnipresent preys in their respective diet, which is considered as the general characteristic property of the ecology and trophic biology of this species in Algeria. Ants are a good food for the youngsters because of their thin *chitinous cuticula*, they are also relatively easy to capture because of their slow-moving speed (ant colonies), and are generally in sufficient size. All these characteristics make ants an energy-efficient prey. Since the spotted is almost exclusively insectivore, the dominance of insects in the trophic menu of Great Spotted Woodpecker becomes related to the fact that the individuals of this class are the most abundant in the environment. The other woodpeckers are also insectivores and differ from one another by their searching mode for food as the Great Woodpecker, such as green and ash woodpeckers are usually found in soil and feed almost exclusively on ants (LEGRAND & BARTOLI, 2005). The diet of *D. major* is mainly insectivore (larvae, dipterans, spiders and especially beetles, like Capricorns) confirms that this class is identified as “helpful insectivore” following the convention for the protection of birds useful for agriculture of March 19, 1902 (SIRIEZ, 1966). In similar, one author has shown that the diet of Great Spotted Woodpecker is highly varied than in other species of woodpecker. Importantly, high insectivore diets during breeding period make the species feed on insect xylophages, ants, spiders, larvae on or under bark, in cracks but also in the woods of trees (LANG, 2012). The food-at the base, must be essentially composed of larvae of phytophage insects searched in the wood that dig for all. Nevertheless, several species are also specialised in the searching of ants found in soil (Torch, green and ash peaks). Some other woodpecker species, like black woodpecker search for ants in soil rather than in trees. As for the colourful woodpecker, they are purely arboreal and more obviously omnivorous (frugivorous, granivorous, and insectivorous). Furthermore, the Great Spotted Woodpecker may have a meat diet, but it feeds willingly on eggs and chicks and does not hesitate to widen the cavities and nest boxes as predator (CLERGEAU & CHEFSON, 1988). In fact, the *D. major* feeds on insects throughout the year, grains in winter as well as eggs and chicks. Also, the species probes the slits, digs the bark and notches the hard wood through its powerful beak, and subsequently extracts the food by its elongated, flexible, sticky and hairy tongue (HAYMAN & HUME, 2003; CHANTELAT, 2001). Interestingly, the diet of this woodpecker species is a very eclectic spectrum, including mainly larvae of Coleoptera and butterflies, but also all types of insects (from ants to grasshoppers, including wasps), in addition to eggs and chicks of various passerines. Indeed, the available data regarding the role of these diets in the food chain highlight the importance of their involving in the trophic networks. Besides, the species find their main food in the insect groups, causing serious hazards to cultivated plants at one hand, and serving as a prey for other animals at the other hand. The established relationships between the plants and ants may be harmful to the human economy, indicating that some species of Formicidae (eg, *Plagiolepis* sp, and especially *Tapinoma* sp.) that can damage the agriculture protect and promote the multiplication of aphids and mealybugs to benefit from their sweet secretions (MAOUCHE-HENINE, 2016). In this context, DOUMANDJI & DOUMANDJI-MITICHE, 1992 have reported that the high significant losses of cereal grains in the highlands of Algeria are related to *Messor barbara.* It must not overlook, also, the damages due to *Crematogaster scutellaris* on the olive trees, and the cork forests, leading subsequently to the diminution of the market value of the forest product. Alike to the agricultural environment, this ant species affects, as well the wood dead than the living wood, and they make their colonies into various tree bark (BERNARD, 1968). The rapid growth of ants can be restrained by some vertebrate animals, involved in the limitation of these insects and contributed at a large extent to safeguard the ecosystem equilibrium. Among the ant enemies, the insectivorous birds, mammals, amphibians, including especially the spotted woodpecker species, feeding on 93% of ants, and consequently is considered as an efficient animal for the agricultural activities. In conclusion, the Great Spotted Woodpecker is selective in its search for food, and places its nest close to its feeding habitat, as well as it acts in the regulation of insect populations, in particular Formicidae family, and thus the species woodpecker proved to be an efficient animal model to study the myrmecofauna of an environment.

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Boughelit Nadia[1], Marniche Faiza[2], Boukhemza Mohamed[3], Meribai Youcef[4], Mouheb Walid[1], Khettar Amazigh[1]
[1]Akli Mohand Oulhadj University of Bouira, Algiers. E-mail: nadia.boughelit@gmail.com)
[2]National Veterinary School of El Alia, Algiers. E-mail: fexena@hotmail.fr
[3]Mouloud Mammeri University of Tizi Ouzou, Algiers. E-mail: ciconia@yahoo.fr
[4]Djurdjura National Park, Bouira, Algeria. E-mail: pnd@hotmail.fr

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APPENDIX. 1. Table 2. Inventory of prey taxa consumed by the Great Spotted Woodpecker during three months of study in the vicinity of the Tikjda Cedars (Djudjura National Park) and frequency of occurrence (FO%).

Classes	Orders	Families	Prey -Taxon	ni	Fc (%)	FO (%)	Occurrence classes
Gasteropoda	Pulmonae	Helicidae	*Eobania* sp.	1	0.01	1.92	Accidental
			Helicidae sp1	1	0.01	1.92	Accidental
			Helicidae sp2	2	0.02	1.92	Accidental
			Theba pisana	2	0.02	3.85	Accidental
Arachnida	Araneae	F.ind.	Araneae sp.	1	0.01	1.92	Accidental
		Dictynidae	Dictynidae sp1	3	0.04	1.92	Accidental
			Dictynidae sp2	1	0.01	1.92	Accidental
		Dysderidae	*Dysdera* sp.	16	0.20	17.31	Secondary
		Scytodidae	Scytodidae sp.	9	0.11	9.62	Accidental
		Lycosidae	Lycosidae sp.	2	0.02	1.92	Accidental
		Linyphiidae	Linyphiidae sp	2	0.02	3.85	Accidental
		Gnaphosidae	Gnaphosidae sp1	4	0.05	5.77	Accidental
			Gnaphosidae sp2	2	0.02	1.92	Accidental
		Salticidae	Salticidae sp.	1	0.01	1.92	Accidental
		Theridiidae	Theridiidae sp.	3	0.04	5.77	Accidental
	Acari	Acari	Acari sp1	1	0.01	1.92	Accidental
			Acari sp2	1	0.01	1.92	Accidental
	Ixodida	Ixodidae	Ixodidae sp1	1	0.01	1.92	Accidental
	Mesostigmata	Parasitidae	*Pergamasus* sp.	1	0.01	1.92	Accidental
Diplopoda	Julida	Julidae	*Cylindroiulus* sp.	68	0.84	30.77	Secondary
	Glomerida	Glomeridae	*Glomeris* sp	8	0.10	15.38	Secondary
	Polydesmida	Polydesmidae	*Polydesmus* sp1	12	0.15	9.62	Accidental
Diplopoda			*Polydesmus* sp2	21	0.26	5.77	Accidental
Chilopoda	Lithobiomorpha	Lithobiidae	Lithobiidae sp1	4	0.05	7.69	Accidental
			Lithobiidae sp2	3	0.04	5.77	Accidental
	Scolopendromorpha	Cryptopidae	*Cryptops* sp	2	0.02	1.92	Accidental
Malacostraca	Isopoda	Oniscidae	*Oniscus* sp.	33	0.41	36.54	Secondary
		Armadillidiidae	*Armadillidium* sp.	27	0.33	48.08	Secondary
		Porcellionidae	*Porcellio* sp.	14	0.17	7.69	Accidental
Insecta	Dictyoptera	Blattidae	*Blatta orientalis*	7	0.09	11.54	Secondary
		Blattellidae	Ectobiinae sp.	4	0.05	3.85	Accidental
			Ectobius sp.	11	0.14	19.23	Secondary
	Orthoptera	Tettigoniidae	Tettigoniidae sp.	2	0.02	3.85	Accidental
		Gryllidae	*Nemobius sylvestris*	12	0.15	23.08	Secondary
		F.ind.	Orthoptera sp.	6	0.07	11.54	Secondary
	Dermaptera	Forficulidae	*Forficula auricularia*	9	0.11	11.54	Secondary
		Carcinophoridae	*Anisolabis mauritanicus*	14	0.17	23.08	Secondary
	Coleoptera	Geotrupidae	*Geotrupes* sp.	2	0.02	1.92	Accidental
	Coleoptera	Scarabaeidae Scarabaeidae	*Rhizotrogus* sp.	2	0.02	1.92	Accidental
			Pentodon sp.	2	0.02	3.85	Accidental
			Sisyphus sp.	1	0.01	1.92	Accidental
			Onthophagus taurus	1	0.01	1.92	Accidental
			Onthophagus sp.	1	0.01	1.92	Accidental
		Staphylinidae	*Ocypus olens*	8	0.10	15.38	Secondary
			Staphylininae sp.	2	0.02	3.85	Accidental
			Atheta sp.	5	0.06	9.62	Accidental
			Othius sp.	5	0.06	5.77	Accidental
		Cetoniidae	Oxythelinae sp.	2	0.02	3.85	Accidental
			Oxythyrea funesta	2	0.02	3.85	Accidental
Insecta		Cetoniidae	*Potosia* sp.	2	0.02	1.92	Accidental
		Elateridae	*Athous* sp1	4	0.05	3.85	Accidental
			Athous sp2	1	0.01	1.92	Accidental
			Elateridae sp.	1	0.01	1.92	Accidental
		Oedemeridae	*Oedemera* sp.	1	0.01	1.92	Accidental
		Tenebrionidae	Tenebrionidae sp.	12	0.15	17.31	Secondary
			Opatrum sp.	12	0.15	15.38	Secondary
			Tribolium sp.	9	0.11	3.85	Accidental
			Tenebrio sp.	3	0.04	5.77	Accidental
		Carabidae	Carabidae sp.	1	0.01	1.92	Accidental
			Pterostichinae sp.	2	0.02	3.85	Accidental
			Nebria sp.	1	0.01	1.92	Accidental
			Harpalinae sp.	33	0.41	63.46	Privileged
			Poecilus sp.	1	0.01	1.92	Accidental
			Carabus morbillosus	2	0.02	3.85	Accidental
			Chlaenius sp.	4	0.05	7.69	Accidental

		Curculionidae	*Otiorhynchus* sp.1	3	0.04	3.85	Accidental
			Otiorhynchus sp.2	6	0.07	5.77	Accidental
			Hylobius sp.	1	0.01	1.92	Accidental
		Meloidae	*Meloe* sp.	11	0.14	15.38	Secondary
		Chrysomelidae	Chrysomelidae sp.	1	0.01	1.92	Accidental
			Halticinae sp.	7	0.09	9.62	Accidental
		Histeridae	*Saprinus* sp.	2	0.02	3.85	Accidental
		Cerambycidae	*Agapanthia* sp.	1	0.01	1.92	Accidental
Insecta	Hymenoptera	Formicidae	*Camponotus micans*	1102	13.66	96.15	Privileged
			Camponotus creuntatus	149	1.85	90.38	Privileged
			Camponotus erigens	74	0.92	42.31	Secondary
			Camponotus barbaricus xanthomelas	3	0.04	3.85	Accidental
			Crematogaster scutellaris	374	4.64	92.31	Privileged
			Cataglyphis viatica	12	0.15	11.54	Secondary
			Pheidole pallidula	77	0.95	61.54	Privileged
			Tapinoma magnum	27	0.33	23.08	Secondary
			Tetramorium biskrens	69	0.86	57.69	Privileged
			Plagiolepis barbara	49	0.61	67.31	Privileged
			Aphaenogaster testaceo pilosa	455	5.64	98.08	Privileged
			Messor picturatus	5185	64.28	100.00	Privileged
	Hymenoptera	Apidae	Apidae sp.	3	0.04	5.77	Accidental
			Apis sp.	1	0.01	1.92	Accidental
		Apoidea	Apoidea sp1	2	0.02	3.85	Accidental
			Apoidea sp2	1	0.01	1.92	Accidental
		Ichneumonidae	Ichneumonidae sp.	1	0.01	1.92	Accidental
		Chalcidae	Chalcidae sp.	1	0.01	1.92	Accidental
	Hemiptera	Pyrrhocoridae	*Pyrrhocoris apterus*	2	0.02	3.85	Accidental
		Coreidae	Coreidae sp.	3	0.04	5.77	Accidental
		Reduviidae	Reduviidae sp.	1	0.01	1.92	Accidental
			Rhinocoris sp.	1	0.01	1.92	Accidental
		Acanthosomatidae	*Elasmucha* sp.	2	0.02	3.85	Accidental
		Lygaeidae	Lygaeidae sp.	2	0.02	3.85	Accidental
		Pentatomidae	Pentatomidae sp.	3	0.04	5.77	Accidental
	Trichoptera	Leptoceridae	Leptoceridae sp.	1	0.01	1.92	Accidental
	Diptera	Stratiomyidae	Stratiomyidae sp.	1	0.01	1.92	Accidental
N = 6	**N = 19**	**N = 55**	**100 Species**	**8066**	**100.00**		

CLIMATIC VARIABILITY IN SOUTHWESTERN ROMANIA IN THE CONTEXT OF CLIMATE CHANGES DURING THE WINTER OF 2018-2019

MARINICĂ Andreea Floriana, MARINICĂ Ion, CHIMIŞLIU Cornelia

Abstract. Although the warm and dry autumn of 2018 ended sooner from a meteorological point of view, with the intense cooling of the night of November 18/19, 2018, and winter phenomena began suddenly, on the whole, the winter 2018-2019 was warm (W) with a general average of 0.55°C and a 1.5°C deviation from the normal values. December was thermally normal and slightly rainy, but it interrupted the autumn excessive drought. January was warm and, in pluviometric terms, exceptionally rainy (ER), which restored the ground water reserve. February was warm (W) and exceptionally dry, but the ground water reserve remained almost optimal due to the persistence of the snow layer, especially in the hilly area. The climatic variability of this winter was particularly high and climatic warming continued, although the solar activity was minimum and the El Niño process was absent. The paper is part of an extensive series of studies on climate variability in southwest Romania and climate change at regional level and it is useful to all those interested in climate issues and its evolution in this part of Romania.

Keywords: temperature monthly averages, Hellmann criterion, warm winter phenomena, cold waves, vegetative processes.

Rezumat. Variabilitatea climatică în iarna 2018-2019 în sud-vestul României în contextul schimbărilor climatice. Deşi toamna călduroasă şi secetoasă 2018 s-a încheiat din punct de vedere meteorologic mai devreme, odată cu răcirea intensă a vremii din noaptea de 18/19 noiembrie 2018 şi fenomenele de iarnă au început brusc, iarna 2018-2019 a fost în ansamblul său caldă (C) cu media anotimpuală generală de 0,55°C şi abaterea faţă de normală de 1,5°C. Luna decembrie a fost termic normală şi puţin ploioasă şi a întrerupt seceta excesivă a toamnei. Luna ianuarie a fost călduroasă, iar din punct de vedere pluviometric a fost excesiv de ploioasă (EP), ceea ce a refăcut rezerva de apă din sol. Luna februarie a fost caldă (C) în ansamblul său şi excesiv de secetoasă, dar rezerva de apă din sol s-a menţinut aproape de optim datorită persitenţei stratului de zăpadă mai ales în arealul dealurilor. Variabilitatea climatică a acestei ierni a fost deosebit de mare, iar încălzirea climatică a continuat deşi activitatea solară a fost la minim şi procesul climatic El Ninõ a fost absent. Lucrarea face parte dintr-o serie extinsă de studii privind variabilitatea climatică în sud-vestul României şi schimbările climatice la nivel regional şi este utilă tuturor celor intersaţi de problemele climatului şi evoluţia acestuia în această parte a României.

Cuvinte cheie: medii lunare de temperatură, criteriul Hellmann, fenomene de iarnă caldă, valuri de frig, procese vegetative.

INTRODUCTION

In January 2019, according to The Weather Department, weather forecasts indicated that, by the end of 2019, "19 of the warmest 20 years ever recorded on Earth were after 2000," (Professor Adam Scaife, Head of the Long Range Forecasting Department of The Weather Department). Dr. Doug Smith, a researcher at The Weather Department, said that "the forecast for 2019 places this year among the warmest five years so far, all of them being registered after 2015". "All these years were about 1°C warmer than the pre-industrial period." WMO indicated that 2018 was among the warmest four years ever recorded, ranking after 2016, 2015, and 2017. It was projected that, in 2019, global average temperatures would be about 1.10°C higher than the pre-industrial period, thus close to those registered in the ***record year 2016*** when temperatures were 1.15°C above the average of the period 1850-1900 (Agerpres). The estimates issued by The Weather Department at the end of 2017 for 2018 were close to what was actually recorded in 2018. (https://www.digi24.ro/meteo/meteorologi-2019-ar-putea-fi-unul-dintre-cei-mai-calzi-ani-din-istorie-1052159). Global warming continued in 2018 even though solar activity was minimum and the El Niño climate process was absent. Thus, in terms of *average global temperature*, 2018 was the fourth hottest year in the history of rigorous climatic observations on Earth, and climate change trends show that temperatures will continue to increase, based on the data supplied by NOAA and NASA. The data of the two agencies show that the global average of 2018 atmospheric temperatures was 0.79°C higher than the average of the 20th century temperature of 13.9°C (Science News). The warming trend became evident in the mid-1970s. For much of the Southern Hemisphere, 2018 marked a record in terms of maximum and average temperatures for the second consecutive year. Certain *regions in the Northern Hemisphere* also recorded the highest average temperatures, including some parts of Europe, the Middle East and the West of the Pacific. In the Arctic region, temperatures continued to increase faster than global average temperatures. In *Romania*, the average annual air temperature in 2018 was 11.57°C, this being the third highest value since 1901 to date, according to recordings from long-term meteorological stations (N.A.M.). The average air temperature in 2018 exceeded by 1.35°C the climatological average for the period 1981-2010 (according to the Deputy Prime Minister and Minister of the Environment, Graţiela Gavrilescu). In *Oltenia*, the average annual temperature in 2018 calculated for the whole region was 11.76°C, and the deviation from the general average of the last century was 1.94°C, which shows that, at the regional level, Oltenia is one of the warmest regions of Romania. In this context, climatic variability was particularly high in Oltenia during the year 2018. After the warm spring, when ***April had the highest monthly climatic averages in the history of climate observations,*** not only in Romania, but also within most of Europe, summer started with exceptionally rainy weather in the first two months. Autumn was exceptionally dry and warm until November 18; then, suddenly, on the night of November 18/19, rain turned into sleet and snow, and the weather became cooler than normal and a consistent layer of snow formed. The paper is part of a series of extensive studies on climate variability in the southwest of the country and the effects of climate warming, being useful to all those interested in climate change in this part of Romania – BOGDAN et al. (2008); MARINICĂ & CHIMIŞLIU (2008); BOGDAN & MARINICĂ (2009); BOGDAN et al. (2010); MARINICĂ et al. (2010, 2011, 2012, 2013); BOGDAN et al. (2014). We will further analyze this exceptional climatic variability characteristic to the winter 2018-2019 at regional level in Oltenia and its consequences for crops, biotopes, economy and environment in general.

MATERIAL AND METHOD

For the achievement of the present study, we used the results of daily data processing based on special software from the forecasting process, the data archive of the N.A.M., the maps achieved during the operative activity and those provided by the international analysis and forecast centres, available online, as well as provided by N.A.M. Bucharest. We used Microsoft Office to draw up tables and charts. The paper analyses the climatic variability of the warm winter 2018-2019 in the southwest of Romania, based on the thermal and pluviometric regime of December 2018, January and February 2019 and the overall thermal and pluviometric regime of the winter 2018-2019. Effects on the environment and biotopes were also analysed.

RESULTS

1. a. The thermal regime of December 2018.

Monthly air temperature averages ranged from -0.7°C in Polovragi to 1.8°C in Drobeta Turnu Severin and their deviations from the multiannual averages were between -1.1°C in Târgu Logreşti and 0.7°C in Voineasa, determining the classification of the thermal types based on the Hellmann criterion as normal within almost the entire region except for a small area at Târgu Logreşti, where December was cool (CO) with a deviation that was very close to the lower limit of the normal (Table 1). *The monthly average air temperature* calculated for the entire region was 0.0°C, and its deviation from the normal was -0.14°C, which confirms that December 2018 was thermally normal as average for the entire Oltenia region. There were 14 days in which the daily air temperature averages for the whole region were positive and 17 days when they were negative (cold days). According to the daily average temperature for the entire region, the warmest day was December 23 with a daily average of 4.94°C, while the coldest day was December 1 with an average of -6.1°C. The *monthly minimum air temperature values* were recorded on December 1, 2, 3, and varied between -7.3°C in Drobeta Turnu Severin and -16.4°C in Bechet; their average for the entire region was -11.0°C. The *coldest morning* of December 2018, based on the average of the minimum temperatures calculated for the entire region, was registered on December 2 and it was -9.59°C. The *monthly maximum temperatures* were recorded on different dates (December 4, 5, 9, 10, 23 and 29) and ranged from 7.4°C in Voineasa to 14.6°C in Târgu Jiu; their average for the entire Oltenia region was 10.9°C. According to the daily averages of the maximum temperatures for the entire region, in December, only five days of winter were recorded. *The hottest day of December 2018*, based on the average of the maximum temperatures for the entire region, was December 23, when the average reached 10.2°C and *the coldest day* was December 1 with an average of -1.85°C. At *the soil surface, the minimum temperatures* were recorded mostly on December 1, 2 and 3 and were between -8.6°C in Apa Neagră and -16.4°C within the Oltenia Plain in Băileşti; their average for the entire region was -12.1°C. The maximum temperatures at the soil surface were registered on different dates (December 5, 9, 10, 23 and 28) and ranged between 7.2°C in Drăgăşani and 17.1°C in Băileşti and their average for the entire region was 12.0°C. There were frequent alternations of frost and thaw at the surface of the soil, and the vernalization[1] process was carried out during the cold periods of the month. The thermal regime specific to December installed in the last two days of November, when temperature dropped below 0.0°C. The minimum monthly temperatures were registered on November 30. The *frost units*[2] ranged from 16.7 in Drobeta Turnu Severin and 46.9 in Voineasa and their average for the entire region was 37.4°C. The heat units ranged from 8.9 at the southern limit of the mountain region in Voineasa and 80.5 in southwestern Oltenia, in Calafat; their average for the entire region was 36.2, only 1.2 lower than the frost units, which reflects a state of thermal balance between slightly cooler weather and slightly warmer weather compared to the normal, that is, ***a mild December month*** from the ***agrometeorological point of view***. The values of agrometeorological frost were insignificant. These thermal characteristics had a particular influence on vegetation and biotopes that, after the

[1] Vernalization represents the acquiring or acceleration of flowering capacity under the influence of low temperature exposure.

[2] The ***degree of winter bitterness*** in agrometeorology (winter type) is classified according to the sum of frost units (∑ of the differences between the daily minimum temperature values <-15°C and the agroclimatic critical threshold of -15.0°C, in the interval December - February). Therefore, ***a frost unit is the difference of 1°C between the critical threshold of -15.0°C and an air minimum thermal value ≤ -15°C*** (for example for T min = -16.0°C then the difference -15.0°C - (-16.0°C) = 1, namely a frost unit, (SANDU et al., 2010); ***Frost units for the entire cold season*** are calculated as Σ of daily average temperatures <0°C, in the period November-March; A ***frost day*** is the day with the average temperature ≤ 0°C; The ***active temperature are those ≥0°C,*** while the temperature of the biological minimum is 0°C. A ***winter day*** is a day with the air maximum temperature < 0°C. ***Heat units*** (∑ of daily average temperatures ≥ 0°C). From the public point of view with regard to weather forecast, ***the notion of frost is associated with temperature values of ≤ -10°C***. Thus, ***frost*** defined in terms of weather forecast (which are adapted to living organisms) is different from ***agrometeorological frost*** (temperatures of ≤-15°C), plants being better adapted to climatic conditions (due to their cellular structure and specific biotic processes).

cooling registered by the end of November and the beginning of December, in the warm days of December, slowly resumed vegetative activity and biotic processes within biocoenoses[3], 0.0°C being the temperature of the biological minimum.

Table 1. Air temperature regime within Oltenia and the minimum and maximum temperature values at the soil surface in December 018 (N XII = December normal values calculated for the period 1901-1990, M XII = monthly averages of December 2018; Δ=M-N = temperature deviation, CH = Hellmann criterion).

No	**Meteorological station**	**Hm**	**N XII**	**M XII**	**Δ=M-N**	**CH**	**Min T air (°C)**	**Date**	**Max T air (°C)**	**Date**	**Min T soil (°C)**	**Date**	**Max T soil (°C)**	**Date**
1	Dr. Tr. Severin	77	1.4	**1.8**	0.4	**N**	***-7.3***	1	13.0	9	-8.8	1	14.6	9
2	Calafat	66	1.0	1.5	0.5	**N**	-10.2	2	13.6	23	-14.8	2	14.4	28
3	Bechet	65	0.4	0.4	0.0	**N**	***-16.4***	1	12.3	23	-14.8	1	9.8	9
4	Băileşti	56	0.4	0.5	0.1	**N**	-13.0	1	11.1	9	***-16.4***	1	**17.1**	6
5	Caracal	112	-0.1	0.0	0.1	**N**	-11.5	2;3	9.5	9	-12.2	2	9.6	9
6	Craiova	190	0.1	-0.3	-0.4	**N**	-10.0	2	9.7	9	-10.5	3	13.8	9
7	Slatina	165	0.3	-0.5	-0.8	**N**	-10.4	2	9.0	29	-11.8	3	10.2	23
8	Bâcleş	309	-0.4	-0.2	0.2	**N**	-10.5	2	9.9	9	-	-	-	-
9	Tg. Logreşti	262	0.1	-1.0	***-1.1***	**CO**	-10.8	2	10.3	10	-15.5	26	12.8	9
10	Drăgăşani	280	0.6	0.1	-0.5	**N**	-7.9	2;26	10.1	29	-9.2	3	***7.2***	9
11	Apa Neagră	250	0.1	-0.8	-0.9	**N**	-11.0	13	12.9	5	***-8.6***	28	8.7	9
12	Tg. Jiu	210	0.1	-0.3	-0.4	**N**	-8.1	3	**14.6**	23	-8.8	31	14.2	10
13	Polovragi	546	0.1	***-0.7***	-0.8	**N**	-12.2	1	9.6	5	-14.2	1	12.3	5
14	Rm. Vâlcea	243	0.5	0.1	-0.4	**N**	-8.1	2	11.6	5	-11.9	26	11.0	5
15	Voineasa	587	-1.9	-1.2	**0.7**	**N**	-12.5	1	***7.4***	23	-	-	-	-
16	Parâng	1585	-3.7	-	-	-	-15.7	1	9.2	24	-	-	-	-
	Average for Oltenia	-	0.18	0.04	-0.14	**N**	-11.0	-	10.9	-	-12.1	-	12.0	-
17	Ob. Lotrului	1404	-4.9	-4.1	0.8	**N**	-19.7	14	4.4	4	-	-	-	-

(Source: processed data from the N.A.M. Archive)

The *graphs of the variation of the parameters* characterizing air temperature (average of daily minimum values, daily average and average of daily maximum values, all calculated for the entire region) in December 2018 presented significant increasing linear trends (Fig. 1).

The statistical analysis of the evolution of average air temperature in December during the last 58 years (1961-2018) leads to the following conclusions (Table 2): The ***coldest December months*** in the last 58 years were recorded in: ***1998*** (CL, with an average of ***-4.03°C***), ***1977*** (CL, with an average of -3.66°C), ***2001*** (CL, with an average of - 3.59°C), ***1962*** (CL, with an average of -3.31°C), ***2002*** (CL, with an average of -3.04°C), ***1991*** (CL, with an average of -2.39°C) and ***1963*** (CL, with an average -2.16). ***December 1998 was the coldest first winter month in the last 58 years, being classified as cold (CL), according to the temperature values registered at the level of 2m above the ground*** (MARINICĂ & MARINICĂ, 2012; 2016). As a result, ***in the last 58 years, there was only one December month with a monthly average below -4.00°C (1998)***. Most of the months colder than the normal were recorded before 1999 (12 months out of a total of 16 months). The warmest December months in the last 58 years were recorded in the years: ***2015*** (VW, with a general average of 5.19°C), ***1979*** (W, with a general average of 3.21°C), ***1982*** (W, with a general average of 3.08°C), ***2017*** (W, with a general average of 2.74°C), ***1971*** (W, with a general average of 2.37°C), ***1985*** (W, with a general average of 2.17°C). Most *December months were thermally normal*, 26 cases (44.8%) and the number of warm and cold months was the same, 16 cases (namely 27.6%); there was registered only one very warm (VW) month in the warmest year in the history of climate observations in Romania (2015 with the annual average for the entire Romania of 11.72°C, and at the regional level, in Oltenia, the annual average was 1.93°C). No December months were very cold. The number of warmish December months (WS) was 10, while the number of cool months (CO) was 9 months. Most December months warmer than the normal have been recorded since 1999 (10 months out of 16). The *increase trend of the average monthly temperature* over the last 58 years, calculated for the entire region, is evident, with a significant increase rate (0.0168) (Fig. 2).

December 2015 was the warmest first winter month (Table 2) and the only very warm (VW) month for the entire Oltenia region during the observation period. ***The monthly average of 5.19°C for the entire Oltenia region, registered in December 2015, is an absolute climatic record for December, recorded in the warmest year in Romania so far***. The average December temperature, calculated for the entire region over the past 58 years, was 0.16°C. As a result of the increase in the average monthly temperature, the frequency, duration and intensity of cold waves in December declined considerably. Climate warming is thus demonstrated also at the regional level, and the continuation of this climate process in 2018 (with an average of -0.04°C) was done under the conditions of minimum solar activity and in the absence of the El Niño climate process.

[3] The term ***biocoenosis*** (from the Greek koinosis – to share) is an over-individual level of organization of living matter and describes the totality of living, vegetal (*phytocenosis)* organisms and animals (*zoocoenosis)* interacting with each other and living in a particular environment or sector from the biosphere (*biotope),* forming with it a unitary one and that is in a dynamic dynamically dependent on that medium. It is characterized by a certain structure and function given by the model of circulation of matter, energy and information. The term biocoenosis was proposed by Karl Möbius in 1877 (http://en.wikipedia.org/wiki/Biocenoz%C4%83).

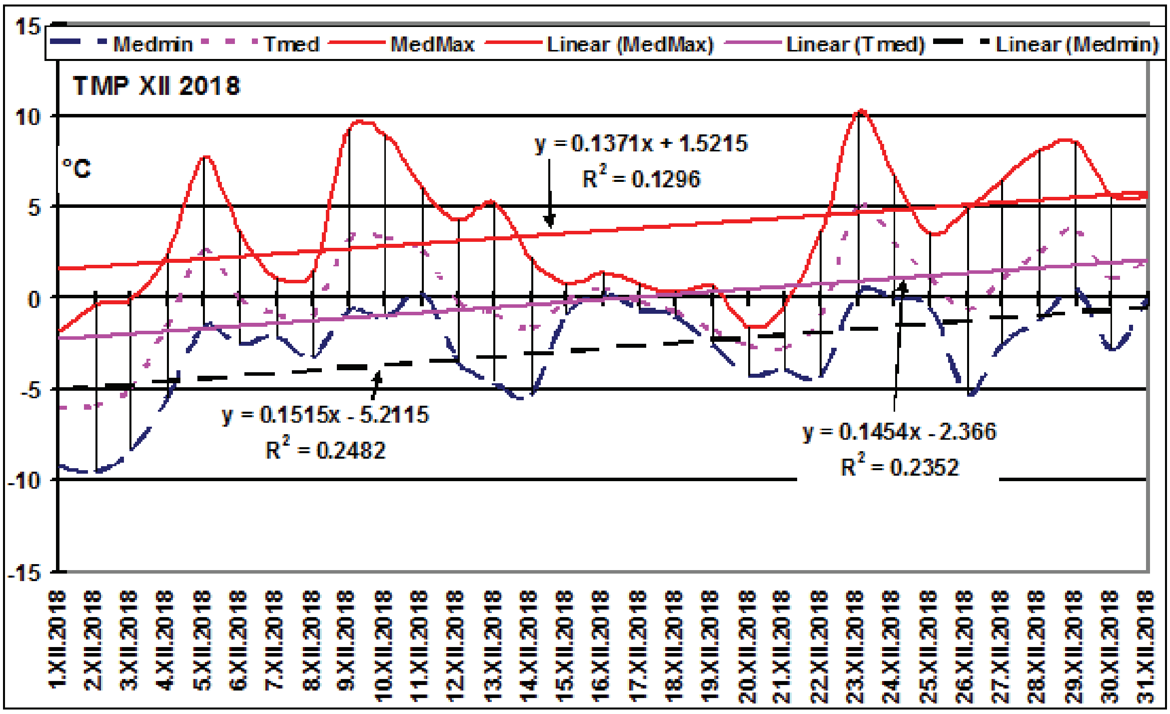

Figure 1. Variation of the parameters characteristic to air temperature (average of daily minimum values, daily average and average of daily maximum values calculated for the entire region) in December 2018. (Source: processed data from the N.A.M. Archive).

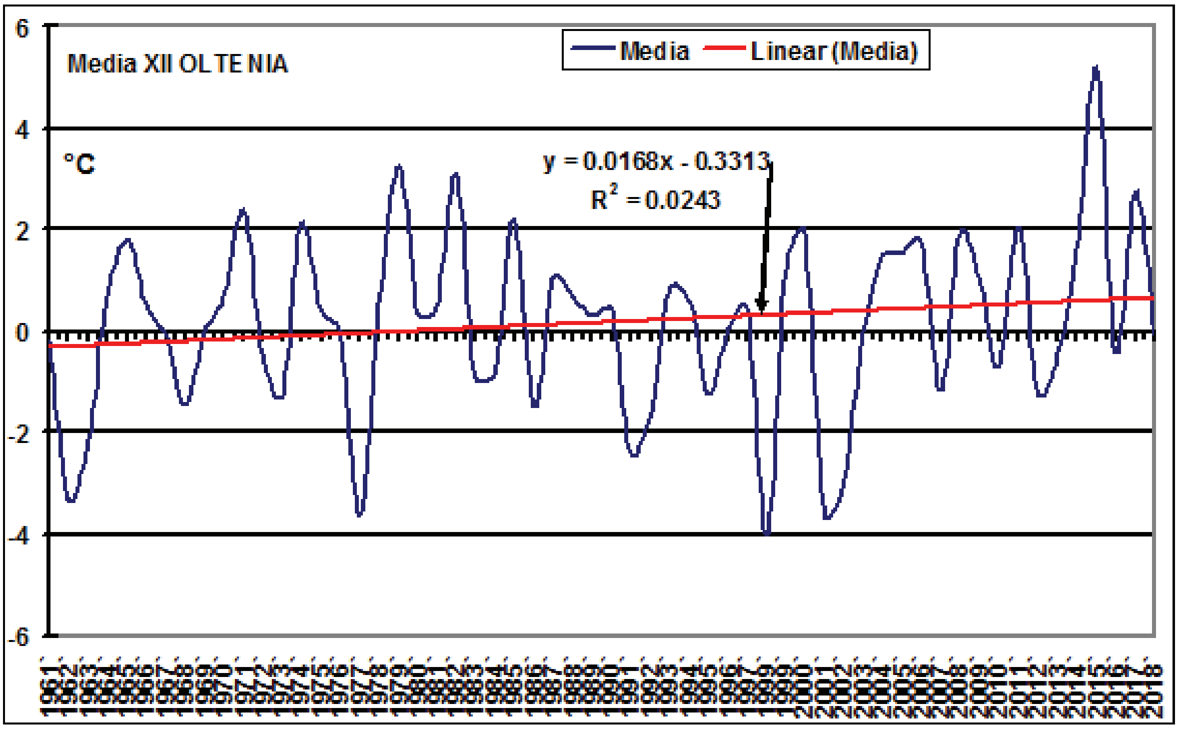

Figure 2. Variation of the air average temperature calculated for the entire region Oltenia in December in the last 58 years (1961-2018).

1. b. The pluviometric regime of December 2018. The *monthly rainfall amounts* ranged between 17.1 l/m^2 at Bechet and 98.2 l/m^2 at Râmnicu Vâlcea. Their percentage deviations from the normal values ranged from -52.9% at Bechet and 112.6% at Râmnicu Vâlcea, determining the classification of pluviometric types from excessively dry (ED) in Bechet to excessively rainy (ER) in the Oltenia Hills in Drăgăşani, in the Subcarpathian Depression in Polovragi, in the Olt Corridor in Râmnicu Vâlcea and in the mountain area in Parâng (Table 3).

Table 2. Thermal classification of December months within Oltenia in the last 58 years. (**AvgT** = December average temperature calculated for the entire Oltenia region with altitudes below 600 m (°C), Type = thermal classification of the month according to Hellmann criterion[4], Cold = no. of cold months and their percentage, Normal = no. of normal months and their percentage, Warm = no. of warm months and their percentage, EC= excessively cold, VC = very cold, CL = cold, CO = cool, N = normal, WS = warmish, W = warm, VW = very warm, EW = excessively warm).

No	Year	AvgT	Type	No	Year	AvgT	Type	No	Year	AvgT	Type	No	Year	AvgT	Type
1	1961	-0.17	**N**	17	1977	-3.66	**CL**	33	1993	0.81	**N**	49	2009	1.00	**N**
2	1962	-3.31	**CL**	18	1978	0.53	**N**	34	1994	0.61	**N**	50	2010	-0.72	**N**
3	1963	-2.16	**CL**	19	1979	3.21	**W**	35	1995	-1.24	**CO**	51	2011	2.05	**WS**
4	1964	0.68	**N**	20	1980	0.34	**N**	36	1996	0.05	**N**	52	2012	-1.22	**CO**
5	1965	1.81	**WS**	21	1981	0.48	**N**	37	1997	0.47	**N**	53	2013	-0.42	**N**
6	1966	0.54	**N**	22	1982	3.08	**W**	38	***1998***	***-4.03***	**CL**	54	2014	1.61	**WS**
7	1967	-0.11	**N**	23	1983	-0.90	**CO**	39	1999	1.21	**WS**	55	**2015**	**5.19**	**VW**
8	1968	-1.44	**CO**	24	1984	-0.82	**CO**	40	2000	1.95	**WS**	56	2016	-0.40	**N**
9	1969	-0.03	**N**	25	1985	2.17	**W**	41	2001	-3.59	**CL**	57	2017	2.74	**W**
10	1970	0.69	**N**	26	1986	-1.48	**CO**	42	2002	-3.04	**CL**	58	2018	-0.04	**N**
11	1971	2.37	**W**	27	1987	1.01	**N**	43	2003	0.00	**N**		Media	0.16	**N**
12	1972	-0.43	**N**	28	1988	0.70	**N**	44	2004	1.45	**WS**		Cold	16	27.6%
13	1973	-1.26	**CO**	29	1989	0.28	**N**	45	2005	1.55	**WS**		Normal	26	44.8%
14	1974	2.12	**WS**	30	1990	0.41	**N**	46	2006	1.80	**WS**		Warm	16	27.6%
15	1975	0.37	**N**	31	1991	-2.39	**CL**	47	2007	-1.19	**CO**				
16	1976	-0.01	**N**	32	1992	-1.61	**CO**	48	2008	1.90	**WS**				

(Source: processed data from the N.A.M. Archive)

Within the Oltenia Plain, December 2018 was characterized by deficit and, in the Bechet area, dry time continued from August 1, 2018 until March 8, 2019. *The average monthly rainfall amount* for the entire Oltenia region was 58.9 l/m² and its percentage deviation from the normal was 16.8%, which, according to the Hellmann criterion, determined the classification of the month as a little rainy month (LR). There was only one interval with significant rainfalls between December 14 and 18, and here we mention December 14, 15, 16 when the average rainfall amount for the entire region was 11.0 l/m² (on December 14), 15.0 l/m² (on December 15) and 20.7 l/m² (on December 16) respectively. In December, rainfall was in the form of rain, sleet and snow. The *snow layer* formed on the night of November 28 / 29 slowly melted in the interval December 1-5 and, on the night of December 14-15, it snowed again and the new layer reached a maximum thickness of 6 cm in Calafat and Râmnicu Vâlcea and 45 cm in Apa Neagră (Padeş) in Gorj County.

Table 3. Rainfall amounts registered in the winter 2018-2019 (Σ) compared to the normal[5] values (N); Δ%=percentage deviation from the normal, CH= Hellmann criterion.

No	**Meteorological station**	**Hm**	**December 2018**				**January 2019**				**February 2019**			
			ΣXII	**N**	**Δ%**	**CH**	**Σ I**	**N**	**Δ%**	**CH**	**ΣII**	**N**	**Δ%**	**CH**
1	Dr. Tr. Severin	77	45.7	61.2	-25.3	**D**	98.5	51.4	91.6	**ER**	31.7	47.9	-33.8	**VD**
2	Calafat	66	23.5	45.5	-48.4	**VD**	68.5	40.4	69.6	**ER**	10.1	38.0	-73.4	**ED**
3	Bechet	65	***17.1***	36.3	***-52.9***	**ED**	20.4	33.5	-39.1	**VD**	12.2	34.8	-64.9	**ED**
4	Băileşti	56	26.0	46.8	-44.4	**VD**	57.7	38.5	49.9	**VR**	11.3	36.1	-68.7	**ED**
5	Caracal	112	42.5	39.5	7.6	**N**	48.6	34.7	40.1	**VR**	14.6	34.5	-57.7	**ED**
6	Craiova	190	59.6	41.8	42.6	**VR**	65.2	37.5	73.9	**ER**	17.2	30.4	-43.4	**VD**
7	Slatina	165	46.2	42.8	7.9	**N**	59.4	36.0	65.0	**ER**	14.0	38.4	-63.5	**ED**
8	Bâcleş	309												
9	Tg. Logreşti	262	64.9	44.8	44.9	**VR**	101.8	35.9	183.6	**ER**	24.9	41.0	-39.3	**VD**
10	Drăgăşani	280	71.1	44.6	59.4	**ER**	81.9	34.1	140.2	**ER**	12.1	35.4	-65.8	**ED**
11	Apa Neagră	250	73.1	82.3	-11.2	**LD**	**164.8**	70.9	132.4	**ER**	24.2	66.4	-63.6	**ED**
12	Tg. Jiu	210	79.1	64.0	23.6	**R**	119.0	53.9	120.8	**ER**	**32.8**	52.0	-36.9	**VD**
13	Polovragi	546	85.6	56.1	52.6	**ER**	103.6	48.9	111.9	**ER**	16.9	48.4	-65.1	**ED**
14	Rm. Vâlcea	243	**98.2**	46.2	**112.6**	**ER**	89.6	35.5	152.4	**ER**	9.1	38.4	-76.3	**ED**
15	Voineasa	587												
16	Parâng	1585	92.5	54.6	69.4	**ER**	84.5	57.7	46.4	**VR**	32.0	47.7	-32.9	**VD**
	Average for Oltenia	-	58.9	50.5	16.8	**LR**	83.1	43.5	91.1	**ER**	16.9	42.3	-60.0	**ED**
17	Ob. Lotrului	1404	173.6				107.0				30.6			

(ER=excessively rainy; VR=very rainy, R=rainy, LR=little rainy, N=normal, LD=little dry, VD=very dry, ED=excessively dry) (Source: processed data from the N.A.M. Archive)

The *warming* of the weather from December 22-31 caused the melting of the snow layer in Oltenia Plain, but in the hilly area, especially in the Gorj County, the Subcarpathians and the mountain area, it persisted until February 11, 2019, with various thicknesses. In the area sheltered by the Carpathian curvature cold air persisted and the

[4] The comparison was made with December multiannual average for the last century, average calculated for the whole region (1901-1990). ***The comparison with the statistical median is irrelevant***, as the median has no connection to the dataset other than that the value is positioned at the middle of the dataset arranged ascending order.

[5] Voineasa and Bâcleș meteorological station cannot be taken into account as they do not have complete pluviometric data series for the cold season.

snow layer was maintained from December 15 until February 11 (59 days), while in the south of Gorj County, the snow layer melted and reappeared several times in the winter of 2018-2019. In Târgu Logreşti, on the morning of December 11, the snow layer was 7 cm thick, but it melted until the evening. The curvature of the Southern Carpathians in the sector between the Almăj and Parâng Mountains, in interaction with air circulation from the western sector (which usually causes warming in Oltenia), has a sheltering effect, similar to the effect of an airplane wing, keeping cold air above Gorj County, an area in the northeast of Mehedinţi County and an area in the northwest of Vâlcea County. This explains the lower monthly average temperatures in Gorj, as well as the lower spring arrival indexes in this area. Cold air advections in this area, from the east and northeast, are not prevented by any orographic barrier and penetrate the entire Oltenia. At the end of December, on December 29, for the crop of autumn wheat, the *water supply* on the soil profile of 0-100 cm was satisfactory, close to the optimal or within optimal limits, in most of Oltenia (N.A.M.)

2. a. The thermal regime of January 2019.

The monthly air temperature averages ranged between -2.9°C in Voineasa and 0.9°C in Drobeta Turmu Severin, and their deviations from the multiannual averages of the last century ranged between 0.4°C in Apa Neagră (Padeş) and 2.3°C in Calafat, which according to Hellmann criterion, corresponds to normal (N), within small areas such as Târgu Logreşti and Apa Neagră, and warm (W) in Drobeta Turmu Severin, Calafat and Caracal. *Warmish time* (WS) had the largest spatial-temporal extension in January (Table 4). *The monthly average air temperature* calculated for the entire Oltenia region was -1.0°C and its deviation from the average of the last century (considered normal) was 1.6°C, which confirms that January 2019 was warmish (Ws) in average for the entire Oltenia region.

Table 4. Air temperature regime within Oltenia and the minimum and maximum temperature values at the soil surface in January 2019 (N I = January normal values calculated for the period 1901-1990, M I = monthly averages of January 2019; Δ=M-N = temperature deviation, CH = Hellmann criterion).

No	Meteorological station	Hm	N I	M I	Δ=M-N	CH	Min T air (°C)	Data	Max T air (°C)	Data	Min T soil (°C)	Data	Max T soil (°C)	Data
1	Dr.Tr. Severin	77	-1.1	0.9	2.0	W	-9.3	8	13.5	17	-10.2	5	13.7	17
2	Calafat	66	-1.8	0.5	2.3	W	-11.1	14	14.3	17	-12.5	12	15.4	17
3	Bechet	65	-2.2	-0.5	1.7	WS	-12.2	8	11.1	17	-11.4	5	14.8	31
4	Băilești	56	-2.3	-0.6	1.7	WS	-12.2	14	10.9	17	-17.6	13	12.1	3
5	Caracal	112	-2.9	-0.8	2.1	W	-12.1	8	9.4	17	-13.0	9	8.9	31
6	Craiova	190	-2.6	-1.0	1.6	WS	-11.7	5;8	11.0	17	-11.8	5	15.2	31
7	Slatina	165	-2.4	-1.2	1.2	WS	-12.7	8	9.9	18	-15.8	8	5.0	30
8	Bâcleș	309	-3.0	-1.1	1.9	WS	-10.7	8	9.2	17	-	-	-	-
9	Tg. Logreşti	262	-2.7	-2.1	0.6	N	-16.5	8	10.1	17	-19.4	8	5.8	17
10	Drăgăşani	280	-2.2	-0.5	1.7	WS	-9.7	8	9.9	18	-11.8	8	18.0	30
11	Apa Neagră	250	-2.6	-2.2	0.4	N	-17.3	12	8.2	16	-18.4	13	6.0	17
12	Tg. Jiu	210	-2.6	-1.5	1.1	WS	-13.7	13	12.5	17	-14.9	13	4.5	17
13	Polovragi	546	-3.2	-1.6	1.6	WS	-12.2	8	7.9	18	-19.4	8	7.2	15
14	Rm. Vâlcea	243	-2.2	-0.5	1.7	WS	-11.1	8	9.6	16	-16.6	13	8.6	18
15	Voineasa	587	-4.7	-2.9	1.8	WS	-16.9	5	8.3	17	-	-	-	-
16	Parâng	1585	-	-	-	-	-17.1	5	3.3	31	-	-	-	-
	Average for Oltenia	-	-2.6	-1.0	1.6	WS	-12.6	-	10.4	-	-14.8	-	10.4	-
17	Ob. Lotrului	1404	-6.2	-5.9	0.3	N	-24.0	5	5.8	29	-	-	-	-

(Source: processed data from the N.A.M. Archive)

Most of *the monthly minimum air temperatures* were registered on January 8 and ranged between -17.3°C in Apa Neagră and -9.3°C in Drobeta Turmu Severin and their average for the entire region was -12.6°C. Most of *the monthly maximum air temperatures* were registered on January 17 and were between 8.2°C in Apa Neagră and 14.3°C in Calafat, and their average for the entire region was 10.4°C. *Frost units* ranged between 11.3 in Drobeta Turmu Severin and 98.6 at Voineasa, and their average for the entire region was 49.7. Most frost units were registered in the interval January 1-14. According to the general average of the daily maximum temperatures for the entire region, there were 4 winter days in January. Vernalization continued especially in the period January 1-14. *Heat units* were between 8.8 in Voineasa and 40.3 in Drobeta Turmu Severin, and their average for the entire region was 19.0. From an agrometeorological point of view, these values mean a ***mild winter month***. Most heat units were registered in the interval January 15-31. According to the daily temperature average for the entire region, *the coldest day* was January 8, with an average of -7.1°C, and the warmest day was January 31, with the average of 2.5°C.

At *the surface of the soil, the monthly minimum temperatures* were registered on January 5, 8, 9, 12 and 13 and ranged between -10.2°C in Drobeta Turmu Severin on January 5 and -19.4°C in Târgu Logreşti and Polovragi on January 8 and their average for the entire region was -14.8°C. *At the surface of the soil, the monthly maximum temperatures* were registered on January 3, 15, 17, 18, 30 and 31 and ranged between 4.5°C in Târgu Jiu on January 17 and 18.0°C in Drăgăşani on January 30. Their average for the entire region was 10.4°C, equal to the average of the maximum monthly air temperature values. *The graphs of the variation of the parameters* characterizing air temperature (average of daily minimum values, daily average and average of daily maximum values, all calculated for the entire region) in January 2019 had markedly increasing linear trends (Fig. 3).

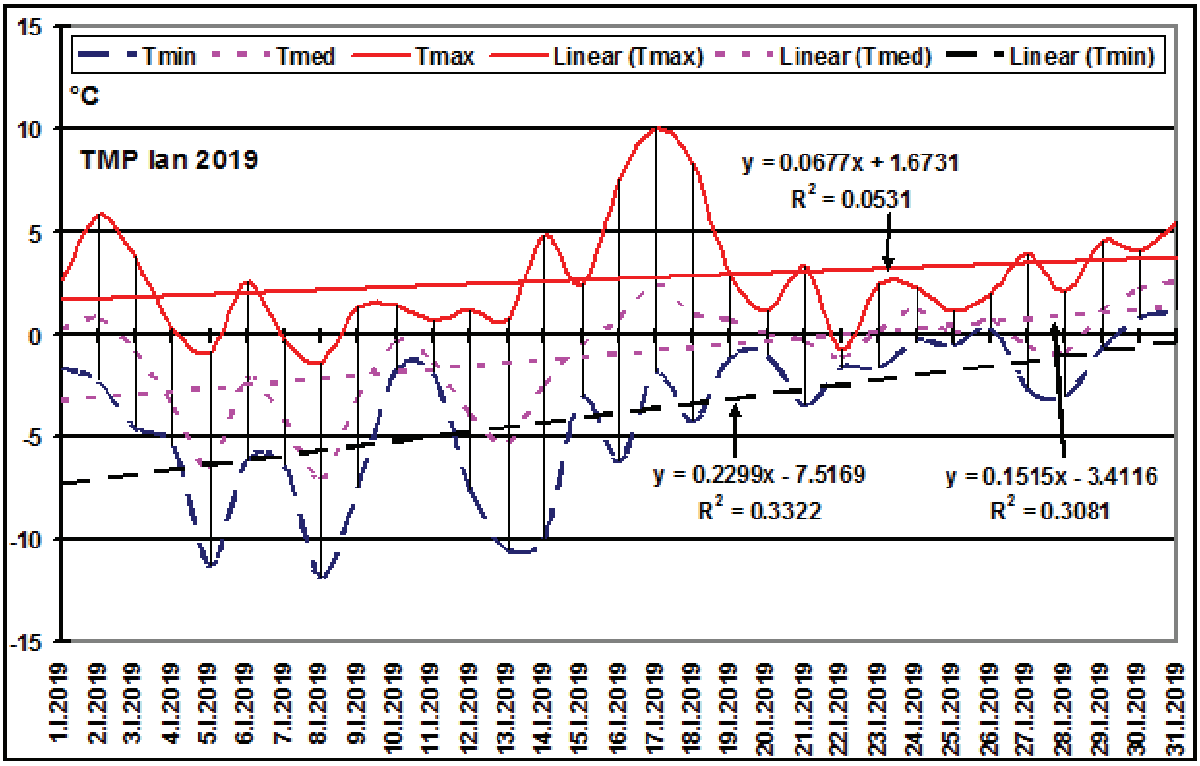

Figure 3. Variation of the parameters characteristic to air temperature (average of daily minimum values, daily average and average of daily maximum values calculated for the entire region) in January 2019. (Source: processed data from the N.A.M. Archive).

2. b. The pluviometric regime of January 2019. *The monthly rainfall amounts* ranged between 20.4 l/m^2 in Bechet and 164.8 l/m^2 in Apa Neagră (Padeş) and their percentage deviations from the multiannual averages calculated for the last century ranged from -39.1% at Bechet (the only one area with negative deviation) and 183.6% in Târgu Logreşti which, according to Hellmann criterion, makes January 2019 excessively rainy (ER) within most of the region. We notice monthly amounts ≥ 100.0 l/m^2 in 5 meteorological stations (Tg. Logreşti 101.8 l/m^2, Polovragi 103.6 l/m^2, Obârșia Lotrului 107.0 l/m^2, Târgu Jiu 119.0 l/m^2, Apa Neagră 164.8 l/m^2) and a value close to 100.0 l/m^2 in Drobeta Turnu Severin (98.5 l/m^2). *The average of the monthly rainfall amounts* calculated for the entire region was 83.1 l/m^2 and its percentage deviation from the normal was 91.1%, which confirms that January 2019 was on average excessively rainy (ER) for the entire Oltenia region (Table 3).

Precipitations were predominantly solid and three intervals with significant amounts were registered: January 9-10, January 22-26 and January 29-30 totalizing 9 days. The highest amount was registered on January 24, 2019, when the average calculated for the entire region was 17.1 l/m^2 and the maximum amount of rainfall recorded in 24 hours was 39.3 l/m^2 in Râmnicu Vâlcea. The *snow layer* in January in the Oltenia Plain gradually increased starting with January 4 and reached the maximum thickness on January 11, when it ranged between 6 cm in Slatina and 15 cm in Craiova. In the hilly area and the Subcarpathians, it persisted throughout the month and reached the maximum thickness on January 23 with values between 10 cm in Drăgăşani and 49 cm in Apa Neagră. The reduction of the snow layer started on January 28 as heating process began. In the mountain area from northern Oltenia, the thickness of the snow layer reached 142 cm in Obârșia Lotrului on January 26, while at the Parâng Peak, it reached 102 cm on January 31. *At the level of the entire country*, the snow layer was consistent, reaching 110 cm in Cavnic (Maramureş County) on January 15; in the area of the settlements Şuior, Firiza, Chiuzbaia, Baiuț located close to the mountains, it reached over 120-130 cm, while the maximum thickness of 228 cm was reached in Cuntu, in the mountain area, on January 16. In the *Southern Hemisphere*, January is the peak summer month, and in Australia[6], in Tarcoola, the absolute thermal maximum of 48.7°C was registered (on the same date, January 16), in Port Augusta the absolute thermal maximum reached 49.5°C and in Adelaide 46.6°C. On the same day, in Russia, at Ikki-Ambar (Yakuția), the temperature dropped to -56.0°C. In January, *the snow layer in Europe* exceeded 2 m in some areas in Austria and southern Germany blocking the rail and air traffic (January 14); in Germany, on this date, a ***violet warning for violent snows*** was issued. The violet warning (in Germany[7]) means the deposition of a layer of fresh snow of at least 1 m in 24 hours (in Romania there is no

[6] January 2019 was the hottest month in the history of meteorological records in Australia (Australian Bureau of Meteorology). The average temperature recorded for the whole Australia in January has exceeded 30°C for the first time since the measurements began in 1910 (BMA and Agerpres) (https://www.profit.ro/stiri/life/luna-ianuarie-2019-cea-mai-calda-din-istoria-australiei-18835783).

[7] In Romania, so far, there ***is no violet code*** for any meteorological phenomenon. In Romania, according to operational regulations and laws, the code indicating ***maximum danger*** in case of meteorological phenomena is the ***orange*** one.

violet warning for any phenomenon). Heavy snowfalls, blizzards and intense frost were recorded in the North American continent and the media said that in some areas of Mars it was warmer than in some areas in North America (https: //www.groundzeromedia.org/2-14-19-apocalypse-theorem/). As a result of the abundant rainfall registered on January 31, in the winter wheat crop, the moisture reserve on the soil depth of 0-100 cm will was close to optimal or within optimal limits, within most of Oltenia (N.A.M.).

3. a. The thermal regime of February 2019. The monthly air temperature averages were between 0.1°C at Voineasa and 4.0°C a in t Drobeta Turnu Severin, and their deviations from the normal values were between 1.6°C in Apa Neagră and 4.3°C in Drăgăşani, which, according to the Hellmann criterion, shows that February was warm (W) within most of Oltenia (Table 5). The *monthly average air temperature* calculated for the entire Oltenia region was 2.7°C (the highest monthly average temperature of the winter) and its deviation from the normal was 3.2°C, which confirms that February was warm on average for the entire Oltenia region.

Table 5. Air temperature regime within Oltenia and the minimum and maximum temperature values at the soil surface in February 2019 (N I = February normal values calculated for the period 1901-1990, M I = monthly averages of February 2019; Δ=M-N = temperature deviation, CH = Hellmann criterion).

No	Meteorological Station	Hm	N II	M II	Δ=M-N	CH	Min T air (°C)	Data	Max T air (°C)	Data	Min T soil (°C)	Data	Max T soil (°C)	Data
1	Dr.Tr. Severin	77	0.9	**4.0**	3.1	**W**	**-11.1**	24	**17.1**	20	**-12.5**	24	**26.2**	28
2	Calafat	66	0.4	3.9	3.5	**W**	**-11.0**	24	**18.5**	18	**-19.0**	24	**16.8**	4
3	Bechet	65	-0.1	3.0	3.1	**W**	**-10.1**	24	**17.7**	20	**-4.2**	23	**19.4**	28
4	Băileşti	56	-0.1	2.9	3.0	**W**	**-11.5**	24	**17.6**	20	**-18.4**	24	**23.8**	18
5	Caracal	112	-0.7	3.5	4.2	**W**	**-7.6**	24	**17.5**	20	**-10.4**	24	**16.2**	19
6	Craiova	190	-0.4	3.2	3.6	**W**	**-10.4**	24	**17.6**	20	**-13.2**	24	**25.2**	20
7	Slatina	165	-0.2	3.2	3.4	**W**	**-9.4**	24	**18.2**	20	**-11.8**	24	**12.2**	4
8	Bâcleş	309	-0.9	2.7	3.6	**W**	**-10**	24	**15.9**	20	-	-	-	-
9	Tg. Logreşti	262	-0.7	1.3	2.0	**W**	**-16.7**	24	**17.0**	18	**-19.5**	24	**22.5**	18
10	Drăgăşani	280	-0.2	4.1	**4.3**	**W**	**-9.3**	24	**18.5**	20	**-11.4**	24	**13.3**	4
11	Apa Neagră	250	-0.6	1.0	***1.6***	**WS**	***-17.2***	24	**16.8**	18	**-18.5**	24	***11.1***	18
12	Tg. Jiu	210	-0.4	2.0	2.4	**W**	**-13.4**	24	**17.9**	20	**-14.5**	24	**20.5**	21
13	Polovragi	546	-1.4	2.1	3.5	**W**	**-12.9**	24	**15.5**	18	***-20.9***	24	**19.7**	28
14	Rm. Vâlcea	243	0.0	3.7	3.7	**W**	**-10.1**	24	**17.9**	18	**-13.8**	24	**20.4**	21
15	Voineasa	587	-2.5	***0.1***	2.6	**W**	**-11.0**	25	***14.8***	20	-	-	-	-
16	Parâng	1585	-	-	-	-	**-17.2**	23	**10.3**	18	-	-	-	-
	Average for Oltenia	-	-0.5	2.7	3.2	**C**	**-11.8**	-	**16.8**	-	**-14.5**	-	**19.0**	-
17	Ob. Lotrului	1404	-5.5	-4.2	1.3	**CL**	**-22.5**	24	**11.0**	18	-	-	-	-

(Source: processed data from the N.A.M. Archive)

The minimum monthly air temperatures were registered atypically, during the last pentad of the month, on February 24, and were between -17.2°C in Apa Neagră and -7.6°C in Caracal; the average for the entire region was of -11.8°C. The *maximum monthly air temperatures* were registered on February 18 and 20 and ranged between 14.8°C in Voineasa and 18.5°C in Calafat and Drăgăşani and their average for the entire region was 16.8°C, being the highest average of the monthly maximum temperatures in the winter 2018-2019. The *agrometeorological frost* was insignificant, and the *frost units*, registered in the interval February 23-25, ranged from 8.5 in Tr. Severin and 23.1 in Târgu Logreşti with an average of 14.7 for the entire region. The *heat units* were registered throughout the month except for the interval 23-25 and were between 25.6 in Voineasa and 126.1 in Drăgăşani; their average for the entire region was 93.4, exceeding the frost units. All this shows that ***February was a mild winter month*** from the agrometeorological point of view. *At the surface of the soil,* most of the minimum monthly temperatures were registered during the cooling period, at the end of February, on 24 February, and were between -20.9°C in Polovragi and -4.2°C in Bechet; their average for the whole region was -14.5°C, being the second average in descending order from this winter after December. The monthly maximum values at the surface of the soil were registered at different dates and ranged from 11.1°C in Apa Neagră and 26.2°C in Drobeta Turnu Severin, and their average for the entire region was 19.0°C, being the highest of the winter.

The only intense cooling interval of February was between 23 and 25. In Oltenia, the weather cooled quickly on the night of February 22/23. The rain that started in the evening, after a warm day (maximum temperatures of 8-12°C on February 22 and early morning rain), quickly turned into snow and the wind intensified. The blizzard recorded between the 9 and 12 p.m. was so intense that it was not possible to distinguish the falling snow from the blown away snow and visibility was particularly low. During the night of February 22/23, snow falling was accompanied by blizzard on extended areas. The wind intensified, the peak gust reaching speeds of ≥ 80km/h between 9 and 12 p.m., then the sky cleared up and the weather continued to cool. A snow layer with a thickness between 4 cm in Calafat and Bechet and 23 cm in Târgu Jiu formed, but it that melted until February 27. In Dobrogea, in Jurilovca, the peak gust was of 130 km/h and 115 km/h in Mahmudia. For Oltenia, ***this was the only blizzard during this winter***. The charts of the variation of the air temperature (average daily, daily average and daily peak average values all calculated for the entire region) in February 2019 had a linearly significant upward trend for daily and decreasing daily and maximum daily and minimum daily temperatures (Fig. 4), aspect due to the cooling of the weather in the period 23-25. *The graphs of the variation of the parameters* characterizing air temperature (average of daily minimum values, daily average and average of daily maximum values, all calculated for the entire region) in February 2019 had markedly increasing linear trends in case of daily maximum temperatures and decreasing in case of daily averages and minimum temperature averages (Fig. 4), due to the weather cooling characteristic to the interval February 23-25.

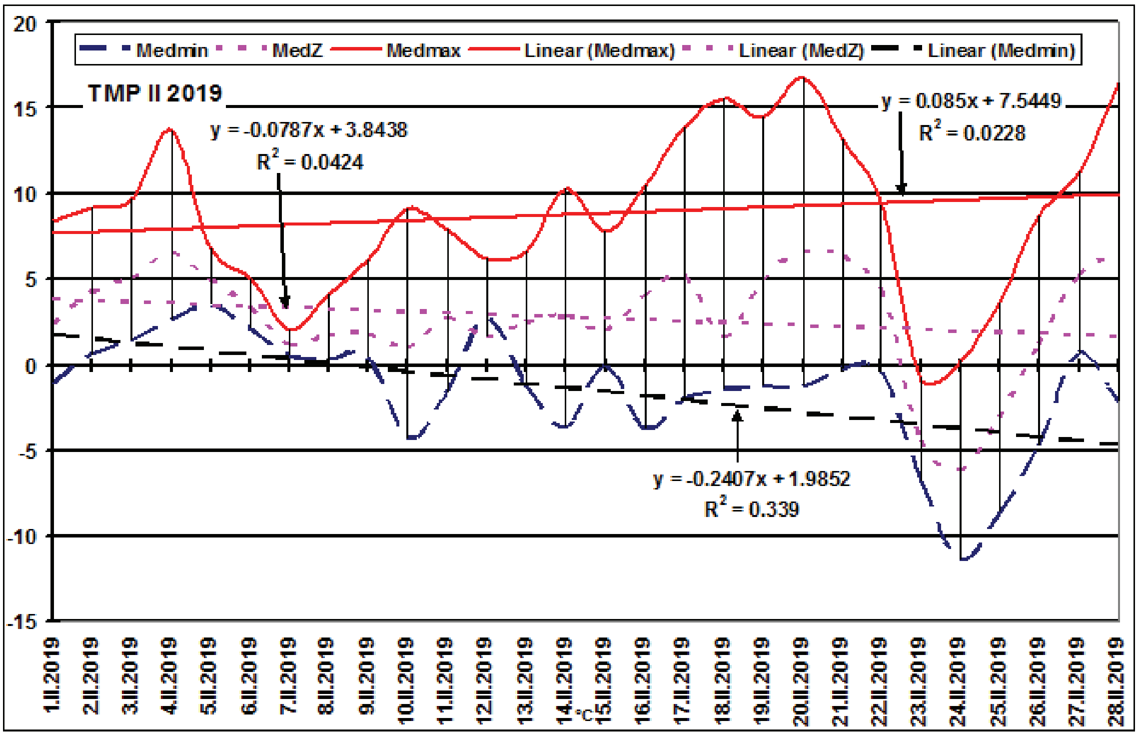

Figure 4. Variation of the parameters characteristic to air temperature (average of daily minimum values, daily average and average of daily maximum values calculated for the entire region) in February 2019.

3. b. The pluviometric regime of February 2019. The monthly rainfall amounts in February were between 9.1 l/m^2 in Râmnicu Vâlcea and 32.8 l/m^2 in Târgu Jiu and their percentage deviations from the normal were between -76.3% in Râmnicu Vâlcea and -36.9% in Tg. Jiu; according to the Hellmann criterion, February was dry with classifications of pluviometric types from very dry (VD) to excessively dry (ED) in all the weather stations (Table 3). The average monthly rainfall amount calculated for the Oltenia region was 16.9 l/m^2 and its percentage deviation from the normal was 60.0%, which confirms that February was an excessively dry (ED) month in the entire Oltenia region. There was only one short interval with significant rainfalls on the night of February 22/23, 2019 with an average of 8.8 l/m^2 for the whole region.

4. The seasonal climatic characteristics of the winter 2018-2019. *The seasonal air temperature averages* were between -1.3°C in Voineasa and 2.2°C in Drobeta Turnu Severin and their deviations from the normal values ranged from 0.3°C in Apa Neagră and 2.1°C in Calafat and Caracal; thus, according to Hellmann criterion, the winter 2018-2019 was warm (W) throughout the region except for two areas, Târgu Logresti and Apa Neagră, where it was thermally normal (N) (Table 6). The *seasonal average* of the air temperature calculated for the entire region was 0.6°C and its deviation from the normal was 1.55°C, which confirms the characteristic of warm winter (W) for the entire Oltenia region. The *seasonal rainfall amounts* ranged between 49.7 l/m^2 in Bechet, in the extreme south of Oltenia, and 262.1 l/m^2 in Apa Neagră, in the area of the Subcarpathian depressions; their percentage deviations from the seasonal normal values were between -52.5% in Bechet and 69.3% in Râmnicu Vâlcea, determining, according to Hellmann criterion, the classification of the pluviometric types in Oltenia from excessively dry (ED) in Bechet area to excessively rainy (ER) in the hilly area at Târgu Logreşti and in the Olt Corridor in Drăgăşani and Râmnicu Vâlcea. *The average of the seasonal rainfall amounts* calculated for the entire Oltenia region was 158.9 l/m^2 and its percentage deviation from the normal was 15.8%, which, according to the Hellmann criterion, means that on average the winter 2018-2019 was a little rainy (LR).

DISCUSSIONS

The coldest interval of the winter 2018-2019 was January 9-14, when there were registered the minimum temperature values for January, which, with few exceptions, also represent the minimum values for the entire season. During this interval, there were 4 days (5, 8, 13 and 14) when the average daily minimum temperature calculated for the entire region was ≤ -10°C, namely, there were 4 frost nights in Oltenia. We will analyse the synoptic situation that triggered this severe cooling of the weather during the maximum phase that lasted for 4 days. Within 24 hours, from the morning of January 4 until the morning of January 5, the average of the daily minimum temperatures calculated for the entire Oltenia region decreased by 5.87°C (from -5.47°C on the morning of January 4 to -11.34°C on the morning of January 5).

Table 6. Air temperature and rainfall regime in the winter of 2018-2019 (Hm = Hm = altitude of the meteorological station, W`18-`19= average temperature values in the winter 2018-2019 (°C), NW = normal values of the seasonal averages winter temperature (°C), Δ = W-N = deviation of temperatures from the normal (°C) CrH = Hellmann criterion; SW = sum of rainfall in the winter 2018-2019 (l/m^2), NW = normal rainfall amounts during winter (l/m^2), Δ = S-N= deviations from the normal (l/m^2), Δ% = percentage deviations from the normal.

No	Meteorological Station	Hm	The thermal regime (°C)				The pluviometric regime (l/m^2)				
			W`18-`19	NW	Δ=W-N	CrH	SW	NW	Δ=S-N	Δ%	CrH
1	Dr. Tr. Severin	77	**2.2**	0.4	1.8	**W**	175.9	160.5	15.4	9.6	**LR**
2	Calafat	66	2.0	-0.1	**2.1**	**W**	102.1	123.9	-21.8	-17.6	**LD**
3	Bechet	65	1.0	-0.6	1.6	**W**	***49.7***	104.6	***-54.9***	***-52.5***	**ED**
4	Băileşti	56	0.9	-0.7	1.6	**W**	95.0	121.4	-26.4	-21.7	**D**
5	Caracal	112	0.9	-1.2	**2.1**	**W**	105.7	108.7	-3.0	-2.8	**N**
6	Craiova	190	0.6	-1.0	1.6	**W**	142.0	109.7	32.3	29.4	**VR**
7	Slatina	165	0.5	-0.8	1.3	**W**	119.6	117.2	2.4	2.0	**N**
8	Bâcleş	309	0.5	-1.4	1.9	**W**		149.3			
9	Tg. Logreşti	262	-0.6	-1.1	0.5	**N**	191.6	121.7	69.9	57.4	**ER**
10	Drăgăşani	280	1.2	-0.6	1.8	**W**	165.1	114.1	51.0	44.7	**ER**
11	Apa Neagră	250	-0.7	-1.0	***0.3***	**N**	**262.1**	219.6	42.5	19.4	**R**
12	Tg. Jiu	210	0.1	-1.0	1.1	**W**	230.9	169.9	61.0	35.9	**VR**
13	Polovragi	546	-0.1	-1.5	1.4	**W**	206.1	153.4	52.7	34.4	**VR**
14	Rm. Vâlcea	243	1.1	-0.6	1.7	**W**	196.9	120.1	**76.8**	**63.9**	**ER**
15	Voineasa	573	***-1.3***	-3.0	1.7	**W**		141.8			
16	Parâng	1585					209.0	160.0	49.0	30.6	**VR**
	Average for Oltenia	-	0.6	-0.95	1.55	**W**	158.9	137.2	21.7	15.8	**LR**
17	Ob. Lotrului	1348	-4.7	-5.5	0.8	**WS**	311.2				

(Source: processed data from the N.A.M. Archive)

The monthly minimum values for many weather stations were registered on the morning of January 5: Craiova (-11.7°C); Voineasa (-16.9°C); Parâng (-17.1°C) and Obârşia Lotrului (-24.0°C), which is the ***minimum thermal value of the winter 2018-2019***) (Table 4). This accelerated cooling of the weather brought an interval of 10 cold days, of which 4 nights were frost nights on average for the entire region. We will further analyse the ***synoptic situation from January 5, 06 UTC***. On January 5, 2019, at 06 UTC, at *ground level*, above Western Europe, the Azores Anticyclone extended northwards and connected, through a high-pressure belt across the Scandinavian Peninsula, to the East European Anticyclone that was further connected with the Asian Anticyclone (Fig. 5). A strong anticyclone centre with pressure above 1040 hPa was positioned above the English Channel. The East European Anticyclone was quite strongly developed, with atmospheric pressure values ≥1040 hPa, as well as the Asian Anticyclone. In the south of the Balkan Peninsula and west of Asia Minor, a weak Mediterranean Cyclone was placed, in occlusion, with pressure at the centre ≤1015 hPa. To the north, separated by an anticyclone belt, there is a quite large cyclone field, located southeast of the Scandinavian Peninsula, above the vast plain area of Eastern Europe. In the south-west of Romania, an anticyclone nucleus acted, with atmospheric pressure values ≥1025 hPa. In these conditions, above Romania, in the *lower troposphere*, the air circulation was from the eastern sector with a continental cold air mass mixed with arctic air (cPk + A). This distribution of the pressure field is a *true mechanism through which cold air penetrates* over Romania. In the *upper troposphere*, at the level of 500 hPa, it was an atmospheric blocking circulation (the shape of the letter "Ω" of the 552 damgp isohypse – Fig. 5). The atmospheric blocking was highly developed with the 576 damgp isohypse extending to the south of Great Britain. For Romania (and Oltenia), at this level, air circulation was northern, with Arctic Air (A) rapidly brought on the "shortest route" from the Arctic region. The advection of cold air over Europe was initiated on January 1 and, on January 3, it began to penetrate over the west of Romania. The maximum intensity of the cold air advection as well as its expansion over Europe was recorded on January 5 at 00 UTC (Fig. 6), when the -12.0°C isotherm was located in the west of Oltenia and, south of the Danube (above Bulgaria), values of -14°C were registered. Extremely cold air advection persisted over Europe (and Romania) until January 14, 2019 at 00 UTC. We remark that this type of atmospheric circulation caused the installation of sudden winter conditions on the night of November 18/19, 2018, thus ending the warm and dry autumn of 2018; they also caused the sharp cooling of the weather from the end of November (when there were registered the thermal minimum values of November) and from the beginning of December (when the minimum thermal values of December were registered). The Scandinavian Peninsula is thus a bridge between Europe and the Arctic, enabling cold air advections across Europe. We also note that, in the first two months of the 2018 summer, this type of atmospheric circulation determined the characteristic of rainy summer. In Oltenia, the *short episode of blizzard from February 2019* was caused by an atmospheric blocking of circulation, which produced a strong hot air advection in Western Europe that led to the registration of thermal records for February. Thus, on February 25, 2019, in the United Kingdom temperature reached 20.6°C at Trawsgoed, Wales (according to the British Meteorological Service) which had never happened before. "There has never been such a thing (...) in Wales, 20.6°C is really like in summer", (Etienne Kapikian, meteorologist, Météo-France).

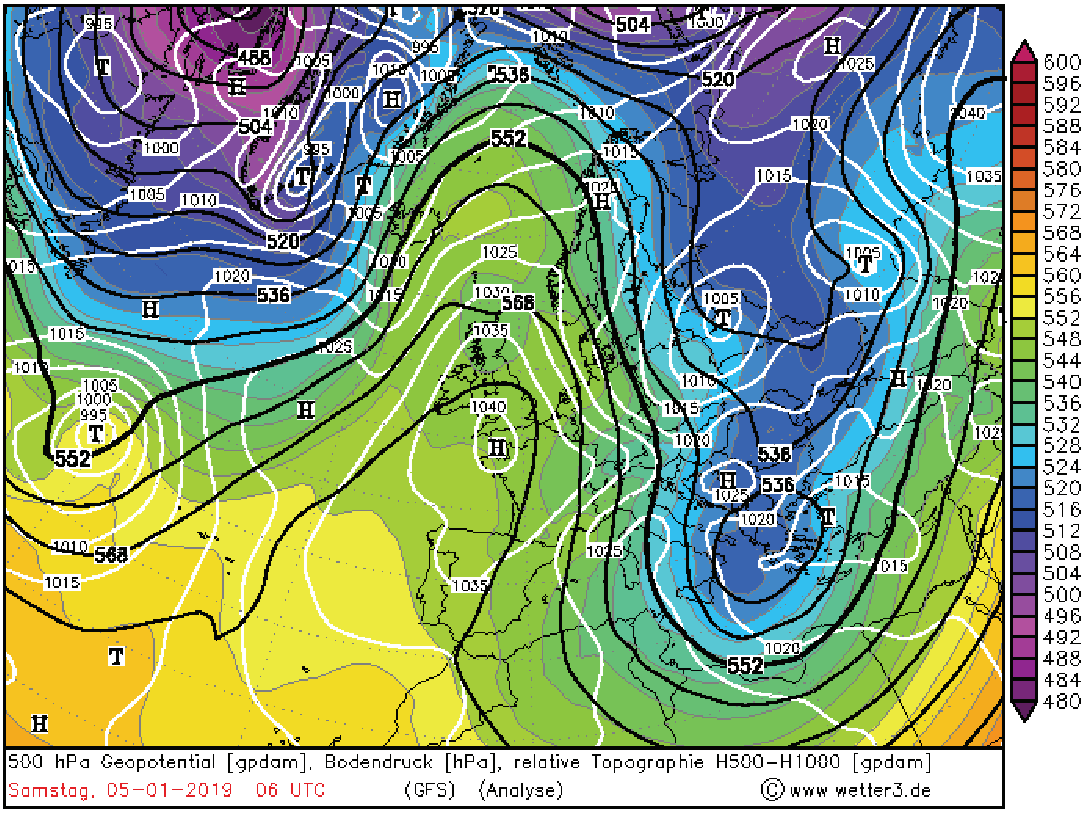

Figure 5. The synoptic situation at the ground level (atmospheric pressure field) overlapped with the altitude synoptic situation (geopotential field at 500 hPa – about 5000 m altitude) and the field of relative baric topography (TR500 / 1000) on January 5, 2019 at 06 UTC (www.wetterr3.de).

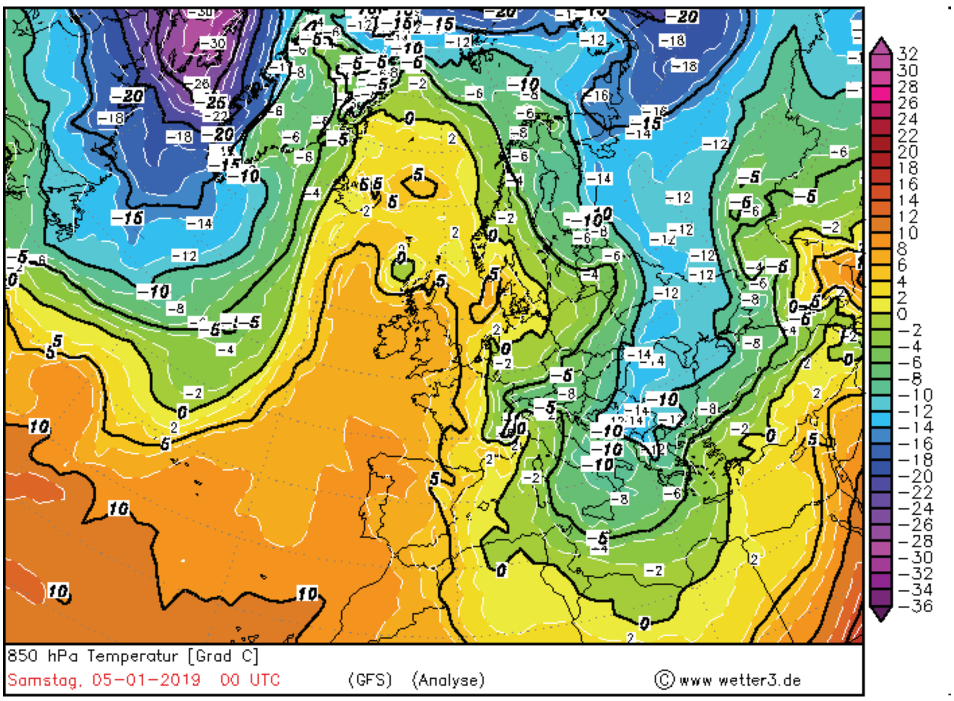

Figure 6. The thermal field at the level of 850 hPa geopotential field – about 1500 m altitude, on January 5, 2019, at 00 UTC (www.wetterr3.de).

Monthly records were also registered in other areas of Western Europe on February 23-25: 25.0°C at Ourense, Spain, 21.0°C at Pleyber-Christ, France, and 18.8°C in Uccle, Belgium. Temperatures were spring-like also in Scandinavia, with a record of 9.1°C for February, registered at Kvikkjokk, Sweden, near the Polar Circle on February 23, 2019 and 17.8°C at Linge, Norway. At the same time, the thermometer did not indicate more than 5.0°C in Lecce, Italy or 3.0°C in Thessaloniki, Greece, where it snowed in the interval February 23-24, as well as in northwestern

Turkey (AFP, Kapikian meteorologist, Météo-France) (https://www.realitatea.net/scenariu-terifiant-devenit-realitate-schimbari-climatice-incredibile_2182130.html).

The thermal classification of the winters in Oltenia in the period 1961-2019. The statistical analysis of the seasonal temperature registered during winter in the period 1961-2019 according to Hellmann criterion, calculated for the entire Oltenia region, shows that: ***the coldest winters*** (cold (C) and very cold (VC)) in the last 58 years were: ***1962-`63 (VC, average -4.48°C)***, ***1963-`64*** (C, average -2.98°C), ***1968-`69*** (C, average -2.96°C), ***1977-`78*** (C, average -2.20°C), ***1984-`85 (VC, average -4.57°C)***, ***1995-`96*** (C, average -2.35°C) and ***2002-`03*** (C average -2.93°C), namely 6 winters (10.3%).

The ***coldest winter*** was ***1984-`85 (VC, with an average of -4.57°C***), and the number of very cold winters was 2 (1962-`63 and 1984-`85), both recorded before 1990. ***The warmest winters*** in the last 58 years (warm (W) and very warm (VW)) were: 1965-`66 (W, average 1.19°C), 1970-`71 (W, average 0.68°C), 1974-`75 (W, average 0.98°C), 1976-`77 (W, average 0.76°C), ***1982-`83 (VW, average 2.05°C)***, 1987-`88 (W, average 1.98°C), 1988-`89 (W, average 1.31°C), 1989-`90 (W, average 0.6°C), 1993-`94 (W, average 1.43°C), 1994-`95 (W, average 0.88°C), 1997-`98) (W, average 1.35°C), ***2000-`01 (VW, average 1.79°C)***, 2001-`02 (W, average 0.51°C), ***2006-`07*** (***VW***, ***average 3.44°C***), 2008-`09 (W, average 0.89°C), 2012-`13 (W, average 0.35°C), 2013-`14 (W, average 0.69°C), 2014-`15 (W, average 1.21°C), ***2015-`16 (VW, average 2.88°C)***, 2017-`18 (W, average 1.48°C), 2018-`19 (W, average 0.55°C), namely 21 winters (36.2% of the total number of winters). ***The warmest winter***, ***which is the absolute climatic record of warm winters throughout the history of weather observations***, ***was 2006-2007 with the average for the entire region of 3.44°C*** (Table 7). *The number of very warm winters was 4*, namely double the number of very cold winters (of the symmetrical class of negative deviations). *The number of winter warmer than normal* (WS + W + VW) was 31, namely 53.5%, which shows that winters warmer than the normal prevail in Oltenia in the proportion > 50.0%. *The number of winters cooler than normal* (CO + CL + VC) was 9, namely only 15.5% of the total. *The average of winter temperature* between 1961 and 2019 is -0.32°C and its deviation from the normal is 0.63°C, indicating that on average, the winters of the last 58 years were warm (W).

Table 7. Thermal classification of winters in Oltenia between 1961 and 2019 (the last 58 years) (**AvgT** = winter average temperature calculated for the entire Oltenia region with altitudes below 600 m (°C), (the normal winter temperature average is -0.95°C in Oltenia) Type = thermal classification of winter according to Hellmann[8] criterion, Cold = number of winters colder than the normal and their percentage, Normals = number of winters thermally normal and their percentage, Warm = number of winters warmer than the normal and their percentage, VC = very cold, CL = cold, CO = cool, N = normal, WS = warmish, W = warm, VW = very warm, EW = excessively warm).

No	winter	AvgT	Type	No	winter	AvgT	Type	No	winter	AvgT	Type	No	winter	AvgT	Type
1	1961-`62	-0.98	**N**	17	1977-`78	-2.20	**CL**	33	1993-`94	1.43	**W**	49	2009-`10	-1.10	**N**
2	1962-`63	-4.48	**VC**	18	1978-`79	-0.81	**N**	34	1994-`95	0.88	**W**	50	2010-`11	-0.91	**N**
3	1963-`64	-2.98	**CL**	19	1979-`80	-0.57	**N**	35	1995-`96	-2.35	**CL**	51	2011-`12	-1.53	**CO**
4	1964-`65	-1.12	**N**	20	1980-`81	-0.37	**WS**	36	1996-`97	0.02	**WS**	52	2012-`13	0.35	**W**
5	1965-`66	1.19	**W**	21	1981-`82	-1.18	**N**	37	1997-`98	1.35	**W**	53	2013-`14	0.69	**W**
6	1966-`67	-0.97	**N**	22	1982-`83	2.05	**VW**	38	1998-`99	-1.18	**N**	54	2014-`15	1.21	**W**
7	1967-`68	-0.10	**WS**	23	1983-`84	-0.19	**WS**	39	1999-`00	-0.03	**WS**	55	2015-`16	2.88	**VW**
8	1968-`69	-2.96	**CL**	24	1984-`85	**-4.57**	**VC**	40	2000-`01	1.70	**VW**	56	2016-`17	-1.35	**N**
9	1969-`70	-0.64	**N**	25	1985-`86	-0.18	**WS**	41	2001-`02	0.51	**W**	57	2017-`18	1.48	**W**
10	1970-`71	0.68	**W**	26	1986-`87	-1.72	**CO**	42	2002-`03	-2.93	**CL**	58	2018-`19	0.55	**W**
11	1971-`72	-0.13	**WS**	27	1987-`88	1.28	**W**	43	2003-`04	-0.62	**N**		Mean	-0.32	**W**
12	1972-`73	-0.40	**WS**	28	1988-`89	1.31	**W**	44	2004-`05	-0.07	**WS**		Cold	9	15.5%
13	1973-`74	-0.24	**WS**	29	1989-`90	0.46	**W**	45	2005-`06	-1.29	**N**		Normal	18	31.0%
14	1974-`75	0.98	**W**	30	1990-`91	-0.94	**N**	46	2006-`07	**3.44**	**VW**		Warm	31	53.5%
15	1975-`76	-0.79	**N**	31	1991-`92	-0.62	**N**	47	2007-`08	-0.51	**N**				
16	1976-`77	0.76	**W**	32	1992-`93	-1.42	**N**	48	2008-`09	0.89	**W**				

(Source: processed data from the N.A.M. Archive)

The graph of winter temperature variation calculated for the entire Oltenia region in the interval 1961-2019 shows a significant increasing linear trend (Fig. 7).

[8] The comparison was made with the December multiannual average for the last century, average calculated for the whole region (1901-1990). ***The comparison with the statistical median is irrelevant***, as the median has no connection to the dataset other than that the value is positioned at the middle of the dataset arranged ascending order.

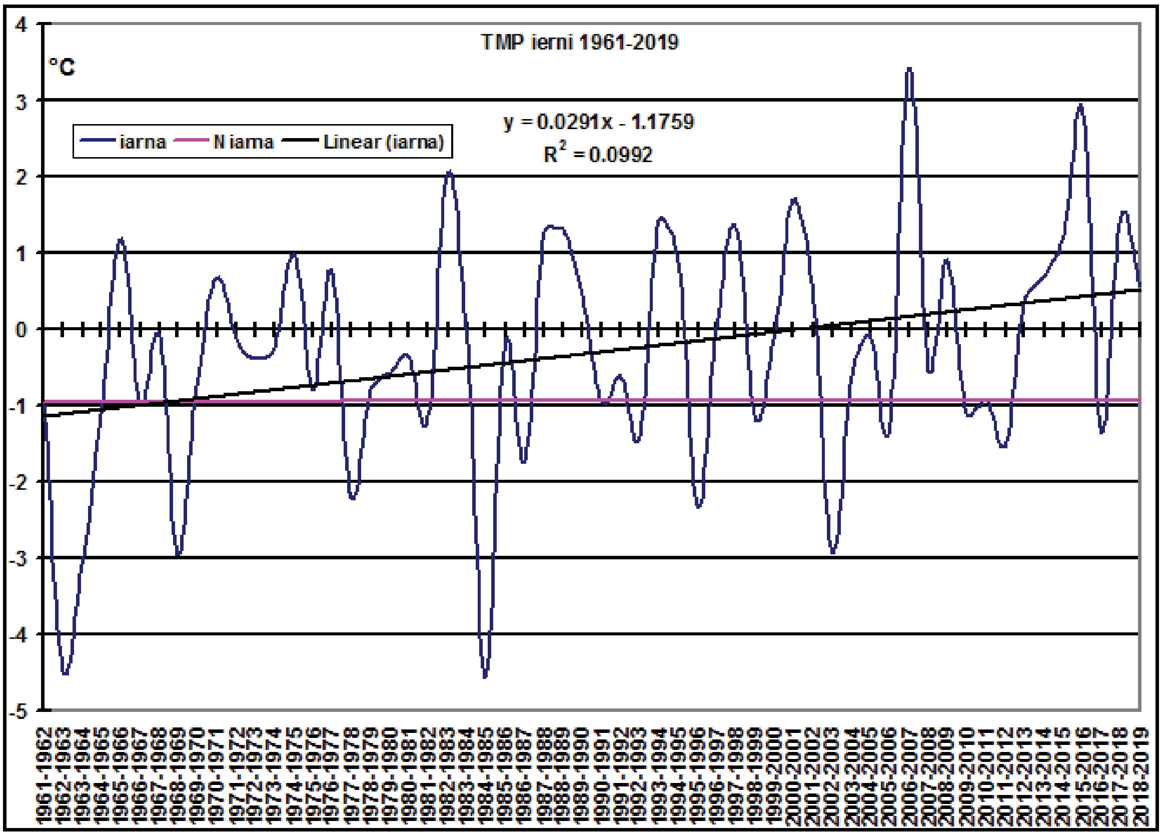

Figure 7. Variation of the average winter temperature calculated for the entire region Oltenia in the interval 1961-2019.

CONCLUSIONS

Although the winter of 2018-2019 began a little earlier than usual from a meteorological point of view (on the night of November 18-19) with intense cooling, snowfalls and snow layer formation. December was thermally normal and the weather gradually warmed up in January, especially in the second half, while in February, the ***warming*** increased. Thus, in February, only one winter day was registered for the entire region on the 23rd, when the average of the maximum temperatures was -0.8°C. This continuous warming process of the weather triggered the early spring arrival[9]. Thus, the winter 2018-2019 was warm (W) with a general average of 0.55°C (for the area with altitudes <600 m, without Oltenia mountain area). From the ***pluviometric*** point of view, the winter was a little rainy (LR) with intermittent snow layer in Oltenia Plain and persistent in Gorj County, northeast of Mehedinţi County and northwest of Vâlcea County. The statistical analysis of the *winter temperature* in the period 1961-2019 shows that warm winters predominate – 53.5%, normal winters represent 31.0% and cold winters only 15.5%. The graph of the variation of ***winter average temperature*** has a markedly increasing linear trend. For the 1961-2019 interval, the average seasonal temperature was -0.32°C, with a deviation from the normal of 0.63°C, which confirms that the winters of this interval were warm (W). The *frost units* for the whole winter season were 36.5 in Drobeta Turnu Severin and 168.0 in Voineasa with the average for the whole region of 101.7. The *heat units* were greater than the frost units and ranged between 44.3 in Voineasa and 233.7 in Calafat with the average for the entire region of 145.6, which signifies a mild winter from an agrometeorological point of view. Climatic warming continued although the El Niño climatic process was absent and solar activity was minimal. Winter weather phenomena suddenly interrupted the dry and warm autumn, and the *spatial-temporal distribution* of rainfalls was particularly variable. At the end of the winter, on February 26, 2019, in the crop of autumn wheat, the supply of water accessible to plants on the soil depth of 0-100 cm was within satisfactory limits, close to optimal and optimal, in most of the region (according to N.A.M.). As a result of the warmer weather than normally, vegetable harvesting in greenhouses started two weeks earlier (on February 9, 2019) than in the previous winter (2017-2018).

[9] ***Spring arrival*** is the climatic process of increasing air temperature that usually occurs starting with February 1, as a result of the increase in daylight, which has important consequences for crops and biotopes, which gradually restart their activity.

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Marinică Andreea Floriana
Bachelor of Sciences, Klimacampus, Hamburg, gGmbH., Germany.
E-mail: marinica.andreea@gmail.com

Marinică Ion
Associate Professor, University of Craiova, Faculty of Sciences, Bibescu Street no. 84, Craiova, Romania.
E-mail: ionmarinica@yahoo.com

Chimişliu Cornelia
The Oltenia Museum Craiova, Str. Popa Șapcă, No. 8, Craiova, Romania.
E-mail: chimisliu_cornelia@yahoo.com

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PALLADIUM NANOPARTICLE SYNTHESIS BY S*hewanella oneidensis* MR-1

MOISESCU Cristina, GHINEA Adrian, IACOB Matei-Tom, BĂLAN Adriana, STAMATIN Șerban, ARDELEAN I. Ioan

Abstract. Metal nanoparticles have multiple uses in industry, technology, medicine, but their production tends to be very expensive and polluting, so scientists are looking into new and greener ways of producing them. One of this eco-friendly method is by using the process of biomineralization done by microorganisms. *Shewanella oneidensis MR-1* is a Gram-negative, facultative anaerobic bacterium that can use a large array of substances as final electron acceptor. When metallic ions are used in the process of respiration as final electron acceptors, metallic nanoparticles may form on the surface of the bacterium. Palladium is one of the many metals that can be used by *S. oneidensis* for the nanoparticles production. Pd nanoparticles have multiple uses, one of its most important utilizations is as a chemical catalyst. In this study, *S. oneidensis* MR-1 was used for the biosynthesis of Pd nanoparticles, as demonstrated by spectrophotometric and fluorometric techniques.

Keywords: biomineralization, nanoparticles, palladium, *Shewanella oneidensis* MR-1.

Rezumat. Sinteza nanoparticulelor de paladiu de către *Shewanella oneidensis* MR-1. Nanoparticulele metalice au utilizări multiple în industrie, tehnologie, medicină, dar producția lor tinde să fie foarte costisitoare și poluantă, de aceea oamenii de știință încearcă să găsească metode noi și nepoluante de a le produce. Una dintre aceste metode ecologice este folosirea procesului de biomineralizare efectuat de către microorganisme. *Shewanella oneidensis* MR-1 este o bacterie Gram-negativă, facultativ anaerobă care poate utiliza o gamă largă de compuși ca acceptor final de electroni. Atunci când ionii metalici sunt utilizați în procesul de respirație ca acceptori finali de electroni, nanoparticule metalice se pot forma pe suprafața bacteriei. Paladiul este unul dintre multele metale care pot fi folosite de *S. oneidensis* pentru producerea de nanoparticule. Nanoparticulele de Pd au multiple utilizări, una dintre cele mai importante fiind cea de catalizator chimic. În acest studiu, *S. oneidensis* MR-1 a fost utilizată pentru biosinteza nanoparticulelor de Pd, fapt demonstrat prin tehnici de spectrofotometrie si fluorimetrie.

Cuvinte cheie: biomineralizare, nanoparticule, paladiu, *Shewanella oneidensis* MR-1.

INTRODUCTION

Nanoparticles (NPs) are particles with sizes between 1 and 100 nm (for at least one dimension) (POTOCNIK, 2011; BATISTA et al., 2015), which have different properties compared with the bulk material. NPs can be classified into natural or synthetic, the latter being produced by either physical, chemical, biological or hybrid methods (JEEVANANDAM et al., 2018). Metal NPs and in special those of noble metals, are of great interest because of their large surface area and their specific function and potential applications (BUZEA et al., 2007; DANIEL & ASTRUC, 2004; HOLT & BARD, 2005; CHEN et al., 2010; AHMAD et al., 2016). Palladium (Pd) is a noble metal from the platinum group metals (PGM) and is one of the most efficient catalysts being intensely studied for its properties (COOKSON, 2012). Pd-NPs play an important role in industry and technology as for example, in the formation of carbon-carbon bound in organic reaction, in the low-temperature reduction of automobile pollutants, in hydrogen storage, electrochemical reactions in fuel cells etc. (KIM et al., 2002; CHEN et al., 2010; SALDAN et al., 2015; SIDDIQI & HUSEN, 2016). The preparation of Pd-NPs can be achieved by different physical, chemical or electrochemical ways (SARTRE et al., 1993; KIM et al., 2003; SON et al., 2004; XIONG et al., 2005a; b; TRISTANY et al., 2006; COOKSON, 2012; ULLAH et al., 2018). However, these methods are very expensive and toxic to the environment due to the use of combustibles, toxic substances, hazardous chemicals, which may pose a biological risk and require lots of energy. The need to develop greener methods that are more energy efficient and environmentally friendly lead the researches into other ways of synthesising nanoparticles such as using organic polymers and different plant extracts (MITOI et al., 2013; KORA & RASTOGI, 2015; SURENDRA et al., 2016). However, true biologically driven production of different metallic nanoparticles is achieved by using different types of living microorganisms (IRAVANI, 2014; MOISESCU et al., 2014; ARDELEAN, 2015; CHEAH et al., 2015). Microorganisms are able to mediate the formation and deposition of minerals directly or indirectly by the so-called process of biomineralization (HEIM, 2011). Microbial biomineralization can be categorised into extracellular or intracellular, depending on the location of the synthesized inorganic materials. For example: *Pseudomonas stutzeri* AG259 can produce Ag-NPs in the periplasmic space as large as 200 nm in diameter (HAEFELI et al., 1984); S*hewanella algae* can produce Au-NPs also in the periplasmic space in anaerobic conditions (NARAYANAN & SAKTHIVEL, 2010); the cyanobacterium *Plectonema boryanum* UTEX485 have been observed to produce Pt-NPs from $PtCl_4$ (LENGKE et al., 2006) and magnetotactic bacteria are known to synthesize Fe-NPs from ferric citrate (MOISESCU et al., 2014). The formation of NPs can even be mediated by viruses, some viral molecules such as fatty acids or amino acids can act as template for the growth of semiconductor nanocrystals (NARAYAN & SAKTHIVEL, 2010). The mechanisms of microbial biomineralization are different, but usually the NPs are formed by trapping the metal ion inside or on the surface of the bacterial cell and then the metal ions are reduced in the presence of enzymes. Another way is by producing organic polymers which can facilitate the nucleation of mineral crystals (LI et al., 2011).

Most metals are toxic to microorganisms (IRAVANI, 2014), therefore microbial resistance to toxic metals is achieved by chemical detoxification, by the energy-dependent ion efflux from the cell through the membrane transport proteins, and also by the alteration in the solubility of the metal, all playing a key role in their resistance. For example, *Shewanella alge* is able to reduce PCl_6 to Pt-NPs, thus making the media less toxic (LI et al., 2011).

Shewanella oneidensis is a Gram-negative, facultative anaerobe, heterotrophic, gamma-proteobacterium, that can use a large variety of final electron acceptors, such as metal ion, sulphates, nitrates, etc. The ability to reduce heavy metals to an insoluble and less toxic form made this bacterium of great interest for bioremediation studies (XIONG et al., 2005a; b; SURESH et al., 2011).

Shewanella is able to deposit the biogenic nanoparticles that may result after the reduction of metallic ions, in the periplasmic space (KONISHI et al., 2007). Several studies have shown that metal reduction might be achieved by a complex of capping proteins, reductases, cytochromes, quinones, electron shuttles, phytochelatins, known to be able to reduce metal oxides and metals (SURESH et al., 2011).

In the present study we tried to show the ability of *Shewanella oneidensis* MR-1 to produce Pd-NPs by biological reduction of $PdCl_2$ under anaerobic conditions, as a means to develop a recovery method of noble metals through the process of biomineralization.

MATERIALS AND METHODS

Bacterial strain and growth conditions. *Shewanella oneidensis* strain MR-1 (LMG 19005) was purchased from BCCM/LMG Bacteria Collection and pre-grown aerobically in 250 ml Luria–Bertani broth containing yeast extract (5 g/L), sodium chloride (10 g/L), and tryptone (10 g/L). After 24 h of batch inoculation at 30 °C and 150 rpm, the cells in the logarithmic growth phase were harvested by centrifugation at 7500 rpm for 10 minutes, re-suspended in bicarbonate buffer pH 7.0 and re-pelleted by centrifugation. This procedure was repeated twice.

Nanoparticles synthesis. The washed cells biomass corresponding to 2.6 g/L was subsequently re-suspended in 15 ml Falcon tubes filled with 14 mL bicarbonate buffer with 30 mM sodium lactate as the electron donor and 1 ml of 10mM palladium chloride ($PdCl_2$). For the anaerobic conditions, compulsory for nanoparticles synthesis, the culture flasks were sealed after inoculation and anaerobic conditions arose in the medium by oxygen consumption of bacterial cells.

Recovery of nanoparticles from bacterial cells. After 48 hours of incubation, the bacterial biomass with nanoparticles was centrifuged at 7500 rpm, for 10 minutes and then washed two times with MiliQ water. The washed biomass is then heated for 10 minutes at 95°C, in 10% NaOH solution to release the nanoparticles and disintegrate the bacterial biomass. The Pd nanoparticles were pelleted by centrifugation at 14000 rpm for 10 minutes and the black deposit visible on the bottom of the tubes was washed twice with Mili-Q water to remove the NaOH residues.

Analytical methods. The UV-VIS absorption spectrum was analysed with a Specord 210 Plus spectrophotometer (Analytik Jena) and the emission spectra (plasmon) was measured with a FP8300 spectrofluorometer (Jasco).

Dark-filed microscopy and hyperspectral imaging (DMHI). For DMHI, 1 ml of cell suspension was centrifuged at 7500 rpm for 10 minutes washed twice with Sorenson buffer and fixed overnight at 4˚C in 2.5% glutaraldehyde. After fixation, the cells were re-pelleted by centrifugation at 7500 rpm for 10 minutes, washed with deionised water and one drop of the cell suspension was placed on a glass microscope slide, dried at room temperature, and heat fixed. The unstained samples were examined in air and at room temperature by using an enhanced dark field illumination system CytoViva Hyperspectral Microscope (Producer CytoViva, USA) with a 100X oil immersion objective. Spectral data within each pixel of the scanned field of view were captured with a CytoViva spectrophotometer and integrated charged-coupled device (CCD) camera. The spectral resolution was 1.5 nm and the pixel size was 6.45 µm. Spectral data were analysed by using the ENVI 4.8 Image Analysis Software (IDL Available).

RESULTS AND DISCUSSIONS

Palladium nanoparticles biosynthesis. The reduction of Pd(II) to Pd(0) was monitored by colour change of the cell suspension. In Fig. 1a it can be observed the macroscopic aspect of the MR-1 cell suspension in the absence of palladium (left) and after 24 hours of physical contact with the palladium chloride salt (right). After exposure to Pd(II), the colour intensity of the cell suspension gradually turned from pink to light brown (after 24 hours) and then to dark brown (after 72 h), which is a preliminary evidence for the formation of Pd-NPs and reduction of Pd(II) to Pd(0). This experiment also showed that the rate of Pd(II) reduction by the MR-1 cells increases with the increase in contact time. The absorption spectra of both cultures (Fig. 1b) show a change in the Pd(II) 24 hours exposed cells spectra as compared with the non-exposed cells.

UV–visible and fluorometric analysis. The bio-synthesized Pd-NPs were further recovered from bacterial biomass and characterised with the help of UV–vis spectrometry. According to scientific literature, as well as our own experience, the extraction of nanoparticles from cells is needed for improved spectroscopic investigations of these nanoparticles. The absorbance was recorded from 300 to 800 nm. Fig. 2a shows the absorption spectra of Pd-NPs suspension and the absorption of $PdCl_2$ solution, used as a reference sample, for comparison. The 1mM solution of $PdCl_2$ shows a sharp peak at 400 nm, corresponding to the Pd(II) ions in the reference solution. In case of Pd-NPs suspension, the UV–visible spectroscopy shows reduced absorbance spectra (which is characteristic for Pd-NPs) and the disappearance of the peak at 400 nm which indicates the reduction of Pd(II) to Pd(0) (VEISI et al., 2017; SRIRAMULU & SUMATHI, 2018).

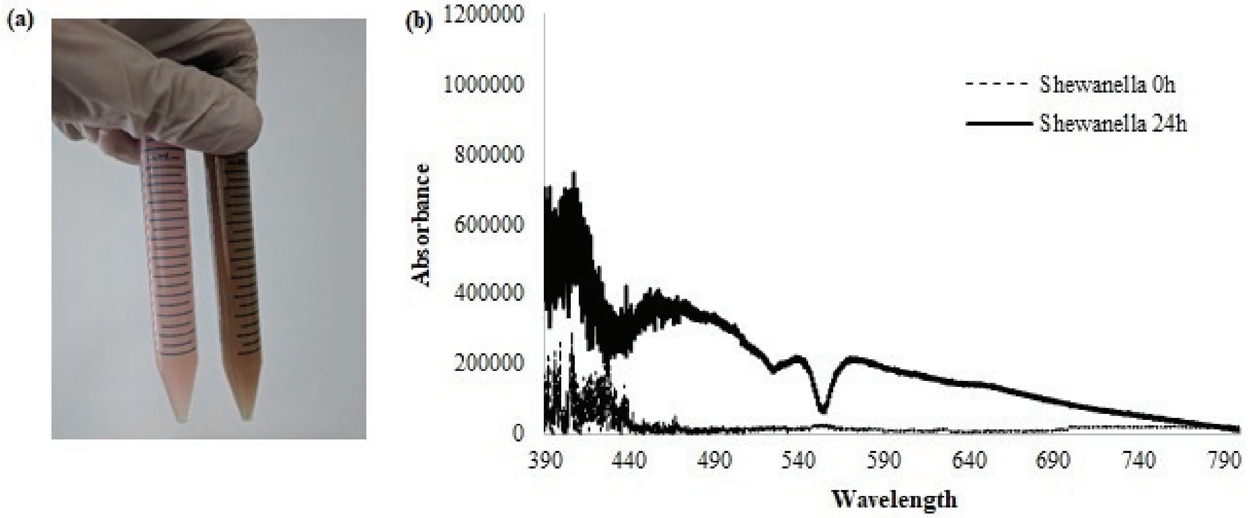

Figure 1. a) The aspect of *S. oneidensis* MR-1 cultivated anaerobically, in the absence (left) and in presence (right) of Pd(II). b) UV-VIS spectra of *S. oneidensis* MR-1 cells cultivated anaerobically in presence of Pd(II), at the beginning (0 hours) and after 24 hours.

Although, in accordance with the available literature (JIANG et al., 2004; NEMAMCHA et al., 2006) a typical absorption spectrum of Pd-NPs solution presents a broad continuous band in the UV-visible range, in our sample a small peak appeared at around 403 nm, that could be assigned to residual Pd(II) from the $PdCl_2$ starting solution.

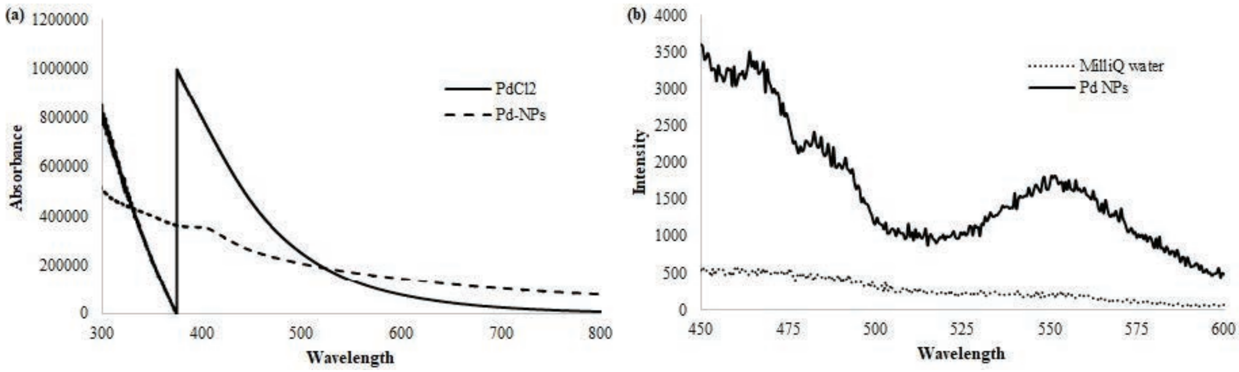

Figure 2. (a) UV-VIS and (b) fluorometric spectra of an aqueous solution of Pd-NPs extracted from *S. oneidensis* MR-1 as compared with the spectrum of $PdCl_2$ solution and deionised water, respectively.

The Pd-NPs suspension thus obtained was further investigated with respect to light emission following specific excitation in UV spectrum (LI et al., 2015; 2017). As one can see the emission spectra of isolated Pd-NPs are clearly different from the matrix (water) in which the nanoparticles are suspended (Fig. 2b), further arguing the different chemical nature of the matrix and of the obtained Pd-NPs through the reduction of palladium chloride by the bacterium *S. oneidensis* MR-1. The solution of $PdCl_2$ in these conditions (e.g. 260 nm voltage of 500V) has a narrow emission peak at 521 nm (98 units in height), completely different (results not shown) in terms of spectrum and intensity from the emission of isolated nanoparticles (Fig. 2b). It has to be noted that chemically synthesized Pd nanoclusters have the maximum excitation wavelength of the 420 nm and the optimal emission wavelength was 500 nm (PENG et al., 2018). Further experiments are needed regarding the size and shape of our reported NPs, in order to better correlate the emission spectrum with these physical details of the NPs produced *in vivo* by *S. oneidensis* MR-1.

Hyperspectral imaging. The CytoViva Hyperspectral Imaging System (HIS) permits the visualization and hyperspectral characterization of nanoscale materials as small as 10 nm, without the need of any fluorescent labelling or pre-treatment of the samples, the nanomaterials appearing brightly lit against a dark background. In the present study we show the results obtained with a hyperspectral enhanced dark-field microscope (HEDFM), consisting of an enhanced dark-field illumination system attached to a standard light microscope, for probing and characterizing biosynthesized Pd-NPs produced by *S. oneidensis* MR-1. Fig. 3a shows a representative hyperspectral image of *S. oneidensis* MR-1 cells exposed to Pd(II) salts. This image reveals the presence of a significant amount of Pd(0) NPs in the cell exterior and associated with cell membrane, identified as bright spots, suggesting that the extracellular and/or membrane-bound proteins play an important role in Pd(II) reduction (NG et al., 2013). These results are consistent with literature data which demonstrates that the preferred localization of Pd-NPs in *S. oneidensis* is in the periplasmic space (NPs <10 nm) or adhere to the surface of the outer membrane facing the extracellular space (NPs ≥ 50 nm) (DE WINDT et al., 2005; KEAT et al., 2015; DUNDAS et al., 2018).

Hyperspectral image analysis was performed on a single, isolated cell and the spectral response was recorded. The spectral profile of the control cells (Fig. 3b) differs substantially compared to the cell with Pd-NPs (Fig. 3c). The control cell profile shows a band with a maximum located at approximately 600 nm while the Pd-NPs cell spectrum has a broader band, with a maximum peak in the range 450-500 nm and a shoulder in the 600 nm region, which was more pronounced in the control cells as compared with the Pd(II) exposed cells, possibly because of the NPs formation. It is interesting to note that the presence of Pd-NPs on the cell membrane induced changes in the peak morphology of *S. oneidensis* cells, revealing a spectral response which combines the spectral features of control and of Pd-NPs cells.

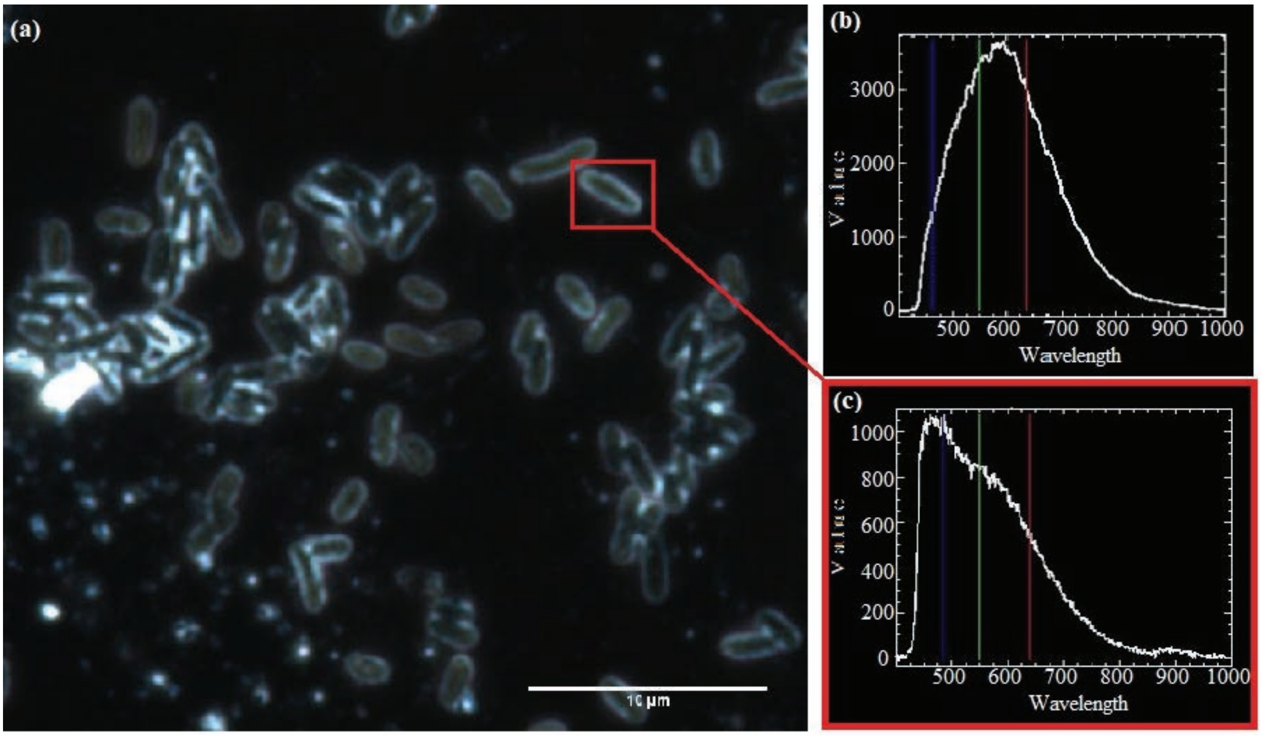

Figure 3. (a) Enhanced darkfield hyperspectral image of bacterial cells with Pd-NPs;
(b) Spectral response of control bacteria and (c) cell with Pd-NPs.

CONCLUSIONS

Our experimental results show, in agreement with the literature, that bacterium S. *oneidensis* MR-1 cultivated anaerobically is able to biologically reduce the Pd(II) from $PdCl_2$ solution to elemental Pd(0) which aggregates and forms nanoparticles. Pd-NPs synthesis verified by various analytical methods such as spectroscopic and microscopic. The Pd-NPs thus synthesized with the bacterium S. *oneidensis* MR-1 can be used as a green alternative to chemical synthesis methods. Therefore, the shape and size and distribution of bio-synthesized Pd-NPs needs to be further investigated using transmission electron microscopy, for their potential use in different applications.

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Moisescu Cristina, Ghinea Adrian, Iacob Matei-Tom, Ardelean I. Ioan
Bucharest Institute of Biology of the Romanian Academy, Spl. Independentei no. 296, sect. 6, 060031, Bucharest, Romania.
E-mails: cristina.moisescu@ibiol.ro, cristina.moisescu@yahoo.com; adrian.ghinea@ibiol.ro, adrianghinea95@gmail.com; iacob.matei@ibiol.ro, iacobtomita@yahoo.com; ioan.ardelean@ibiol.ro, ioan.ardelean57@yahoo.com

Bălan Adriana, Stamatin Șerban
Faculty of Physics, University of Bucharest, Atomistilor 405, Magurele – Bucharest, Ilfov County, Romania.
E-mails: andronie@3nanosae.org, adriana.balan@unibuc.ro; serban@3nanosae.org; serban.stamatin@unibuc.ro

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DIRTY ENVIRONMENTS AND ANTIBIOTICS RESISTANCE

CÎRSTEA Doina Maria, ŞTEFĂNESCU Mugur Cristian

Abstract. Studies on the resistance to antibiotics are carried out mainly on bacterial strains from clinical environments. Resistance reservoirs from natural environments or polluted environments have not been sufficiently studied, as they are a genuine source of maintenance of the phenomenon of resistance as well as its origin. Antibiotic resistance is present in the world of microorganisms before antibiotics appear, this was stimulated by the presence in the environment of various substances that led to the emergence and development of resistance mechanisms. Such pollutants are the stress factors for microbiota area, leading to the development of defence strategies against pollutant, strategies that can be used as efficient mechanisms of antibiotic resistance phenomenon. The present study was aimed to signal the importance dirty environments of the antibiotic resistance phenomenon.

Keywords: antibiotic resistance, pollutant, microorganism.

Rezumat. Medii poluate și rezistența la antibiotic. Studiile asupra rezistenţei la antibiotice sunt frecvente, efectuate mai ales pe tulpini bacteriene provenite din medii clinice. Rezervoarele de rezistenţă din mediile naturale, respectiv poluate nu au fost suficient studiate, acestea costituind o reală sursă de întreţinere a fenomenului de rezistenţă cât şi originea acestuia. Antibiorezistenţa este prezentă în lumea microorganismelor înainte de apariţia antibioticelor, aceasta a fost stimulată de prezenţa în mediu a diferitelor substanţe ce au condus la apariţia şi dezvoltarea mecanismelor de rezistenţă. Astfel, poluanţii sunt factorii de stres pentru microbiota zonală, ce conduc la dezvoltarea unor strategii de apărare contra poluantului, strategii ce pot fi utilizate ca mecanisme eficiente în fenomenul de antibiorezistenţă. Prin prezentul studiu s-a urmărit semnalarea importanţei mediilor murdare în fenomenul de rezistenţă la antibiotice.

Cuvinte cheie: antibiorezistenţă, poluant, microorganism.

INTRODUCTION

Antibiotic resistance represents the ability of microorganisms (bacteria, fungi, etc.) to survive and multiply in the presence of antibiotic doses, frequently a lethal dose (ZAMAN et al., 2017; DUGASSA & SHUKURI, 2017).

The uncontrolled use of antibiotics over the last 80 years and the increase in pollution have exerted a major impact on bacterial communities, leading to the selection of antibiotic-resistant bacteria, which are a major health problem (LEVY, 1992), so studying the phenomenon of antibiotic resistance is important for both human health and the environment.

Much of the specialty studies focus on discovering and understanding of the resistance mechanisms, which are carried out on bacterial strains in clinical and veterinary isolated, whereas other environmental reservoirs of antibiotic resistance are not well characterized (NWOSU, 2001; SEVENO et al., 2002; RIESENFELD et al., 2004).

ORIGIN OF ANTIBIOTIC RESISTANCE

The origin of antibiotic resistance has not been established and will most likely not be, but antibiotic resistance is known to have occurred before Penicillin was discovered by Alexander Fleming in 1928. The assertion that antibiotic resistance existed prior to the therapeutic use of antibiotics, as the first patient was treated with penicillin in 1942, supports the discovery of penicillinases (β-lactamases) in 1940 (DAVIES et al., 2010). Moreover, in the history of antibiotics, one can notice the discovery of resistance mechanisms specific to certain antibiotics almost simultaneously with their introduction into the clinical environment. Thus, in 1944 streptomycin was introduced for the treatment of Tuberculosis, during the treatment of the first patients, a bacterial strain of Mycobacterium tuberculosis proving to be resistant to the antibiotic concentrations used (DAVIES & DAVIES, 2010).

Resistance mechanisms are present in natural environments prior to the emergence and use of antibiotics, they have emerged as a result of the selective pressure of some favoured agents, which probably evolved in bacterial populations in water and soil in millions of years. (MARTINEZ, 2012). Resistance has emerged as a way of defending against toxic compounds present in the environment, such as plant metabolites and microbiota from soil or pollutants.

SELECTIVE PRESSURE OF EXTERNAL FACTORS ON THE OCCURRENCE, MAINTENANCE AND TRANSMISSION OF ANTIBIOTIC RESISTANCE PHENOMENON

Both pathogenic and non-pathogenic microorganisms are pressured by the selective exercise of natural, but especially anthropogenic factors (Fig. 1), we can talk about a wide variety of toxins or inhibitory molecules found in the environment.

Stress factors can be representations of many sources, such as: herbal products, natural and synthetic antibiotics, produced as a result of organic degradation. Biocides secreted by insect plants and fungal compounds that inhibit the growth of bacteria in the rhizosphere. A selective pressure factor is also lysozyme from the nasal secretion, which favoured the selection of antibiotic-resistant strains.

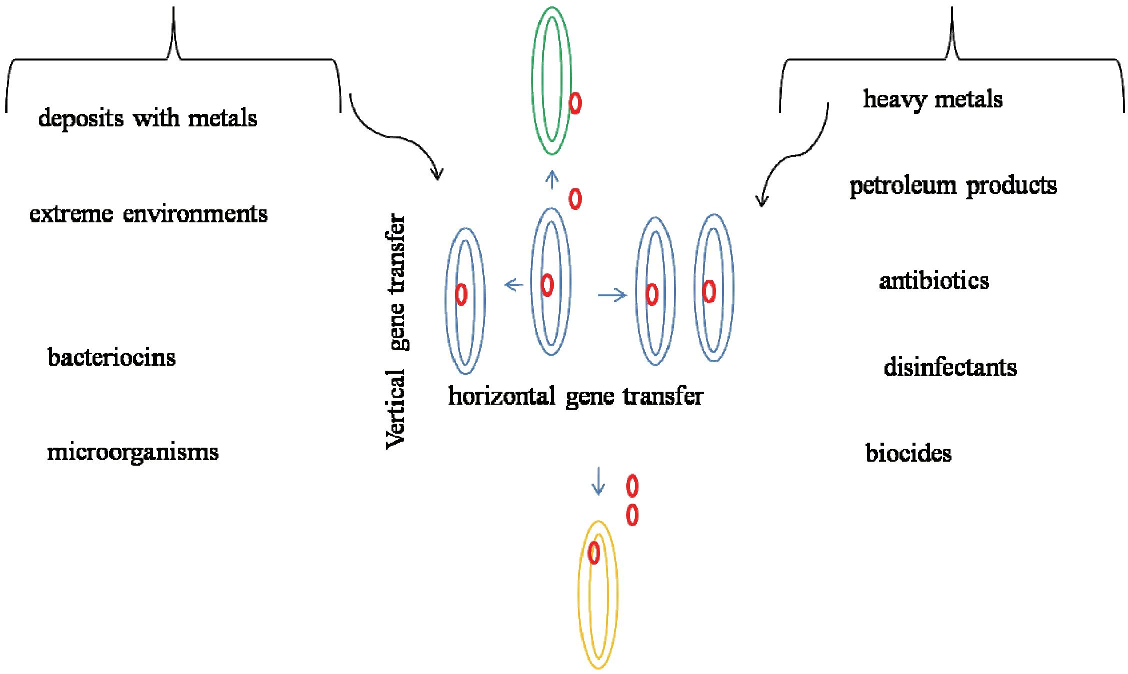

Figure 1. Factors for the occurrence, maintenance and transmission of antibiotic resistance phenomenon (original).

These factors can lead to mutations (GULLBERG et al., 2014; LEEKITCHAROENPHON et al., 2016; DIARMAID & ANDERSSON, 2017), with effect on the resistance to different antibiotics. These mutations can be maintained within the bacterial line that appears, horizontal gene transfer, but may be transmitted to other species by vertical gene transfer.

Thus, antibiotic resistance genes are ubiquitous in natural environments (AMINOV & MACKIE, 2007; MARTINEZ, 2009; ALLEN et al., 2010), and soil bacteria are a reservoir of new antibiotic resistance genes (RIESENFELD et al., 2004). These stress factors cause the emergence of resistance mechanisms, implicitly resistance genes.

POLLUTED MEDIA AND ANTIBIOTIC RESISTANCE

Antibiotic resistance is a due to chromosomal genes, mobile DNA segments (transposons, integrated by genetic recombination or resulting by mutation of normal, integron genes, but most often given by the presence of the plasmids. These genetic determinants can lead to multiple resistance to antibiotics, which facilitates the spread of resistance in natural bacterial populations. In some cases, plasmid-induced resistance has specific molecular mechanisms, which are fundamentally different from those of chromosomal-induced resistance. In most cases, multiple antibiotic resistance is provided by efflux systems (RAMOS et al., 2002).

PUTMAN et al., 2000 described two major classes of transporters that are involved in multiple antibiotic resistance: the ABC transporter that uses energy released by ATP hydrolysis, to pump antibiotics from inside the cell to the outside, and the secondary transporter that uses the gradient. electrochemical transmembrane of H^+ or Na^+ ions, to pump antibiotics from inside the cell to the outside.

Some mechanisms of multiple antibiotic resistance have been observed in some bacteria, functioning as hydrocarbon excretion systems, used to maintain the intracellular concentration of hydrocarbons below the equilibrium level. These systems involve an efflux pump, which also contributes to tolerance to n-peptane, cyclohexane, toluene, phenanthrene, anthracene (RAMOS et al., 2002; HEARN et al., 2003).

Since 1999, KOBAIASHI et al. have demonstrated the connection between toluene efflux pumps and antibiotic resistance efflux pumps. They obtained a mutant of the Pseudomonas putida strain IH-2000, a toluene-tolerant strain. In the mutant strain, some of the outer membrane proteins were lost, including the Srp protein. which is a channel protein of the toluene efflux pump. Thus, the decrease of the tolerance to hydrocarbons, but also the reduction of the minimum inhibitory concentration (CMI) to antibiotics was found, from which it was concluded that the efflux pump systems are linked or shared with the efflux pump system involved in antibiotic resistance.

MARTINEZ, 2009; 2012 considers that antibiotic resistance is similar in many aspects to the contamination with heavy metals.

WRIGHT et al., 2008, believes that bacteria isolated from polluted environments with heavy metals have high antibiotic resistance.

In 2009 THOMPSONET et al., highlights the presence of the *tet A* gene, a gene that confers tetracycline resistance to a strain of *Sratia marcascens*, a strain isolated from heavy metal water.

Thus it is possible to speak of the selective pressure of the pollutants on the zone microbiota (DERORE et al., 1994; D'COSTA et al., 2006), conferring a simultaneous resistance to both the pollutant and the antibiotic.

CONCLUSIONS

The genetic support underlying the phenomenon of antibiotic resistance has been present in nature long before the finding of this phenomenon in the clinical environments.

The mechanisms involved in resistance may be common or similar to the mechanisms involved in pollutant removal.

Pollutants can be considered as selective pressure factors in the phenomenon of resistance.

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Cîrstea Doina Maria
The Research Institute of the University of Bucharest, ICUB, Bucharest, Romania.
Institute of Biology Bucharest of the Romanian Academy, Spl. Independentei no. 296, sect. 6, 060031, Bucharest, Romania.
E-mails: maria_2na@yahoo.com, doina.cirstea@ibiol.ro

Ştefănescu Mugur Cristian
Institute of Biology Bucharest of the Romanian Academy, Spl. Independentei no. 296, sect. 6, 060031, Bucharest, Romania.
E-mail: mugur.stefanescu@ibiol.ro

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MONITORING PHYSICO-CHEMICAL AND BIOLOGICAL PARAMETERS FROM THE MOTRU HIDROGRAPHIC BASIN UNDER THE INFLUENCE OF ANTHROPIC FACTORS

CIOBOIU Olivia, GAVRILESCU Elena, BREZEANU Gheorghe, CISMAŞIU Carmen-Mădălina

Abstract. Fresh water is a finite resource, essential for human existence, for agriculture and industry. It has been unambiguously demonstrated that good quality water is of crucial importance for sustainable socio-economic development. Aquatic ecosystems are affected on a global level by a range of pollutants such as waste, chemical fertilizers or poor water management. They are also populated by hydrobionts that are harmful and pathogen for people, plants, animals, that can bring significant damage to the economy, especially when affecting water sources. In this context, a range of physicochemical and biological analyses were performed to establish the water quality category of the Motru River in three sections, which was monitored between 2015-2018. Depending on these values, water was classified in the categories of I (SI) and II (SII) quality. Biological indicators show positive deviations from the reference values of the five invertebrates groups, with the prevalence of oligochaetes (60%), followed by coleoptera (15%), ephemeroptera, odonata (10%) and diptera (5%).

Keywords: hydrographic basin, the Motru River, physicochemical and biological analyses, saprobic index, biocoenotic indices.

Rezumat. Monitorizarea unor parametri fizico-chimici și biologici din bazinul hidrografic Motru sub influenţa factorilor antropici. Apa proaspătă este o resursă finită, esenţială pentru existenţa umană, pentru agricultură şi industrie. S-a demonstrat uniechivoc că apa de bună calitate este de o importanţă crucială pentru o dezvoltare durabilă socio-economică. Ecosistemele acvatice sunt afectate la scară mondială de o serie de poluanţi cum ar fi: deşeurile, îngrăşămintele chimice sau de un slab management al apei. Ele sunt populate şi de hidrobionţi dăunători şi patogeni pentru om, plante şi animale, ce pot aduce prejudicii însemnate economiei, mai ales atunci când afectează sursele de apă. În acest context s-au efectuat o serie de analize fizico-chimice și biologice stabilind categoria de calitate a apei râului Motru în 3 secțiuni, aceasta fiind monitorizată în perioada 2015-2018. În funcție de aceste valori apa s-a incadrat in categoria I (SI) și II de calitate (SII). Indicatorii biologici prezintă abateri pozitive faţă de valorile de referinţă la cele 5 grupe de nevertebrate, dominante fiind oligochetele (60%), urmate de coleoptere (15%), efemeroptere, respectiv odonate (10%) și diptere (5%).

Cuvinte cheie: bazin hidrografic, râul Motru, analize fizico-chimice și biologice, indicele saprobic, indici biocenotici.

INTRODUCTION

Hydrobiology has grown and developed to the extent that man is increasingly in need of aquatic and water basin products, and the apparent abundance of water has led the society to ignore the need to develop a viable management of water reserve, according to their limited availability (BREZEANU & GĂȘTESCU, 1996; JOHNSON, 1999; BREZEANU et al., 2011; PACEȘILĂ, 2015).

On the Motru Valley, the aspect of the relief is given by the alternation of isolated hills with high hills and the dividing valleys that widen in the confluence zone, giving the appearance of a small depression (the confluence between Ploştina Stream and Motru River). The average altitude of the relief is comprised between 200-300m, with the highest being Tâlvei Peak of 415 m at NE from Roşiuta village. The Motru municipality is located at an altitude of 185m, the lowest slope is 171m in the Merişului meadow, located upstream from the commune of Broşteni. The relief ensemble is given by the high pools of the NE sector with rounded aspect and the valleys that widen towards confluence. A brief overview of the map shows us the existence of high fragmentation surfaces in the N part due to the branching of the tributary reception basins, with a density between 0.1-1km/km^2 in the Motru Meadow, in the south part of the peak between Motru and Peşteana. The Motru River is the main hydrographic artery and has an orientation given by the appearance of the relief. The hills have heights between 200-300m, the slopes occupying very large surfaces with inclinations between 0-30%, the more pronounced being produced by human activity is intense (Fig. 1). After water treatment, the recorded values for suspensions and detergents are over the allowable limits. The most significant exceedances are observed in the NH_4^+ and CBO_5 indicators, the recorded values are well above the permissible limits and demonstrate an inefficiency of the biological treatment of the station in the Motru municipality (GAVRILESCU & OLTEANU, 2003; CIOBOIU, 2005).

The Motru River Valley is the largest occupying a central place in the landscape of the relief and due to the ubiquitous anthropic activity in the region an anthropic specific relief has been created. The Motru River presents a winding course with changes of direction (NV-SE at Glogova, N-S at Meriş). The important tributaries of the Motru River – on the left side, Ploştina and Lupoiţa, on the right side, Crainici and Peşteana – gave rise to the valleys bearing their name, rather narrow valleys in the upper sector and wide to the place of discharge. The Motru Valley is centrally oriented within the Motru Coal Basin. The Motru Coal Basin is located within the Motru Perimeter, presenting specific features within a Piedmontese aspect determined by the geological structure of the surface deposits arranged monoclinically, by the general inclination of the relief in the region from NV to SE. From a geographic point of view, the Motru River Basin is located in the western part of the Getic Piedmont and covers an area of 691 km^2 (Fig. 2).

Figure 1. The location of the Motru River – General Overview (Google Earth, accessed: March 5, 2019).

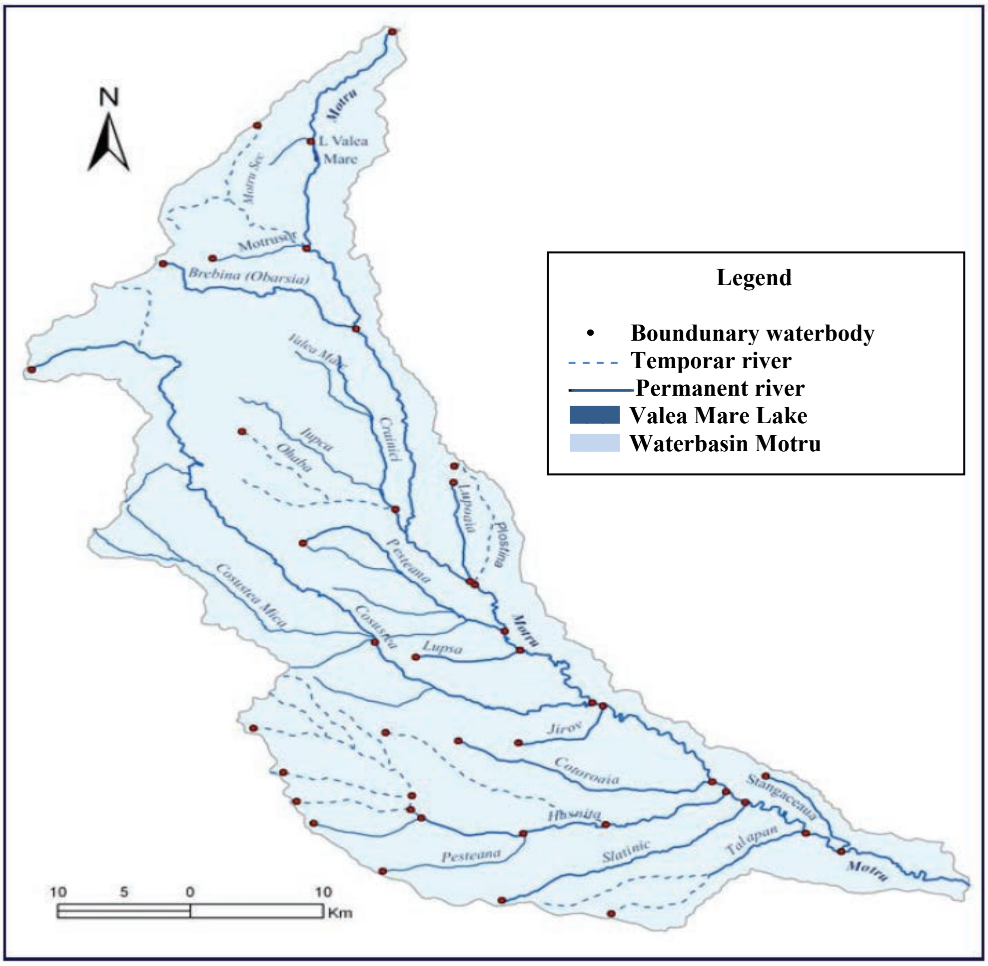

Figure 2. Surface water bodies in the Motru River Basin (processing after topographic map 1:25.000, 1979).

MATERIAL AND METHODS

The research carried out aimed at assessing the water quality of the Motru River, which was appreciated from a physical, chemical and biological point of view. The study was conducted in three areas, located on the upper, middle and lower course of the river. Physical (temperature, conductivity, pH, fixed residue) and chemical (chlorides, sulphates, nitrogen, ammonium ions) characteristics were determined from the water samples collected according to the regulations in force. Also, biological monitoring of invertebrates was performed using the B.M.W.P (Biological Monitoring Working Party) method. Invertebrates were collected using a colonization sample and stored in the field by adding 4% formaldehyde until the animals are completely submerged. The value of B.M.W.P. is effective in highlighting small changes in water quality and varies between 1 and 10. The method is based on the number of invertebrate groups found in the water samples. According to their sensitivity to pollution, they are assigned a certain value between 1 and 10.

The more sensitive the group is to pollution, the higher the number will be. As more groups may appear in the water, the B.M.W.P index does not have the maximum limit, although values over 150 are rare. In order to calculate the B.M.W.P index, 50 samples were taken, followed by the numerical values of the examined groups. In a more precise calculation, the B.M.W.P. of water is divided by the number of invertebrate groups identified in the samples. The data were then analysed using different techniques: a) The Trent index; b) the Shannon-Weiner index; c) The dominance K (SAVIN, 2004; ROBESCU, 2008; GAVRILESCU & GAVRILESCU, 2009).

RESULTS

In assessing surface water quality for rivers in Romania, indicators of the thermal and oxygen regime were used, such as temperature and dissolved oxygen (SAVIN, 2001). The water temperature of the rivers in the Motru hydrographic basin is characterized by a fairly large variability both in terms at space and time, being directly proportional to the thermal regime of the air and inversely proportional to the altitude.

In the graph of the monthly variation of the surface water temperature in the basin (Fig. 3), in addition to the influence of the climatic factor (the highest values were recorded in June – 23^{0}C, Broşteni; 22^{0}C, Fața Motrului and Gura Motrului and the lowest values in february - 2^{0}C, Corcova), the correlation of its values with the altitude can be seen (average annual values of water temperature decrease with the altitude - 9^{0}C, Cloşani; 13,6^{0}C, Broşteni; 13,8^{0}C, Gura Motrului).

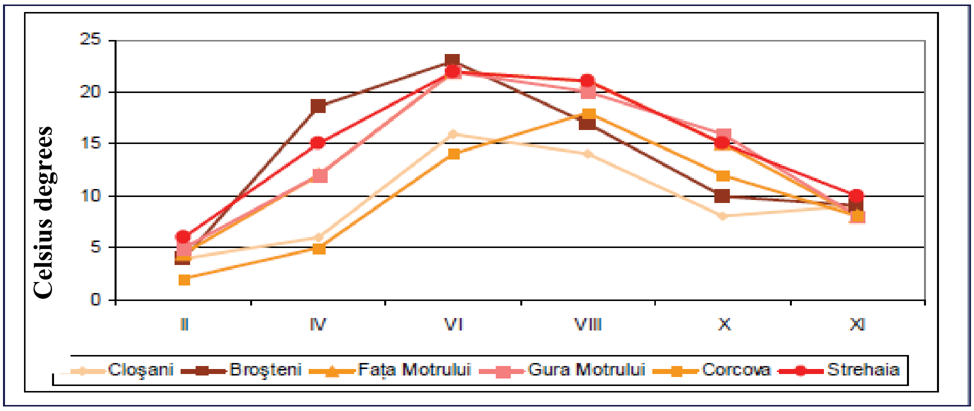

Figure 3. Monthly variation of surface water temperature in the Motru Hydrographic Basin (source: ABA Jiu).

The chemistry of surface waters in the Motru River Basin was assessed by the values of nutrients, salinity and other relevant chemical pollutants and it was found that monitoring stations such as Brosteni (located downstream of the town of Motru) and Gura Motrului (station located upstream from the Jiu River) constitute a monitoring section of the entire basin for reception. In terms of pollution sources, it was found that significant values are recorded at the level of the two urban settlements Motru and Strehaia. The waste water is discharged in the Motru River (for the town of Motru), in the Huşniţa stream (for the city of Strehaia) and in Brebina (for the city of Baia de Aramă), and the pollution of the aquatic environment is due to the organic loading to which nutrients and suspensions are added (SAVIN, 2008).

The industrial activity in the Motru River Basin consists of the extraction and preparation of lower coal at the units of the E.M.C. Motru. Lupoiţa and Ploștina can be considered a point source of pollution, registering the following exceedances: in domestic waters - NH4 (0.420 mg / l), and in technological waters - suspensions (32 mg / l) and calcium (98.400 mg / l). Other sources of pollution are: the administration of chemical fertilizers, especially phosphorus, most communes falling below 0.5 kg / ha x year; the specific quantity of nitrogen used at the commune level is mostly below 5 kg / ha x year; the growth of animals and cattle, respectively, is the most important source of diffuse pollution due to the impact of elements such as ammonia, nitrogen (nitrates) and phosphorus (phosphates) from animal manure.

The use of land in the Motru River Basin, according to Corine Land Cover 2010 (Calculated Area by GIS techniques) is characterized by the predominance of the following areas: 48.1% agricultural areas, 45.6% forests and semiarid areas and 5.7% areas anthropized (Fig. 4). Sources of anthropogenic pollution present a particular importance and are the main cause of contamination by the Motru Hydrographic Basin.

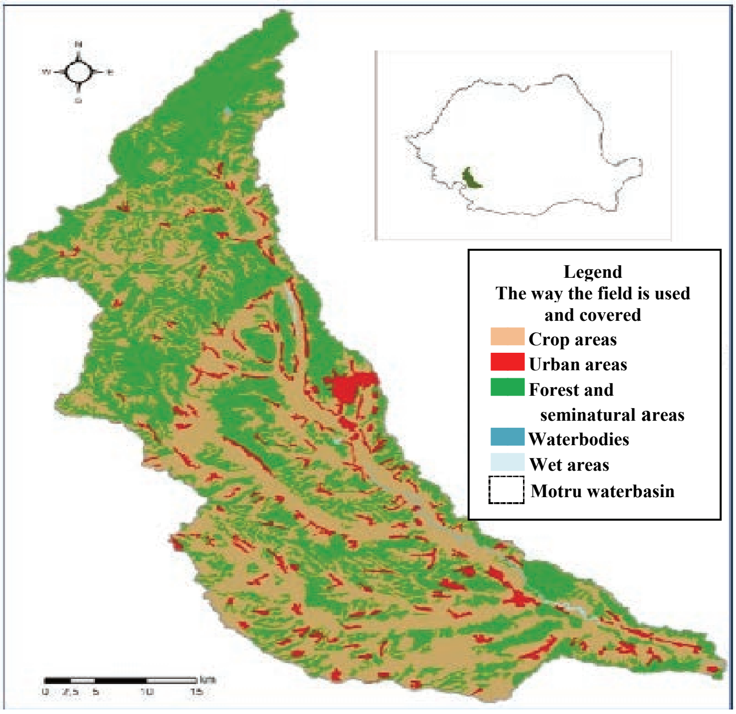

Figure 4. The degree of human intervention on the land of the Motru Hydrographic Basin
(processing after Corine Land Cover 2010, ABA Jiu).

Physicochemical indicators were determined on three distinct sections of the river Motru: Motru at Apa Neagră (S1), Motru upstream of the town Motru (S2), Motru downstream of the Motru city (S3), namely: pH, conductivity, fixed residue, chlorides, sulphates, nitrates, nitrates, ammonium ions in each season in the period 2015-2018 (CIOBOIU, 2003). The pH and conductivity of the evacuated water have values within the limits allowed by the Normative regarding the discharge of urban waste water in natural receivers (Figs. 5, 6).

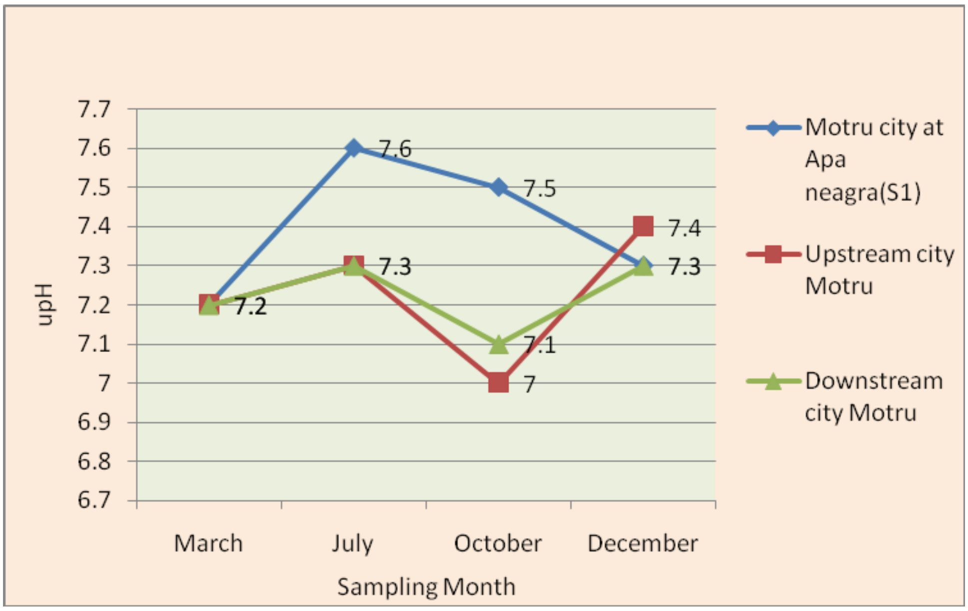

Figure 5. The evolution of pH in the Motru Hydrographic Basin.

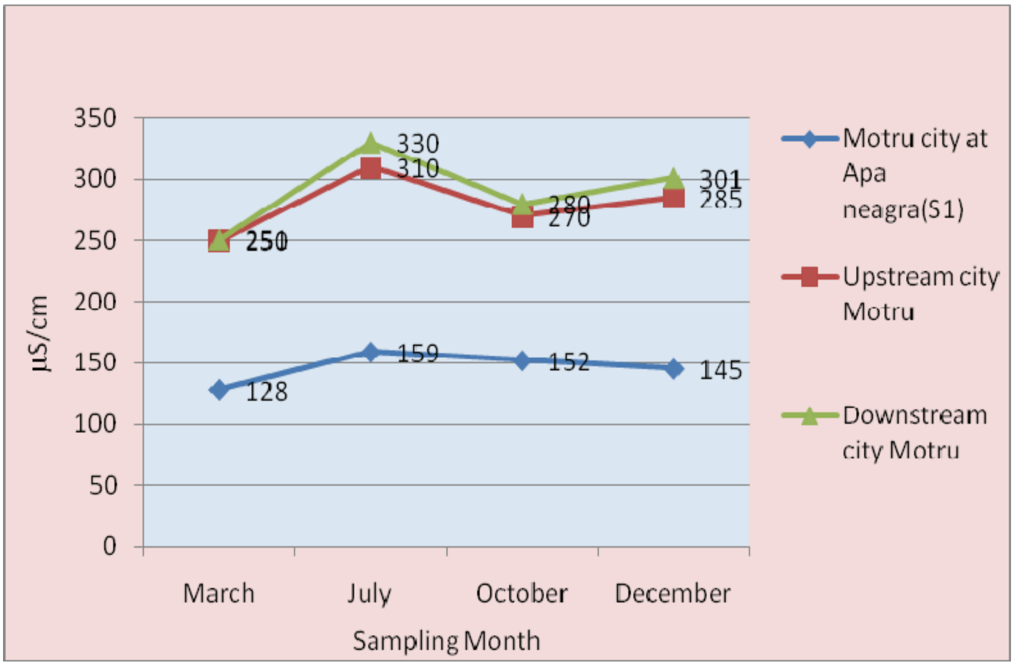

Figure 6. The evolution of conductivity in the Motru Hydrographic Basin.

Thus, in the section of the Motru River at Apa Neagră for fixed residue indicators, chlorides and sulphates, the obtained values are below the limits set for quality class I. At the fixed residue indicator, the highest value obtained (114 mg / l) represents only 22.8% of the limit for the quality of the class I (CÎRȚÎNĂ, 2005; GAVRILESCU & BUZATU, 2014).

As for the other indicators – nitrates, nitrates, ammonium – the obtained values fall within the second quality class. Results were interpreted according to the Order of the Ministry of Environment and Water Management no. 161/2006 for the approval of the Normative regarding the classification of surface waters in order to establish the ecological status of the water bodies. Also, in section (S2), the characteristic values of the quality class II were recorded in the indicators regarding the regime of nutrients in water, namely, nitrogen, nitrogen and ammonium, which indicates an organic pollution. Furthermore, this finding can be observed in section (S3), where the urban waste water from Motru municipality is discharged, in a sub-dimensioned sewage treatment plant, with a very low efficiency (Figs. 7, 8, 9, 10, 11 , 12).

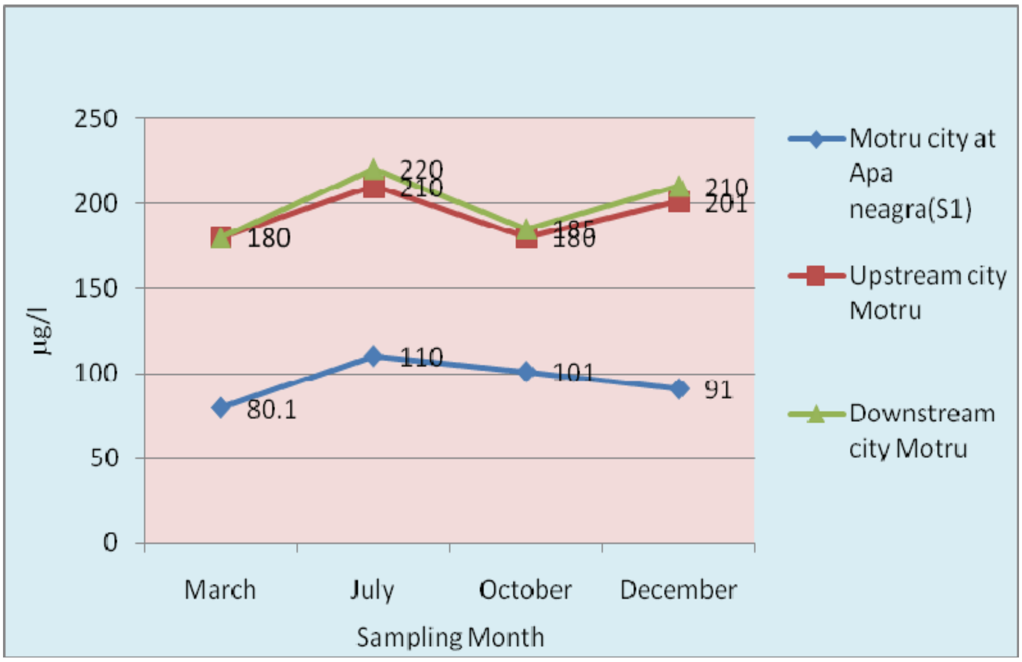

Figure 7. The evolution of the fixed residue in the Motru Hydrographic Basin.

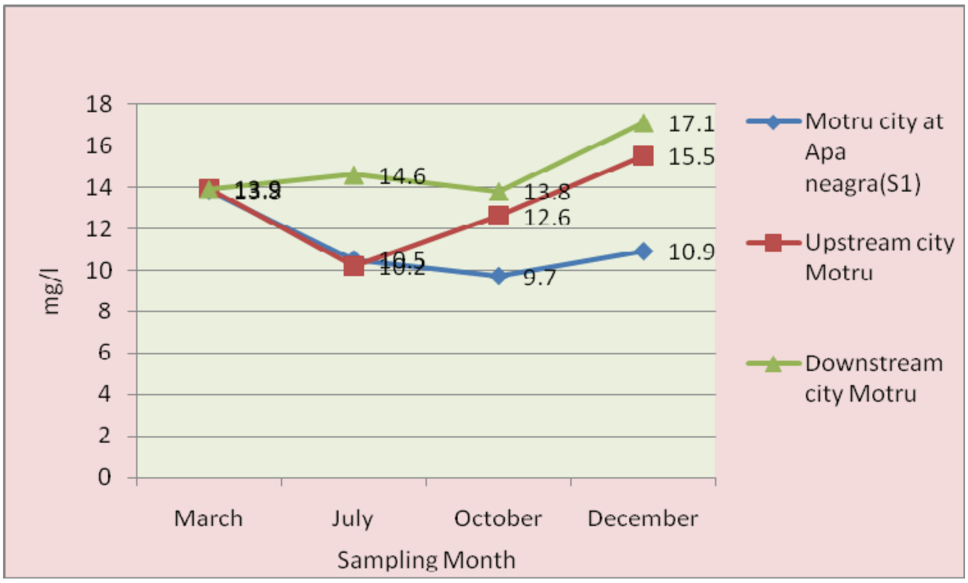

Figure 8. The evolution of chlorides in the Motru Hydrographic Basin.

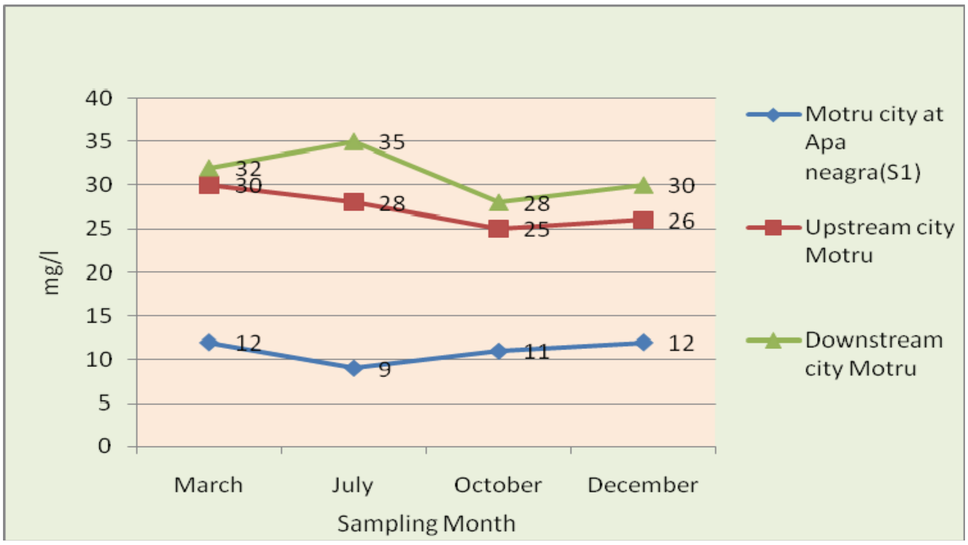

Figure 9. The evolution of sulphates in the Motru Hydrographic Basin.

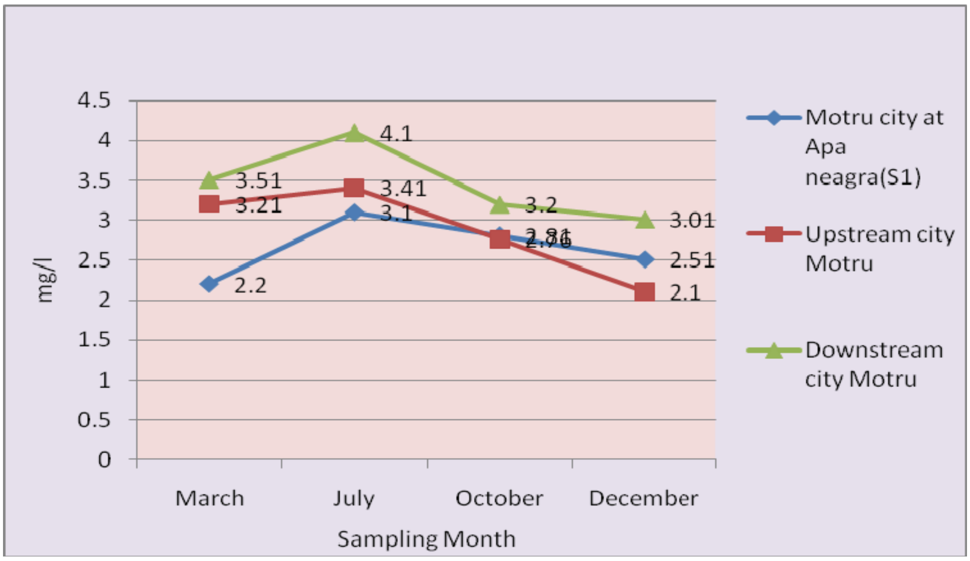

Figure 10. The evolution of nitrates in the Motru Hydrographic Basin.

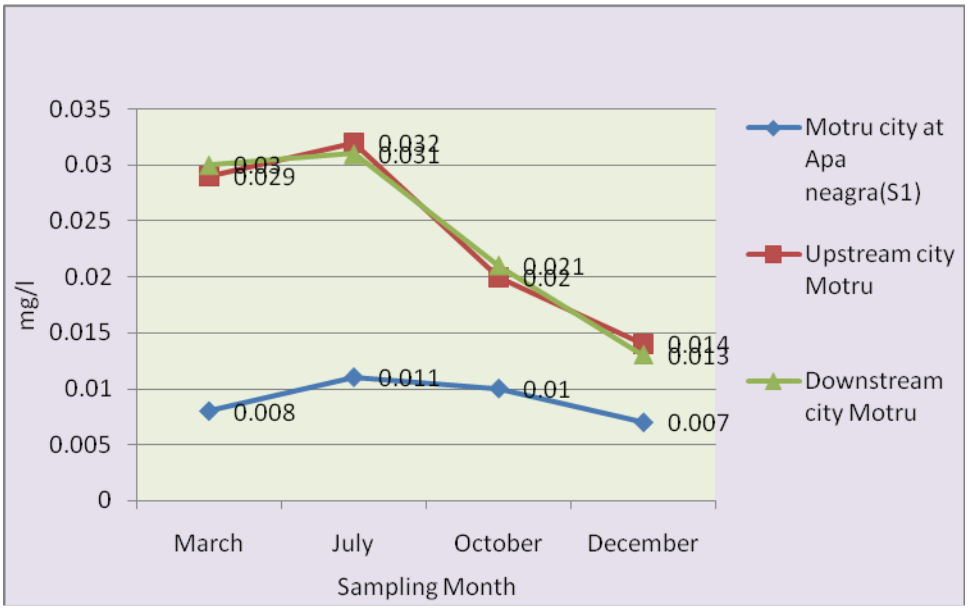

Figure 11.The evolution of nitrates in the Motru Hydrographic Basin.

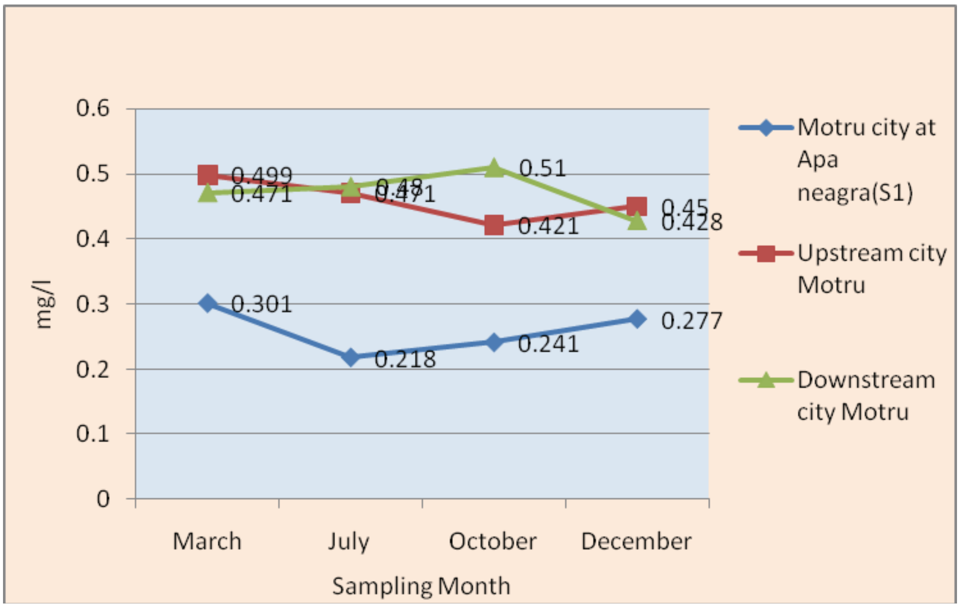

Figure 12. The evolution of ammonium in the Motru Hydrographic Basin.

Biological indicators. The assessment of the ecological status by invertebrate groups was performed by interpreting the values of the biological indices presented in the Specific Reference Conditions (JOHNSON, 1999; CIOBOIU & BREZEANU, 2002; BREZEANU et al., 2011). Some of them reported positive deviations from the benchmarks (Shannon-Wiener Diversity Index - 2.87). As for biological indicators, they were analysed at the Fața Motrului monitoring station. In 2018 it was found that the saprobic index 30% had the value of 2.2, while the reference value was 1.55; insect index: Ephemenoptera, Odonata and Diptera 10% is 0.43 while the reference value is 0.3; the Shannon-Wiener diversity index 20% is 2.87 while the reference value is 1.9; the index of the number of families 10% is of 13.33 while the reference value is 14; the Oligochaeta – Chironomidae 10% index is 0.31 while the reference value is 0.25; the index of the 10% functional groups is 0.34 while the reference value is 0.3; the 10% water flow preference index is 0.97 while the reference value is 0.9; the multimeter index of macroinvertebrates is 0.929 while the reference value is 0.921, all indicating a good ecological status (Source: ***. Ord. 161/2006; National Institute for Research and Development for Environmental Protection - ICIM Bucharest, 2012).

The analysis at the monitoring station upstream of Motru city presents exceedances of the following biological indicators: Saprobic index, Insect index, Shannon-Wiener diversity index, Family number index, ecological status being good. Thus, in the Motru to Apa Neagră section, the obtained values fit in the section S1 and S2 for the first class of quality, and in the section S3 for the second class of quality (Figs. 13, 14, 15).

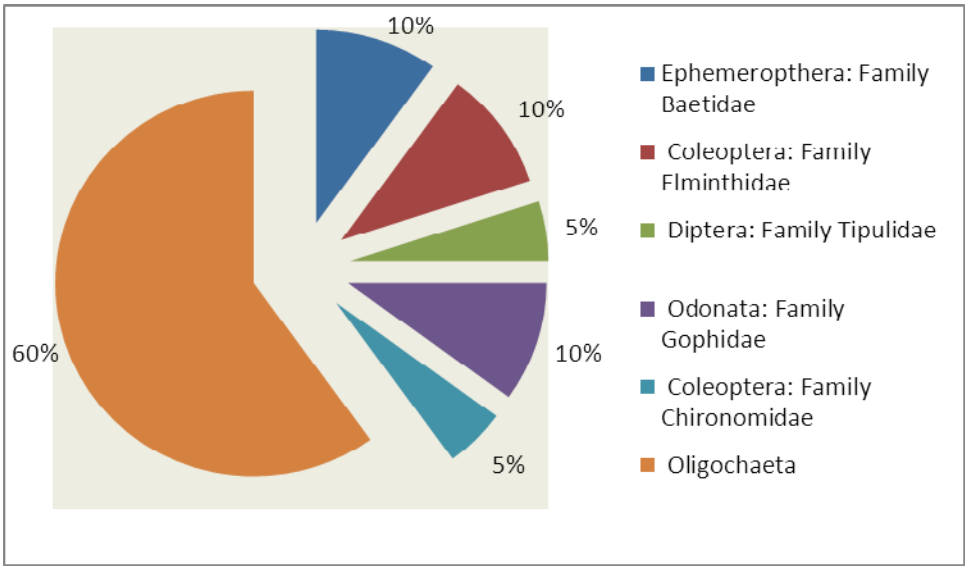

Figure 13. The percentage composition of the invertebrate groups in the Motru Hydrographic Basin.

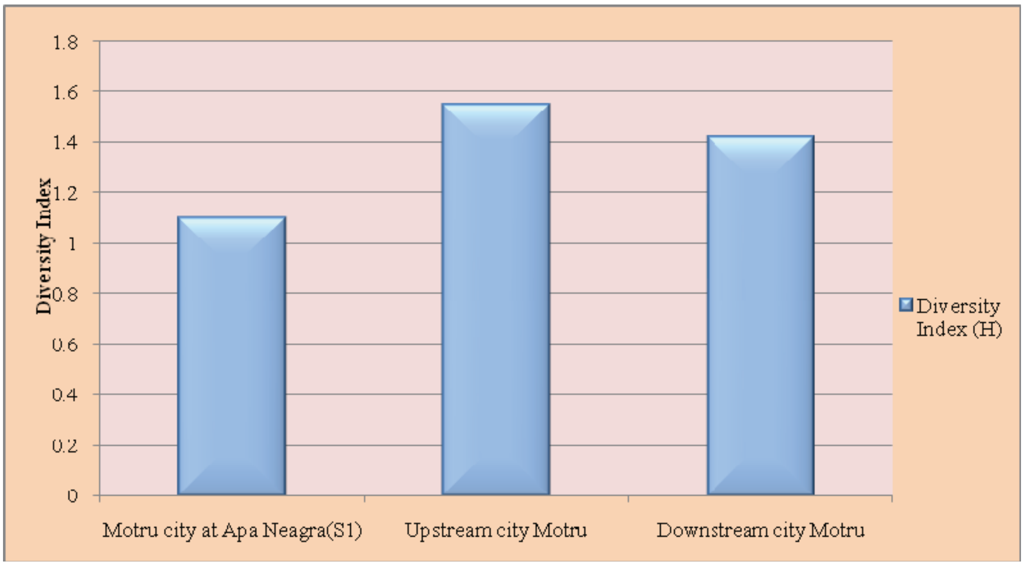

Figure 14. The variation of the Shannon-Wiener diversity index on the course of the Motru River.

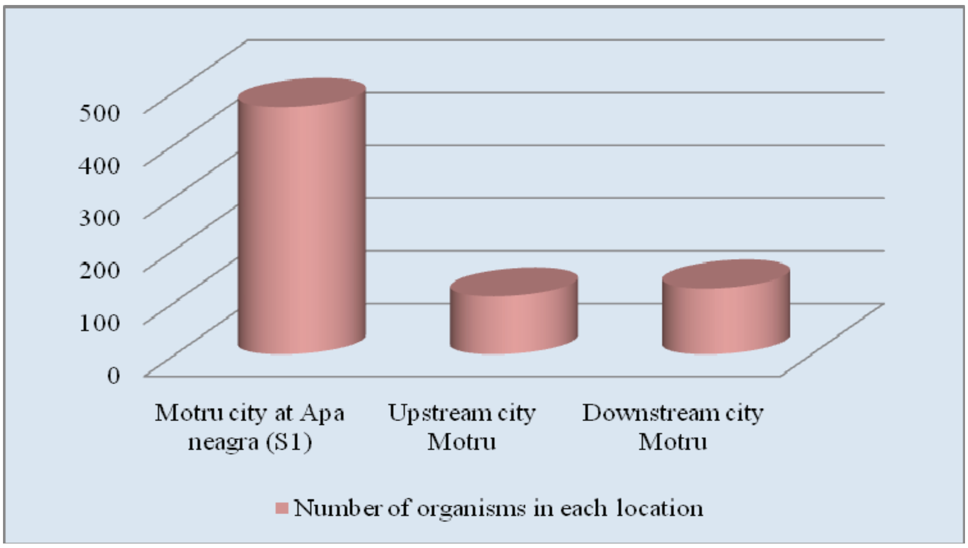

Figure 15. The numerical density of invertebrate populations from sites along the Motru River.

DISCUSSIONS

The modification of the biocoenosis composition entails structural and functional changes of the whole ecosystem leading to a change in its informational content. The dynamic balance that characterizes the integrity of the open systems, like aquatic ecosystems, is achieved through complex mechanisms of self-regulation, which work on the basis of the cybernetic principles of direct and reverse connection (GAVRILESCU, 2007; CIOBOIU et al., 2017; CIOBOIU & CISMAȘIU, 2018; CISMAȘIU et al., 2017).

Also, aquatic organisms have a highest diversity than terrestrial ones, dominating those with a simpler morphophysiological structure, so that the influence of environmental conditions is more strongly felt. These characteristics are particularly important for the biology of polluted basins, as the physicochemical composition of the water and the hydrological and hydrographic conditions of the basins are essential factors in determining the quantitative and qualitative composition of biocoenoses. (PĂTROIESCU et al., 1980; BREZEANU & GRUIȚĂ, 2002).

CONCLUSIONS

Sources of anthropogenic pollution present a special importance and they are the main cause of the contamination of the Motru River (the waters resulting from then household activities of the population, from public institutions and public food, as well as those from the mining units in the area).

The biological indicators analysed at the monitoring station upstream of Motru city show exceedances of the following biological indicators: the Saprobic Index, the Insect Index, the Shannon-Wiener diversity Index, the Number Index of families, the ecological status being good. In the section of the Motru River to Apa Neagră, the biological indicators analysed at the monitoring station upstream of Motru city show exceedances of the following biological indicators: Saprobic index, Insect index, Shannon-Wiener diversity index, Index of the number of families, the ecological status being good. the obtained values falling in the section of S1 and S2 in the first class of quality, and the section of S3 in the second class of quality. From a biological point of view, we highlight the presence of a large number of oligochaetes with less susceptible organisms and indicators of industrial contamination.

In order to achieve an advanced treatment, in order to reach the required level of treatment, it is necessary to expand and rehabilitate the treatment plant in the municipality of Motru.

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Cioboiu Olivia
The Oltenia Museum, Craiova, Str. Popa Şapcă, No. 8, 200422, Craiova, Romania.
E-mails: oliviacioboiu@gmail.com; cioboiu.olivia@yahoo.com

Gavrilescu Elena
University of Craiova, Faculty of Horticulture,
Biology and Environmental Engineering Department, A.I.Cuza Street 13, Craiova, 200585, Romania.
E-mail: gavrilescu_elena@yahoo.com

Brezeanu Gheorghe
Institute of Biology Bucharest, Romanian Academy, Spl. Independentei No. 296, sect. 6, 060031, Bucharest, Romania.
E-mail: aurelia.brezeanu@ibiol.ro

Cismaşiu Carmen - Mădălina
Institute of Biology Bucharest, Romanian Academy, Spl. Independentei No. 296, sect. 6, 060031, Bucharest, Romania.
E-mails: carmen.cismasiu@ibiol.ro, carmencismasiu@gmail.com.

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THE INFLUENCE OF GLOBAL WARMING REGARDING SOME BIOLOGICAL AND ECOLOGICAL ASPECTS OF INSECTS FROM TINCA AREA BIHOR COUNTY (NORTH-WESTERN PART OF ROMANIA)

ILIE Aurelian Leonardo, MARINESCU Mariana, ILIE Lorena Cosma

Abstract. This paper presents biological and phenological anomalies observed at the insects from the Tinca area, Bihor county (north-western part of Romania) due to the consequences of global warming. These anomalies were observed during 2010-2019 in 105 species of insects. These climate changes caused the extension of the activity or flight period, the appearance of additional generations or the hibernation in another development stage, sometimes simultaneously with the stage known in the scientific literature, precocious appearances in nature, some resistance of some species to dryness and heat, copulation and even the laying down of eggs in November – December.

Keywords: phenological anomalies, insects, Tinca area.

Rezumat. Influența încălzirii globale privind unele aspecte biologice și ecologice ale insectelor din zona Tinca, județul Bihor (partea nord-vestică a României). În această lucrare sunt prezentate anomalii biologice și fenologice observate la insectele din zona Tinca, județul Bihor (partea nord-vestică a României) datorate consecințelor încălzirii globale. Aceste anomalii au fost observate în perioada 2010-2019 la 105 specii de insecte. Aceste schimbări climatice au cauzat prelungirea activității sau a perioadei de zbor, apariția de generații suplimentare sau hibernarea în alt stadiu de dezvoltare, uneori simultan cu stadiul cunoscut în literatura științifică, apariții precoce în natură, o anumită rezistență la secetă și caniculă ale unor specii, împerechere și chiar depunerea ouălor în perioada noiembrie-decembrie.

Cuvinte cheie: anomalii fenologice, insecte, zona Tinca.

INTRODUCTION

Precocious and short springs, droughty summers, autumns with high temperatures and thermic shocks, mild winters, the replacement of snow with rain are the effects of global warming observed in the seasons structure (CIOBOIU, 2005; 2014).

The extension of the activity or flight period, the premature beginning of the activity of flight period, the appearance of additional generations, hibernation in another development stage, sometimes with the stage known in the scientific literature, copulation and even lay eggs in November-December, are phenological changes observed in insects, due to the consequences of global warming. Researches were undertaken in Romania regarding the effects of the global warming over different groups of insects (DYJKSTRA, 2006; ILIE, 2012; 2014a, b, c; 2015a, b; 2016a, b; 2017; ILIE L. C., 2017; ILIE, 2018; ILIE & MARINESCU 2018; ILIE et al., 2018).

This paper, a premiere at a national level, is a synthesis of the observations performed by authors regarding the influence of global warming over the insects from the Tinca area (Bihor county, north-western part of Romania). These phenological anomalies must be attentively supervised because some species of insects are pests for forestry and agriculture and protection treatments are performed depending on the activity and development stage of insects.

The Tinca area is located in the north-western part of Romania, in the south-western part of Bihor county having a hilly relief. The climate is temperate-continental, the hydrographic system is represented by the Crișul Negru river and some lakes, the average altitude is 110 m. The vegetation belongs to the oak stage. Tinca village is formed by five villages: Tinca, Râpa, Belfir, Girișu-Negru and Gurbediu.

MATERIAL AND METHODS

The researches were performed during 2010-2018, in the Tinca area. Insects were captured with entomological nets or manually. Species were identified in the laboratory, using sources mentioned in specialized literature (CÂRDEI & BULIMAR, 1965; KIS, 1984; PÂRVU et al., 1985; RAKOSY, 1996; WARCHALOWSKY, 2003; SZEKELY, 2008, 2010; RAKOSY, 2013; PANIN et al., 2015).

RESULTS AND DISCUSSIONS

In the Tinca area, during 2010-2019, phenological anomalies were observed in 105 species (Table 1).

Table 1. The phenological anomalies at the species of insects.

Species	Specimens, period, village, temperature	Flight period
Maculinea arion Linnaeus 1758	2 M, Tinca, 10. XII. 2018, t=6^{0}C	15. IV – 15. VI
Polypogon tentacularia Linnaeus 1758	1 M, Tinca, 15. II. 2018, t=5^{0}C;	15. V – 15. VII

	1 M, Tinca, 23. XI. 2018, t=5^{0}C; 1 M, Tinca, 8. XII. 2018, t=4^{0}C	
Hyles euphorbiae Linnaeus 1758	1 M, Tinca, 24. I. 2018, t=5^{0}C; 1 M, Tinca, 13. XI. 2018, t=17^{0}C; 1 M, Tinca, 7. XI. 2018, t=20^{0}C; 1 ex ♂, Tinca, 8. XI. 2018, t=27^{0}C	15. IV – 15. VI
Lasiommata megera Linnaeus 1767	1 M, Tinca, 3. XI. 2015, t=15^{0}C; 2 F, Tinca, 21-22. X. 2017, t=16,5^{0}C; 1 M, Tinca, 8. XI. 2018, t=18^{0}C; 1 M, Tinca, 9. XI. 2018, t=15^{0}C	15. IV – 7. X
Melitaea phoebe Denis 1775	1 F, Râpa, 1. XI. 2015, t=14^{0}C; 1 M, Tinca, 7. XI. 2018, t=20^{0}C	V – IX
Melitaea athalia Rottemburg 1775	1 F, Tinca, 4. XI. 2018, t=25^{0}C	V – 15. IX
Pyronia tithonus Linnaues 1758	1 F, Tinca, 2. XI. 2018, t=25^{0}C	15. VI – VIII
Maniola jurtina Linnaeus 1758	1 F, Tinca, 4. XI. 2018, t=25^{0}C	VI – VIII
Lycaena virgaureae Linnaeus 1758	1 F, Tinca, 11. X. 2018, t=24^{0}C; 1 M, Tinca, 20. X. 2018, t=17^{0}C	15. VI – 15. VIII
Brintensia circe Fabricius 1775	1 M, Tinca, 28. XI. 2018, t=23^{0}C; 1 M, Tinca, 12. XI. 2018, t=27^{0}C	15. VI – 15. VIII
Neptis sappho Pallas 1771	1 F, Tinca, 6. X. 2018, t=24^{0}C	15. IV – VIII
Pieris brassicae Linnaeus 1758	2 M, Tinca, 15. XI. 2010, t=19^{0}C; 1 M, Tinca, 19. II. 2014, t=20^{0}C; 2 M, Râpa, 14. I. 2015, t=9,5^{0}C; 3 M, Tinca, 25. X-7. XI 2017, t=15-17^{0}C; 1 M, Tinca, 28. III. 2018, t=9^{0}C; 2 M, Tinca, 3-4. XI. 2018, t=25^{0}C.	20. IV – 15. X
Pieris rapae Linnaeus 1758	1 M, Râpa, 6. III. 2016, t=12^{0}C; 1 M, Tinca, 4. XI. 2015, t=14^{0}C; 1 M, Tinca, 12. X. 2015, t=16^{0}C; 1 M, Tinca, 4. I. 2018, t=7^{0}C.	IV – 15. X
Pieris napi Linnaeus 1758	1 M, Tinca, 23. II. 2017, t=11^{0}C	20. III – X
Colias croceus Foucroy 1785	1 M, Tinca, 16. X. 2010, t=21^{0}C; 25 specimens, Râpa, 2. XI. 2013, t=16^{0}C; 1 M, Tinca, 16. XI. 2015, t=16^{0}C; 1 M, Tinca, 22. XI. 2016, t=14^{0}C	V – X
Colias hyale Linnaeus 1758	1 M, Tinca, 15. XI. 2015, t=14^{0}C	V – X
Colias alfacariensis Ribbe 1905	3 M, Râpa, 21. I. 2015, t=13^{0}C	V – X
Gonopterys rhamni Linnaeus 1758	1 M, Râpa, 13. II. 2014, t=17^{0}C	20. III – IX
Zerynthia polyxena Dennis 1775	1 M, Râpa, 12. III. 2018, t=16^{0}C	V – 15. VI
Lycaena phleas Linnaeus 1761	1 M, Râpa, 4. II. 2014, t=16^{0}C; 1 M, Belfir, 18. II. 2014, t=18^{0}C; 1 M, Râpa, 2. III. 2014, t=20^{0}C	15. IV – X
Cupido alcetas Hoffmannsegg 1804	1 M, Râpa, 2. XI. 2013, t=16^{0}C	20. IV – 7. X
Polymmatus icarus Rottenburg 1775	Resistant species at the drought during 2015 and 2016	20. IV – X
Vanessa atalanta Linnaues 1758	1 M, Râpa, 6. III. 2016, t=12^{0}C; 1 M, Tinca, 14. XII. 2011, t=11^{0}C; 1 M, Tinca, 22. I. 2015, t=12^{0}C; 1 M, Tinca, 6. I. 2014, t=14^{0}C; 1 M, Tinca, 20. I. 2014, t=14^{0}C; 1 M, 2 F, Râpa forest, 26. X. 2014, t=12^{0}C; 11 specimens, Tinca, 20. X. 2017- 25. I. 2018, t=8-17^{0}C; 1 F, 1 M, Tinca, 10. XII. 2018, t=6^{0}C	IV – IX
Inachis io Linnaeus 1758	1 M, Tinca, 18. XII. 2012, t=2^{0}C; 1 F, Râpa, 2. XI. 2013, t=16^{0}C; 1 F, Tinca, 9. XI. 2015, t=12^{0}C; 1 M, Râpa, 4. XII. 2016, t=4^{0}C; 1 M, Tinca, 8. I. 2018, t=13^{0}C; 1 M, Tinca, 4. XI. 2018, t=25^{0}C; 1 M, Tinca, 30. X. 2018, t=24^{0}C; 1 F, Tinca forest, 5. X. 2018, t=20^{0}C	III – IX
Polygonia c-album Linnaeus 1758	1 M, Râpa, 24. I. 2017, t=14^{0}C; 1 M, Tinca, 17. II. 2016, t=16^{0}C	III – X
Aglais urticae Linnaeus 1758	1 M, Râpa, 26. I. 2017, t=14^{0}C; 1 M, Tinca, 7. I. 2018, t=13^{0}C; 1 M, Tinca, 24. I. 2018, t=13^{0}C	III – VIII
Nymphalis antiopa Linnaeus 1758	1 F, Belfir, 17. XI. 2013, t=16^{0}C; 1 F, Tinca, 28. XI. 2013, t=15^{0}C	IV – VIII
Nymphalis polychloros Linnaeus 1758	1 F, Râpa, 2. XI. 2014, t=19^{0}C	III – IX
Pararge aegeria tircis Godat 1821	1 F, Râpa, 2. XI. 2013, t=16^{0}C; 1 F, Tinca, 6. XI. 2017, t=15^{0}C	IV – IX
Erebia medusa Denis 1775	2 M, Tinca, 5. III. 2017, t=18,5^{0}C; 1 F, Tinca, 22. III. 2017, t=20^{0}C; 1 caterpillar, Tinca, 3. II. 2017, t=7^{0}C	V – VII
Minois dryas Scopoli 1763	1 F, Tinca, 29. X. 2015, t=15^{0}C;	VII – 7. IX

	1 F, Râpa, 2. XI. 2014, t=19^{0}C	
Apatura ilia Denis 1775	1 M, Râpa, 2. XI. 2014, t=19^{0}C	VI – VIII
Apatura iris Linnaeus 1758	1 F, Râpa, 3. XI. 2014, t=19^{0}C	VI – VIII
Hesperia comma Linnaeus 1758	1 M, Râpa, 25. III. 2018, t=10^{0}C	15. IV – IX
Pyrgus alveus alveus Hubner 1803	1 M, Râpa, 5. X. 2014, t=16^{0}C	VI – VIII
Parnasius apollo jaraensis Kertesz 1922	1 F, Râpa, 20. V. 2015, t=19^{0}C; 1 F, Râpa, 15 VI 2015, t=21^{0}C	15. VII – VIII
Iphiclides podalirius Linnaeus 1758	1 M, Râpa, 4. III. 2016, t=10^{0}C; 1 F, Râpa, 25. XI. 2016, t=8^{0}C; 1 M, Tinca, 7. I. 2018, t=13^{0}C	15. IV – VIII
Papilio machaon Linnaeus 1758	1 M, Gurbediu, 6. XI. 2013, t=14^{0}C; 1 M, Gurbediu, 15. XI. 2013, t=15^{0}C; 1 M, Râpa, 8. III. 2016, t=12^{0}C; 1 M, Tinca, 8. I. 2018, t=13^{0}C; 1 M, Belfir, 13. III. 2016, t=12^{0}C	15. IV – VIII
Leptidea sinapis Linnaeus 1758	1 M, Râpa, 2. XI. 2014, t=19^{0}C	IV – 7. XI
Anthocaris cardamines Linnaeus 1758	2 F, Tinca forest, 30. VIII. 2011, t=28^{0}C; 1 M, Râpa, 2. XI. 2014, t=19^{0}C	III – VI
Trachys troglodytiformes Obenberg 1918	2 F, 1 M, Tinca, 2. XI. 2018, t=25^{0}C	IX
Psyllobora 22-punctata Linnaeus 1758	1 F, Tinca, 17. XI.-21. XII. 2017 , t=6-17^{0}C	IV – X
Coccinella 7-punctata Linnaeus 1758	6 specimens, Tinca, 12. XII. 2017-19. I. 2018, t=6-17^{0}C	IV – X
Otiorrhynchus fuscipes Olivier 1790	1 M, Tinca, 17. I. 2018, t=5^{0}C	IV – X
Anthrenus scrophulariae Linnaeus 1758	1 F, Tinca, 21. II. 2017, t=7,5^{0}C	IV – X
Rhynchites bacchus Linnaeus 1758	1 M, Tinca, 24. X. 2017, t=12^{0}C	IV– X
Harmonia axiridis Pallas 1773	1 M, Tinca, 28. XII. 2017, t=13^{0}C; 1 M, Tinca, 8. XII. 2016, , t=1^{0}C	III – X
Chrysolina fastuosa Scopoli 1763	2 M, 4 F, 50 larva specimens, Tinca, 1. XI. 2017-12. I. 2018, t=0-17^{0}C; Two larva specimens, Tinca, 28. XI. 2016, t=3,5^{0}C	IV – X
Chrysolina herbacea Duftschmidt 1825	One larva specimen, Tinca, 27. XI. 2011, t=4^{0}C; 4 larva specimen, Tinca, 11. XII. 2011, t=7^{0}C; One larva specimen, Tinca, 31. I. 2012, t=8,5^{0}C; One larva specimen, Tinca, 28. XI. 2016, t=4^{0}C	IV – X
Podagrica menetriesii Faldermann 1837	One pair in copula, Tinca, 3. XI. 2013, t=16^{0}C; 2 M, Tinca, 23. XII. 2015, t=13^{0}C	IV – IX
Longitarsus tabidus Fabricius 1775	One pair in copula, Tinca, 12. XI. 2014, t=18^{0}C; One pair in copula, Tinca, 13. XII. 2014, t=12,5^{0}C;	IV – IX
Phaedon laevigatus Duftschmidt 1825	3 specimens, 27. XII. 2015, Râpa forest, t=12^{0}C; 8 specimens, Tinca 25. XI.-26. XII. 2014; 4. XI. 2016, t=3-11^{0}C; One pair in copula, Tinca, 13. XII. 2014, t=12,5^{0}C	IV – IX
Phyllotreta diademata Foudras 1860	3 F, 1 M, Tinca, 15. XII. 2012, t=11^{0}C;	IV – IX
Psylliodes chrysocephalus Linnaeus 1758	2 F, 4 M, Tinca, 15.-21. XII. 2012, t=3 - 11^{0}C;	IV – IX
Longitarsus minimus Kutchera 1863	1 M, Tinca, 10. XII. 2017, t=2^{0}C	V – IX
Longitarsus minusculus Foudras 1860	2 M, Tinca, 28. XII. 2017, t=13^{0}C; 29 specimens, Tinca, 24. XI.-15. XII. 2012; 20. XI. 2014-28. II. 2015; 23. XI. 2015, t=3,5-13^{0}C; 1 M, Tinca, 11. XI. 2016, t=8,5^{0}C	IV – IX
Chrysolina limbata Linnaeus 1758	One larva specimen, Tinca, 21. XII. 2017, t=8^{0}C	IV – IX
Podagrica malvae Illiger 1807	20 specimens, Tinca, 11. I.-29. I. 2018, t=4-10^{0}C	IV – IX
Altica oleracea Linnaeus 1758	86 specimens, Tinca, 20. X. 2017-24. II. 2018, t=4-21^{0}C; 19 specimens, Tinca, 17. XI. 2014-28. II. 2015; 27. XII. 2015; 22. XI. 2016; 30. I. 2016, t=4-14^{0}C; 6 specimen, Râpa, 28. XI.-7. XII. 2014, t=10-11^{0}C	III – IX
Galeruca rufa Germar 1824	1 F, Tinca, 18. XII. 2017, t=7^{0}C	IV – X
Galeruca tanaceti Linnaeus 1758	1 F, Tinca, 21. XI. 2012, t=3^{0}C;	IV – X
Longitarsus longipennis Kutchera 1863	1 M, Râpa forest, 6. XII. 2014, t=11^{0}C	IV – IX
Longitarsus brisouti Heikertinger 1912	1 M, Tinca, 25. XI. 2015, t=6^{0}C	V – IX
Longitarsus holsaticus Linnaeus 1758	5 specimens, Tinca, 25. XI.-27. XII. 2012, t=6-16^{0}C	IV – IX
Longitarsus pratensis Panzer 1794	2 M, 2 F, Tinca, 24.-25. XII. 2014, t=10^{0}C	IV – IX
Longitarsus brunnaeus Duftschmid 1825	1 M, Râpa forest, 24. XI. 2014, t=7^{0}C; 15 specimens, Tinca, 25. XI. 2014-5. II. 2015, t=5-13^{0}C	IV – IX
Longitarsus ballotae Marsham 1802	2 F, 3 M, Tinca, 9-27. XII. 2015, t=5,5-13^{0}C	IV – IX
Longitarsus aeneicollis Faldermann 1837	19 specimens, Tinca, 23. XI.-27. XII. 2015, t=5,5-16^{0}C; 2M, 1 F, Râpa forest, 27. XII. 2015, t=12^{0}C	IV – IX
Longitarsus fuscoaeneus Redtenbacher 1849	2 M, 2 F, Tinca, 9-27 XII 2015, t=5,5 - 16^{0}C;	IV – IX
Hispa atra Linnaeus 1758	2 M, Tinca, 13-23. XII. 2015, t=13-16^{0}C	IV – IX
Chaetocnema tibialis Illiger 1807	3 M, 27. XII. 2015, Tinca, t=12^{0}C	IV – IX
Chaetocnema clorophana Duftschmidt 1825	2 M, 3 F, Tinca forest, 27. XII. 2015, t=12^{0}C	IV – IX
Sympecma fusca Van der Linden 1823	2 F, 20. X. 2017, Tinca forest, t=17^{0}C;	III – IX
Libellula depressa Linnnaeus 1758	1 F, Tinca, 23. IX. 2018, t=25^{0}C	V –VIII
Gomphus vulgatissimus Linnaeus 1758	1 M, Tinca, 16. X. 2018, t=23^{0}C; 1 F, Tinca, 12. X. 2018, t=25^{0}C;	V –VIII

	1 M, Tinca, 11. X. 2018, t=24⁰C; 1 M, Tinca, 25. IX. 2018, t=24⁰C	
Lasius niger Linnaeus, 1758	1 specimen, Tinca, 25. XI. 2017, t=13⁰C; 1 specimen, Tinca, 26. XII. 2017, t=8⁰C; 1 specimen, Tinca, 11. XII. 2016, t=8,5⁰C	IV – X
Mantis religiosa Linnaeus 1758	6 F, Tinca, 20. XI. 2017, t=6⁰C	IV – X
Vespa germanica Linnaeus 1758	6 specimens, Tinca, 14. XI.-28. XII. 2017, t=5-13⁰C; One specimen, Tinca, 5. XII. 2016, t=3⁰C	III – X
Tetramonium caespitum Linnaeus 1758	2 specimens, Tinca, 15. XII. 2017-12. I. 2018, t=10⁰C 11 specimens, Tinca, 16. II. 2019, t=18⁰C	III – X
Lygaeus equestris Linnaeus 1758	3 specimens, Tinca, 3. II.-17. II. 2018, t=7-8⁰C	III – X
Pentatoma rufipes Linnaeus 1758	5 specimens, Tinca, 20. XI. 2017-4. II. 2018, t=6-18⁰C 1 specimen,Tinca, 15. II. 2019, t=12⁰C	IV – X
Aphrophora alni Fallen 1805	1 specimen, Tinca, 3. II. 2017, t=7⁰C	IV – IX
Pyrrhochorus apterus Linnaeus 1758	15 specimens, Tinca, 22. XI. 2017-3. II. 2018, t=6-13⁰C 26 specimens, Tinca, 1. II. 2019, t=7⁰C	III – X
Palomena praxima Linnaeus 1758	9 specimens, Tinca, 14. XI. 2017-7. I. 2018, t=3-17⁰C	III – X
Lucilia sericata Meigen 1826	8 specimens, Tinca, 7. I.-17. II. 2018, t=8-13⁰C	IV – X
Culex pipiens Linnaeus 1758	32 specimens, Tinca, 20. XI. 2017-3. II. 2018, t=3-13⁰C; One specimen, Tinca, 2. II. 2017, t=7,5⁰C 3 specimens,Tinca, 27. I. 2019, t=1⁰C 6 specimens, Tinca, 1. II. 2019, t=7⁰C	III – X
Calliphora erythrocephala Macquart 1834	53 specimens, Tinca, 30. XI. 2017-24. II. 2018, t=(-5)-17⁰C One specimen,Tinca, 27. I. 2019, t=1⁰C	III – X
Muscina stabulans Fallen 1817	2 specimens, Tinca, 7. I. 2018, t=13⁰C	IV – X
Musca domestica Linnaeus 1758	3 specimens, Tinca, 30. XI. 2017-6. I. 2018, t=7-17⁰C	III –X
Calliphora vomitoria Linnaeus 1758	3 specimens, Tinca, 13. XI. 2016, t=2⁰C; 1 specimen, Tinca, 29. XI. 2016, t= - 5⁰C; 4 specimens, Tinca, 13. XII. 2016, t= - 3⁰C; 3 specimens, Tinca, 27. XII. 2016, t=3⁰C; One pair in copula, Tinca, 26. XI. 2016, t=12⁰C	III – X
Apis mellifera Linnaeus 1758	1 specimen, Tinca, 9. II. 2016, t=15⁰C; 1 specimen, Tinca, 17. II. 2016, t=17⁰C; 3 specimens, Tinca, 3. II. 2017, t=7⁰C; 1 specimen, Tinca, 23. II. 2017, t=11⁰C 1 specimen,Tinca, 3. II. 2019, t=15⁰C	III – X
Melolontha melolontha Linnaeus 1758	1 M, Tinca, 28. III. 2016, t=20⁰C	20. IV – VI.
Anax imperator Leach 1815	1 F, Tinca, 12. XI. 2013, t=12⁰C	VI – IX
Sympetrum flaveolum Linnaeus 1758	1 M, Tinca forest, 6. XII. 2014, t=11⁰C	VII – X
Brachytron hafniense Muller 1764	2 F, Tinca, 7. X. 2015, t=21⁰C	V – VI
Agriotes nitidulus Marsham 1802	1 M, Tinca, 3. II. 2017, t=7⁰C	III – IX
Clytra laeviuscula Ratzeburg 1837	1 M, Gurbediu forest, 14. IV. 2017, t=14⁰C	15. V – VIII
Longitarsus gracilis Kutchera 1864	2 M, 1 F, Tinca forest, 27. XII. 2015, t=12⁰C	IV – IX
Longitarsus parvulus Paykull 1799	1 M, Tinca forest, 27. XII. 2015, t=12⁰C	V – IX
Altica saliceti Weise 1888	1 M, Tinca, 2. II. 2016, t=12⁰C	III – X
Otiorrhinchus ligustici Linnaeus 1758	1 M, Tinca, 6. XII. 2016, t=2⁰C	IV – IX
Colias erate Esper, 1805	1M, Râpa, 9. II. 2019, t=18⁰C	15. V – 7. XI
Chelis m. maculosa Gerning, 1780	2M, Râpa, 4.-5. IV. 2019, t=21⁰C	15. V – 15. VI
Leptidea morsei major Grund, 1907	1M, Tinca, 22. III. 2019, t=15⁰C	25. IV – 7. IX
Hipparchia fagi Scopoli,1763	1F, Tinca spa,13. III. 2019, t=19⁰C	15. VI – 7. IX
Melanargia galathea satnia Linnaeus,1758	1F, Tinca, 4V 2019, t=24⁰C	15. VI – 7. IX

Legend: M – male, F – female, t=temperature, C=Celsius, I – XII – months of year (I-January - XII-December)

During the analysed period, phenological anomalies were recorded in 105 species of insects in the Tinca area. Inside the Insecta class, concerning the number of species collected by orders, the situation is the following: the Lepidoptera order with a total of 44 species (41.90%), followed by the Coleoptera order with 39 species (37.14%), Odonata order with 6 species (5.71%), Heteroptera order with 5 species (4.76%), Hymenoptera order with 3 species (2.85%), Mantodea order with 1 species (0.95%). It is interesting to note the presence of a very rare species at national level: *Parnasius apollo jaraensis* Kert., the species being accidental, even vagrant in the Tinca area.

Precocious appearances in nature were observed in the following species: *Colias erate* Esp., *Chelis maculosa* Ger., *Leptidea morsei major* Gr., *Hipparchia fagi* Scop., *Melanargia galathea* L., *Polypogon tentacularia* L., *Hyles euphorbiae* L., *Pieris rapae* L., *Pieris napi* L., *Colias alfacariensis* Rib., *Gonopteryx rhamni* L., *Zerynthia polyxena* Den., *Lycaena phleas* L., *Vanessa atalanta* L., *Inachis io* L., *Polygonia c-album* L., *Aglais urticae* L., *Erebia medusa* Den., *Hesperia comma* L., *Parnasius apollo jaraensis* Kert., *Iphiclides podalirius* L., *Papilio machaon* L., *Otiorrhynchus fuscipes* Ol., *Anthrenus scrophulariae* L., *Chysolina herbacea* Duft., *Podagrica malvae* L., *Altica oleracea* L., *Longitarsus brunnaeus* Duft., *Lygaeus equestris* L., *Pentatona rufipes* L., *Aphrophora alni* Fall., *Pyrrhochorus apterus* L., *Lucilia sericata* Meig., *Culex pipiens* L., *Calliphora erythrocephala* Marq., *Muscina stabulans* Fall., *Apis mellifera* L., *Melolontha melolontha* L., *Agriotes nitidulus* Marsh., *Clytra laeviscula* Ratz., *Altica saliceti* Wse.

The extension of the activity or flight period was observed for almost all species, additional generations in *Vanessa atalanta* L., *Chrysolina fastuosa* Scop., *Chrysolina herbacea* Duft. Hibernation in another development stage, sometimes simultaneously with the stage known in the scientific literature: *Pieris napi* L., *Papilio machaon* L., *Chrysolina fastuosa* Scop., *Chrysolina herbacea* Duft., *Chrysolina limbata* L., *Hyles euphorbiae* L.

Some species revealed some resistance to heat and drought: *Pieris brassicae* L., *Polyommatus icarus* Rott. Other species were observed in copula during November-December: *Calliophora vomitoria* L., *Culex pipiensis* L., *Longitarsus tabidus* Fabr., *Phaedon laevigatus* Duft., *Podagrica menetriesii* Fald., and some species were observed laying eggs late in autumn: *Galeruca tanaceti* L., *Chrysolina fastuosa* Scop., *Chrysolina herbacea* Duft.

CONCLUSIONS

During nine seasons, 2010 – 2019, phenological anomalies were observed in the Tinca area in 105 species of insects. These anomalies, due to consequences of global warming, recorded in a big number of insect species, represent a premiere at national level.

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Ilie Aurelian Leonardo
«Nicolae Jiga» Theoretical School Tinca, str. Republicii No 36A, Bihor County, Romania.
E-mail: aurelian_ilie@yahoo.fr

Marinescu Mariana
University of Oradea, Didactic Staff Training, Departament (DTS), Str. Universităţii No 1, Romania.
E-mail: marinescum54@yahoo.com

Ilie Lorena Cosma
Gymnasium School no 1 Batăr, Bihor County, Romania.
E-mail: aurelian_ilie@yahoo.fr

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HUMAN IMPACT DROVE IMPORTANT CHANGES TO FOREST ECOSYSTEMS DURING THE LAST FOUR MILLENNIA: CASE STUDIES FROM THE ROMANIAN CARPATHIANS

GRINDEAN Roxana, FEURDEAN Angelica, TANȚĂU Ioan

Abstract. Pollen percentage and statistical data from four peat bogs are used to investigate the impact of past human activities on the composition and diversity of forest ecosystems beginning with the Bronze Age (2200–1200 BC). The studied sites (Avrig, Mohoş, Luci, Tăul Muced) are located at elevations ranging between 440 and 1360 m in the Romanian Carpathians, within distinctive vegetation zones and forest belts. The percentage values in pollen spectra of anthropogenic indicators (cereals and ruderal flora) as well as pollen richness suggest a gradual decline of main forest taxa (*Picea abies*, *Fagus sylvatica*, *Quercus*, *Carpinus betulus*) and increase in pollen diversity over the last four millennia, more evident in the lowlands. From the Medieval Period until recent times, enhanced floristic changes occurred at all sites, which together with the decline in primary forest constituents suggest the degradation of the original forests and the formation of mosaic landscapes. The pollen-based reconstruction of major forest loss over the last decades is also shown by modern satellite imagery.

Keywords: pollen analysis, palynological richness, anthropogenic indicators, elevational gradient, Romanian Carpathians.

Rezumat. Impactul uman a cauzat schimbări importante în ecosistemele forestiere în cursul ultimelor patru milenii: studii de caz din Carpații Românești. Date procentuale și statistice de polen din patru turbării ombrotrofe sunt folosite pentru a investiga impactul activităților umane din trecut asupra compoziției și diversității ecosistemelor forestiere începând cu epoca bronzului (2200–1200 BC). Siturile studiate (Avrig, Mohoş, Luci, Tăul Muced) sunt localizate la diferete altitudini cuprinse între 440 și 1360 m din Carpații Românești, în zone și etaje de vegetație caracteristice. Valorile procentuale din spectrele polinice ale indicatorilor antropici (cereale si floră ruderală) dar și diversitate polinică sugerează un declin treptat al principalilor taxoni lemnoși (*Picea abies*, *Fagus sylvatica*, *Quercus*, *Carpinus betulus*) și o creștere a diversității palinologice, mai evidente în zonele joase. Din perioada medievală până în prezent s-a remarcat începutul unor schimbări floristice semnificative în toate siturile, care împreună cu declinul constituenților primari din pădure sugerează degradarea pădurilor inițiale și formarea peisajelor mozaicate. Reconstituirea defrișărilor masive din ultimele decenii este ilustrată de asemenea de imaginile satelitare moderne.

Cuvinte cheie: analiză palinologică, diversitate palinologică, indicatori antropici, gradient altitudinal, Carpații Românești.

INTRODUCTION

Natural environments were transformed into anthropogenic landscapes by the long-term action of humans who have selected and exploited cultivated and wild plants for thousands of years (e.g., BEHRE, 1981; BIRKS et al., 1988; FAEGRI & IVERSEN, 1989; MARINOVA et al., 2012; MERCURI et al., 2013). The identification of the human impact on vegetation is largely based on the use of palynology, which attempts to identify the presence and development of human activities, phases of intensification and abandonment from fossil pollen spectra. The pollen types that are directly associated with human activities (anthropogenic pollen indicators) are usually grouped into primary indicators (cereals and arable weeds) and secondary indicators (ruderals and pastureland flora) (BEHRE, 1981; REILLE, 1999; BRUN, 2009). Furthermore, the heterogeneous and semi-open landscapes with origins often related to human activities have shown a higher floristic diversity than forested landscapes (FEURDEAN et al., 2013).

Changes in the composition and distribution of forested versus open landscapes in Romania are known to have occurred under direct or indirect human actions, particularly since the mid-Holocene (FEURDEAN & TANȚĂU, 2017). The first signs of crop cultivation were recorded from the early Neolithic (ca. 5500 BC) with human impact effects intensifying over millennia and especially during the last centuries (FĂRCAȘ et al., 2003, 2013; FEURDEAN et al., 2009, 2015; GEANTĂ et al., 2014; GRINDEAN et al., 2015, 2019; MAGYARI ET AL., 2009; TANȚĂU et al., 2003, 2006, 2014a).

This study focuses on the impact of humans on forest ecosystem composition, dynamics and diversity over the last 4000 years as depicted in fossil pollen spectra and statistical determination of palynological richness from four peat bogs from Romania (Fig. 1). These ombrotrophic wetlands are located within different vegetation zones and forest belts so there is the possibility to assess and compare the variability of vegetation response to anthropogenic disturbance over time at different elevations (Table 1).

The Avrig peat bog is part of a larger complex of peat bogs on an old terrace of the Olt River, in the southern part of the Transylvanian Depression (Fig. 1). It is located within the mixed oak-hornbeam forests (*Carpinus betulus*, *Quercus robur*, *Q. petraea* and partly *Fagus sylvatica*) vegetation zone. The current surrounding landscape is represented by intensely grazed meadows.

The Mohoş peat bog from the Ciomadul massif (Eastern Carpathians) is partly covered by *Pinus sylvestris* and *Betula pubescens* (Fig. 1). The mire is situated at the transition of the *Fagus sylvatica*-dominated and the mixed conifer-*Fagus sylvatica* vegetation belts. Current main protective management measures for this biodiversity-rich area include the interdiction of deforestation, pastoral activities and artificial draining channels. The Luci peat bog is located in the Harghita Mountains (Eastern Carpathians) (Fig. 1) and is the largest of its kind in Transylvania. The mire is covered with *Pinus sylvestris* and surrounded by dense *Picea abies* forests. The challenging road and thick vegetation have provided protection for the local biodiversity to some extent.

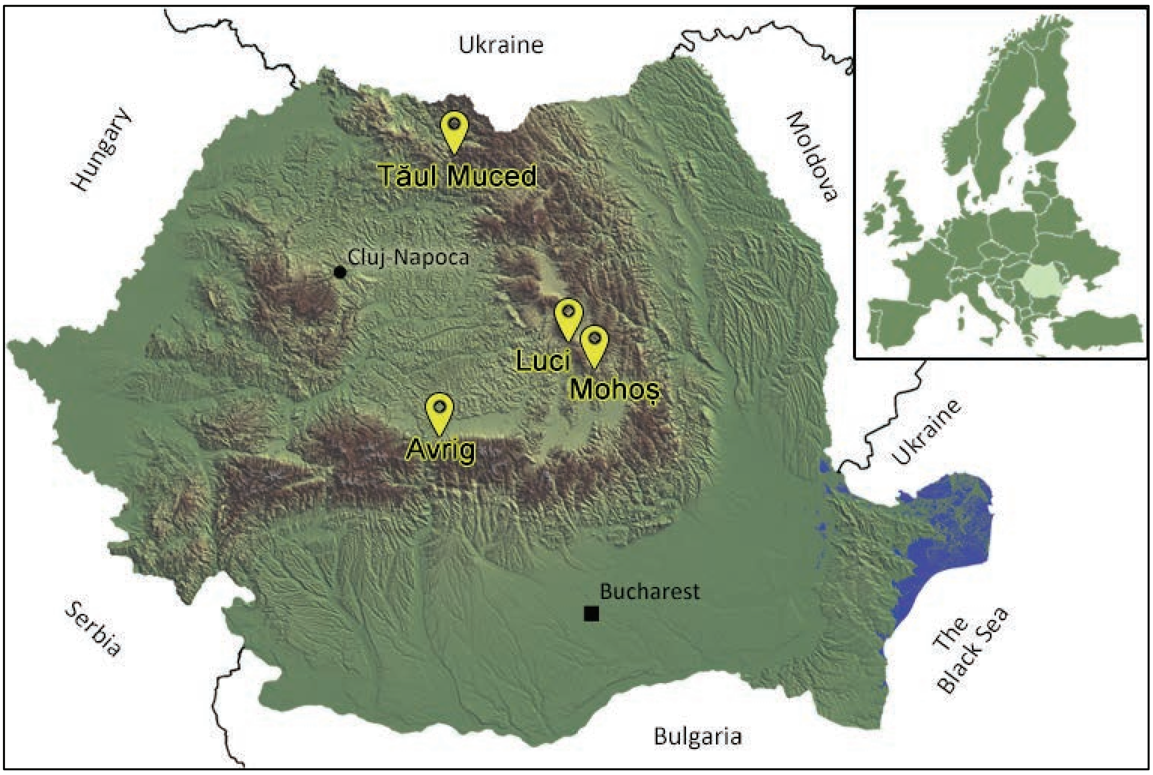

Figure 1. Location map of the studied sites from the Romanian Carpathians (original).

Table 1. Characteristics of the study sites.

Site/ Location	Type of basin	Basin area (ha)	Elevation (m)	Modern local vegetation	References
Avrig 45°43'N, 24°23'E	Peat bog	10	440	*Sphagnum* and Cyperaceae peat bog, surrounded by grazed meadows with patchy forests dominated by *Quercus petraea*	TANȚĂU et al., 2006
Mohoș 46°08'N, 25°54'E	Peat bog	80	1050	*Sphagnum* peat bog partly covered with *Pinus sylvestris* and *Betula pubescens*, with *Alnus glutinosa*, *Picea abies* and *Betula pendula* at the periphery	TANȚĂU et al., 2003
Luci 46°17'N, 25°44'E	Peat bog	120	1080	*Sphagnum* peat bog covered by *Pinus sylvestris* and surrounded by *Picea abies* forests	TANȚĂU et al., 2014a
Tăul Muced 47°34'N, 24°32'E	Peat bog	2	1360	*Sphagnum* peat bog surrounded by *Picea abies* forests	GRINDEAN et al., 2019

The Tăul Muced peat bog is located in the Rodna Mountains (Fig. 1) and surrounded by forests dominated by *Picea abies*. Despite being part of a protected area (Rodna National Park and Biosphere Reserve), the current landscape is exposed to ongoing deforestation.

MATERIALS AND METHODS

For a detailed description of the chronology and vegetation history from each sequence, please see the references mentioned in Table 1.

The groups of plants included in the present study are listed in Table 2. The main types were grouped following a protocol for assigning pollen taxa to functional types of plants (FEURDEAN et al., 2015). The selection and grouping of anthropogenic indicators (crops and ruderals) followed BEHRE (1986), BRUN (2009) and FEURDEAN et al. (2013).

Palynological richness was used to examine changes in vegetation diversity through time at the landscape scale. Recent detailed studies demonstrate that pollen-assemblage richness depicts a reliable representation of floristic richness, as well as a function of landscape structure, openness and diversity (BIRKS et al., 2016, and references therein). Pollen richness was determined by applying the rarefaction analysis (BIRKS & LINE, 1992) to the pollen proportions of all terrestrial taxa using the Psimpoll software (BENNETT, 2009). The lowest pollen count from each studied sequence (T110, T245, T170 and T328) was used to standardize the size of pollen counts.

Table 2. Groups of main pollen types included in this study: (a) pollen types included in the main terrestrial pollen sum; (b) herbaceous pollen types included in human impact indicators.

(a)	**Main land cover type**	**Pollen types**
	Conifers	*Pinus*, *Picea abies*, *Abies alba*, *Larix*, *Taxus*, *Juniperus*
	Cold deciduous trees	*Alnus*, *Betula*, *Salix*, *Populus*, *Vaccinium*
	Temperate deciduous trees and shrubs	*Ulmus*, *Quercus*, *Tilia*, *Corylus avellana*, *Acer*, *Fraxinus*, *Carpinus betulus*, *Fagus sylvatica*, *Hedera*, *Sambucus*, *Viscum*, *Viburnum*, *Juglans*, *Castanea*, *Vitis*
	Grassland and pastures	Poaceae, *Artemisia*, Chenopodiaceae, *Plantago lanceolata*, other NAP

(b)	**Main land use categories**	**Herbaceous pollen types**
	Crops	Cerealia (*Triticum*, *Zea mays*), *Secale cereale*, *Cannabis sativa*
	Ruderals	*Artemisia*, Chenopodiaceae, Brassicaceae, *Echium*, *Plantago lanceolata*, *P. major*, *Rumex*, *Urtica*, *Centaurea cyanus Verbascum*, *Mercurialis*, *Anchusa*, *Linaria*, *Melampyrum*, *Polygonum aviculare*

RESULTS

In all our sequences, palynological richness increased moderately from the oldest part towards the present, with generally low values between 2000 BC and 500 AD, moderate values between 500 and 1500 AD and high pollen diversity between 1500 AD and present (Figs. 2; 3). The highest values were recorded at Tăul Muced during the approximately last two millennia. Human impact was mainly derived from percentages of pollen associated with anthropogenic agro-pastoral activities (Fig. 3). Main changes in pollen diversity correspond to notable changes in vegetation composition and human impact along an elevational gradient (Fig. 2).

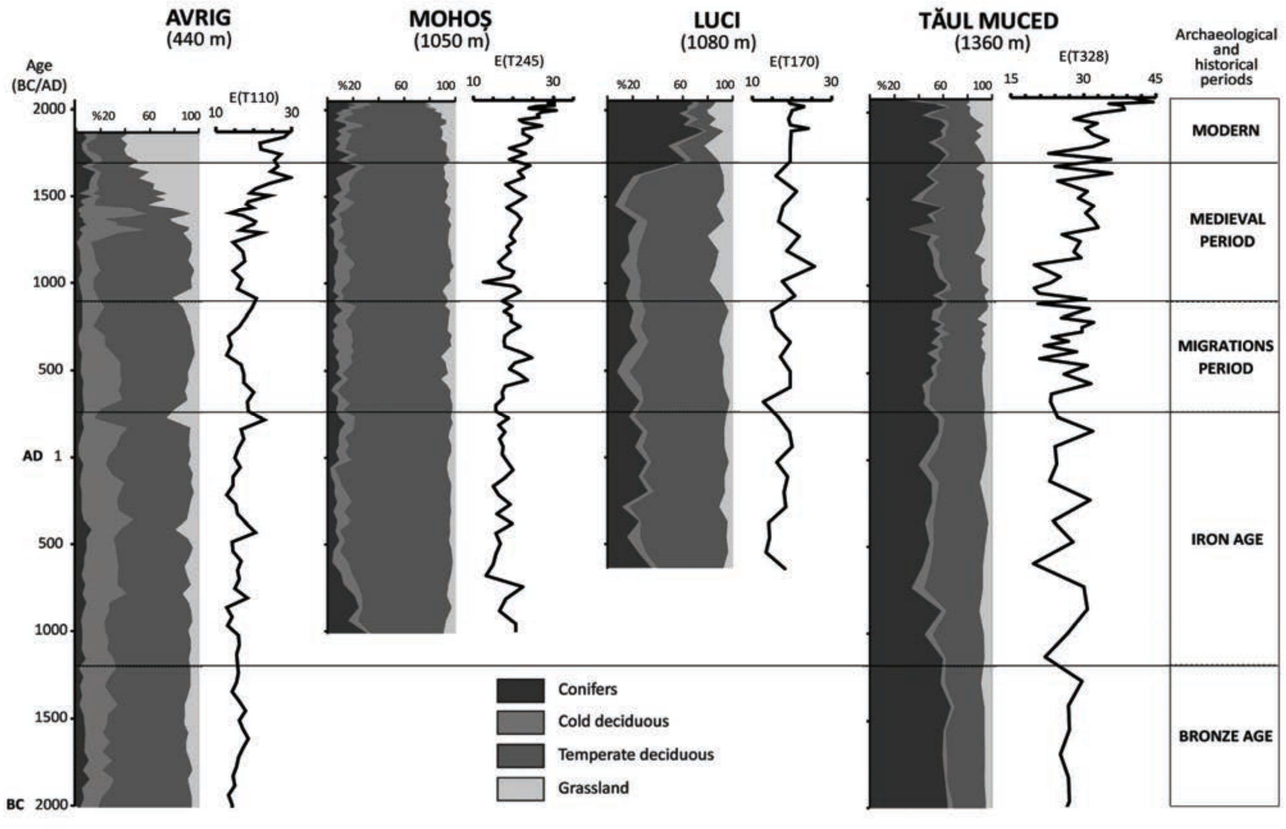

Figure 2. Summary percentage diagrams of vegetation changes since 2000 BC. See Table 2(a) for vegetation groups. Black curves represent palynological richness.

During both the Bronze (2200–1200 BC) and Iron Age (1200 BC–271 AD), all our sequences had relatively low values of pollen richness (Fig. 3). In the lowlands (Avrig), the vegetation was characterized by dense forests (AP>80%) of *Quercus* and *Fagus sylvatica*, with increasing presence of cereals and decreasing *Carpinus betulus* proportions during the Iron Age (TANŢĂU et al., 2006). At mid and high elevations (Mohoş, Luci and Tăul Muced), the Bronze/Iron Age transition was marked by the rise and dominance of *Fagus sylvatica* and *Picea abies*, mostly to the detriment of *Carpinus betulus*. Scattered occurrences of cereals were recorded between 1200 BC and 271 AD (TANŢĂU et al., 2003, 2014a; GRINDEAN et al., 2019).

The palynological richness during the Migrations Period (271–900 AD) was low to moderate in the low- and midlands (Avrig and Mohoş), and low at mid (Luci) and high elevations (Tăul Muced) (Fig. 3). Pollen percentages indicate an overall forested landscape dominated by *Fagus sylvatica* admixed with *Picea abies* in the montane environments (TANȚĂU et al., 2003, 2014a; GRINDEAN et al., 2019). In other cases (Avrig, Mohoș and Luci), higher proportions of cold deciduous taxa (*Alnus*) were also observed. Increasing occurrences of ruderal species as well as pastureland herbaceous taxa can be observed in all sequences (Fig. 3).

Starting with the Medieval Period (900–1700 AD), pollen diversity had increased, particularly in the lowlands (Fig. 3). The AP percentage values from the Avrig sequence gradually declined in favor of open-land taxa (cereals, ruderals and grasslands), with *Carpinus betulus* as the most affected tree species (TANȚĂU et al., 2006). At elevations above 1000 m, the AP decline was not as visible, although the proportions of open-land taxa slightly and gradually increase (Fig. 3).

The highest values of palynological richness in all sequences were recorded over the last three centuries (Fig. 3). Pollen percentages reveal a sharp decline of tree taxa (AP) and overall expansion of land openness (settlements and agricultural land) (Fig. 2).

DISCUSSIONS

Depending on the intensity of the anthropic impact, pollen records and palynological richness analyses from the four sequences indicate three distinct periods in the past vegetation dynamics: i) with negligible impact during the Bronze Age (2200–1200 BC) and Iron Age (1200 BC–271 AD); ii) with low to moderate effects during the Migrations Period (271–900 AD); and iii) with moderate to high impact from the Medieval Period (900–1700 AD) to the present (Fig. 3).

Low anthropogenic impact during the Bronze Age and Iron Age (2200 BC–271 AD)

The low values of pollen richness and irregular percentages of anthropogenic human indicators corresponded to a time period when the regional landscape was dominated by dense deciduous forests (*Quercus* and *Fagus sylvatica*) in the lowlands, and mixed forests (*Picea abies* and *Fagus sylvatica*) above 1000 m (TANȚĂU et al., 2003, 2006, 2014a; GRINDEAN et al., 2019) (Figs. 2; 3). The regional expansion of *F. sylvatica* and the corresponding decline of *Carpinus betulus* at the beginning of the Iron Age was associated with moist climate conditions and low disturbance by fire and human impact in many sequences of the Romanian Carpathians (e.g., DIACONU et al., 2017; FEURDEAN et al., 2009, 2016, 2017; PANAIT et al., 2017; TANȚĂU et al., 2011, 2014b). Archaeological research suggests that the Bronze Age and Iron Age periods were characterized by extensive deforestation phases associated with the construction of large fortified settlements, as well as the development of a primitive rotational crop agriculture and, eventually, the iron ploughshare (URSULESCU & ZUGRAVU, 2014). Thus, human impact may have had a larger role in the retreat of *Carpinus betulus* and the rise of *Fagus sylvatica* than what pollen percentages suggest in our study areas. Hornbeam usually grows at lower elevations (100–450 m), where it prefers organically rich soils, and it has hard and strong wood, particularly excellent for fuel wood and charcoal (PRACIAK et al., 2013). These characteristics would have made *Carpinus betulus*-dominated forests prone to partial devastation during periods of intense settlement of a growing population (Bronze/Iron Age transition), due to the productivity of the occupied habitats. The later regular occurrences of cereals during the Iron Age support the presence of progressing agricultural practices (Fig. 3).

Low to moderate anthropogenic impact during the Migrations Period (271–900 AD)

Palynological richness was estimated as moderate for Avrig and Mohoș and low for Luci and Tăul Muced (Fig. 3). *Fagus sylvatica* remained the dominant tree species, admixed with *Picea abies* above 1000 m, and with *Quercus* and *Carpinus betulus* in the lowlands (TANȚĂU et al., 2003, 2006, 2014a; GRINDEAN et al., 2019). A slight decline of the forested landscape is visible in all sequences and corresponds to an increase in the proportions of cold, early successional deciduous taxa (*Alnus* and *Betula*) especially during the first half of the period (Figs. 2; 3). This had a stronger effect around Avrig and Mohoș where pollen richness increased with these changes in vegetation. Another important shift in the vegetation composition and pollen richness was marked by the concomitant expansion of ruderal and grassland taxa noticeable in all sequences (Figs. 2; 3). These changes in vegetation could have been directly related to socio-economical changes during the Migrations Period. The migratory movements are believed to have been triggered by climate conditions on one hand, and the need for new pasturelands and settlement areas following a growing population and agricultural land (arable and pastures) degradation (CARPENTIER & FRANÇOIS, 2006). Thus, the lower abundance of cultivated plants (crops) and increase of ruderals and open land (pasture) species recorded in our sequences could be associated with the re-organization of rural settlements following the establishment and/or assimilation of migratory populations. Moreover, higher disturbances by fires during the last half of the period would have likely been promoted by human activities rather than climate conditions (cool and wet) (FEURDEAN et al., 2017), which was probably used for creating and/or expanding agricultural land.

Moderate to high anthropogenic impact from the Medieval Period (900-1700 AD) to the present days

Pollen richness values increased from moderate to high for most of the studied sequences during the Medieval Period, particularly in the lowlands (Fig. 3). The pollen percentages depict a gradual decrease of the main forest taxa (*Fagus sylvatica* and *Picea abies*) associated with an increase of cold deciduous taxa (*Betula* and *Alnus*) especially at the onset of an open landscape (AP<80%). These changes are less visible in the forests at higher elevations (above 1000 m), while in the lowlands *Carpinus betulus* declined rapidly (TANȚĂU et al., 2003, 2006, 2014a; GRINDEAN et al., 2019; Fig. 2). However, a common characteristic feature throughout the studied areas is the noticeable increased proportions of herbaceous anthropogenic indicators (crops and ruderals) (Fig. 3).

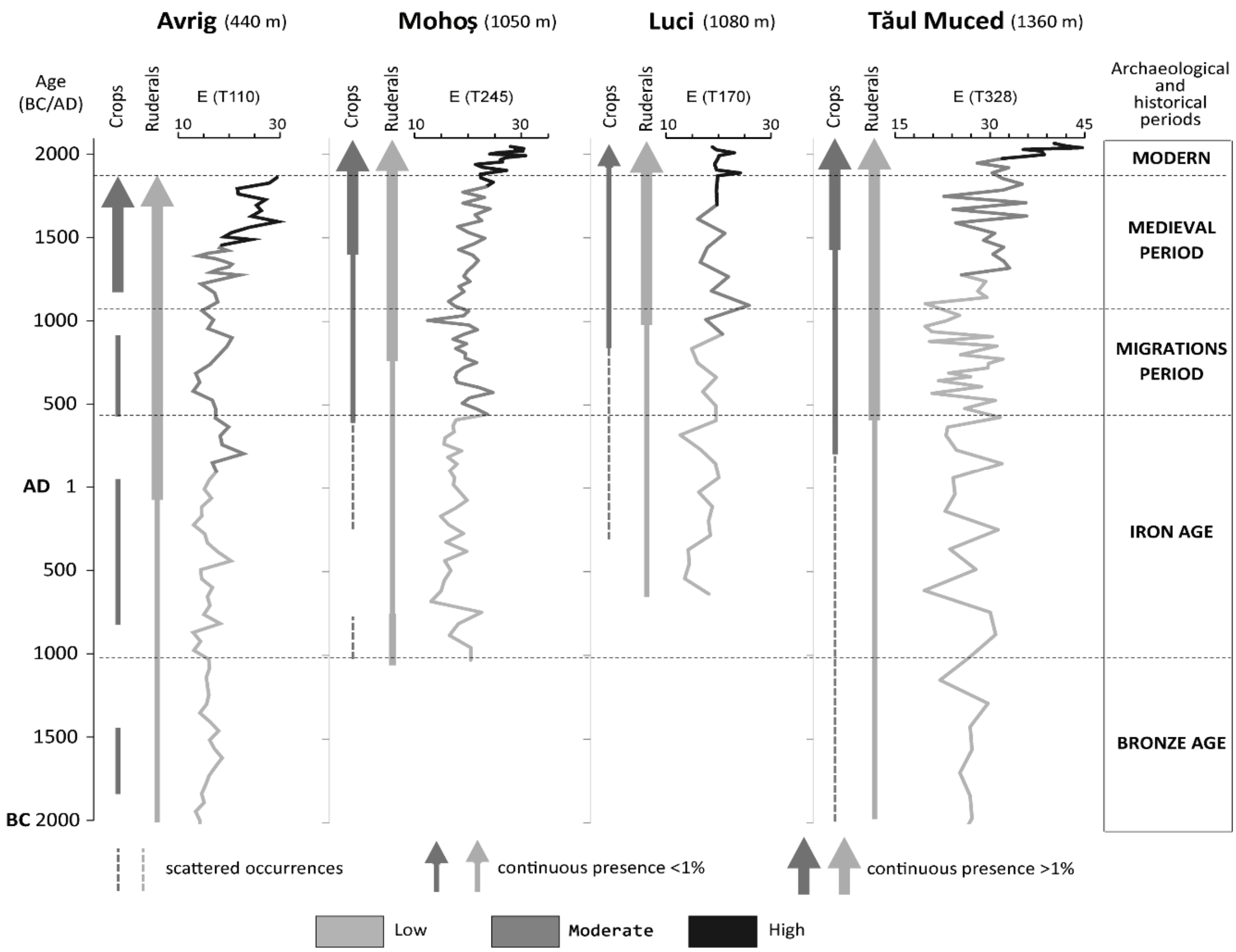

Figure 3. Schematic representation of the occurrence of crops and ruderal anthropogenic human indicators and values of palynological richness (grey gradient) at each site. See Table 2(b) for vegetation groups.

The Medieval Period was characterized by extensive deforestation and agricultural practices as the main economy followed a demographic rise. Trees were mainly used for firewood and large quantities were also used in the mining industry (WILLIAMS, 2003; KAPLAN et al., 2009). The fallow land maintained for agricultural purposes, as well as abandoned terrain, were probably the media for increasing floristic richness during this period. Recent studies have emphasized the importance of mosaic landscapes (semi-open sites) over forested sites, as a driver of greater palynological diversity (CIOCÂRLAN, 2000; FEURDEAN et al., 2013). Forest clearance, expansion of cropland and tree plantations over the past 300 years have led to a severe change in the autochthonous woody species and grasses across the Romanian Carpathians. These changes were intensified during more recent decades due to increased human pressure, which, if not approached by future forestry policy and conservation measures, could lead to significant losses in Romania's remaining old-growth forests.

Furthermore, recent studies focused on the deforestation process throughout the Romanian Carpathians based on state-of-the-art satellite imagery technology, having issued similar concerns regarding the rapid changes on the forest cover under the recent increased anthropogenic activities (Global Forest Watch, 2016; KNORN et al., 2012; KUCSICSA & DUMITRICĂ, 2019; MURARIU et al., 2017; PETRIŞOR, 2015; PINTILII et al., 2017).

CONCLUSIONS

Starting with the late Bronze Age a continuous and abundant presence of ruderal and crop plant species occurred, which gradually increased thereafter and expanded rapidly at the onset of the Medieval Period. Human impact on the vegetation was earlier and stronger in the lowlands than at high elevations. However, the continuous occurrence of secondary anthropogenic pollen indicators (ruderals) at pollen sites from mountainous areas indicates the increasing use of these habitats for seasonal pastoral activities. The ongoing rise in the abundance of pollen types associated to human impact starting with the late Iron Age was paralleled by a gradual decrease in forest cover mainly involving dominant tree taxa.

From the Medieval Period onwards, heavily exploited ecosystems have led to irreversible changes following the decline of main forest taxa (*Fagus sylvatica*, *Picea abies*, *Quercus*, *Carpinus betulus*), the increase of secondary forest taxa (*Pinus*, *Betula* and *Alnus*) and herbaceous anthropogenic pollen indicators. Thus, the composition and proportion of contemporary forests of the Romanian Carpathians are different from the original forests. Our results are further supported by the satellite imagery of recent forests changes in the Romanian Carpathians in that ongoing deforestation is markedly affecting the vestigial forests, particularly those from within protected areas.

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Grindean Roxana, Feurdean Angelica, Tanțău Ioan
Babeș-Bolyai University, Faculty of Biology and Geology 1 Kogălniceanu Street, Cluj-Napoca, RO-400084, Romania.
E-mails: roxana.grindean@ubbonline.ubbcluj.ro; angelica.feurdean@gmail.com; ioan.tantau@ubbcluj.ro

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EVALUATION OF SOME PHYSIOLOGICAL FACTORS OF SPONTANEOUS AND CULTIVATED PLANTS FROM SOUTH-WEST OF OLTENIA (I)

GAVRILESCU Elena, CIOBOIU Olivia, NĂSTASE Adrian, MĂRĂCINEANU Liviu Cristian

Abstract. The study was carried out in the Calafat and Maglavit localities between the 2017-2018 period, on 38 spontaneous and cultivated species, characteristic of the zonal soils (protisols, cernisols and hydrosoles class) in the Danube meadow. Due to the biotope, plants use a series of adaptive strategies to respond to different types of abiotic stress (drought, salinity, radiation, high or low temperatures, floods) and biotic stress (pathogens, competition with other organisms) that alter the plant-environment equilibrium. In this context, two physiological processes, namely the Chlorophyll content index (CCI) and AVG, the average of mean chlorophyll concentration were determined. Variations of these processes were also found in the intensity of photosynthesis in *Sambucus ebulus, Rumexs anguineus, Solanum nigrum, Thuja occidentalis, Mirabilis jalapa* (between 100 – 607 CCI), heat-tolerant plants with significant photosynthetically active radiation.

Keywords: plants, Chlorophyll content index - CCI, AVG, Oltenia.

Rezumat. Evaluarea unor factori fiziologici la plante spontane și de cultură din sud-vestul Olteniei (I). Studiul a fost realizat în perioada 2017-2018, în localitățile Calafat și Maglavit, pe 38 de specii spontane și cultivate, caracteristice solurilor zonale (clasa protisolurilor, cernisolurilor și hidrosolurilor) din Lunca Dunării. Datorită biotopului, plantele recurg la o serie de strategii adaptative privind răspunsul la diferitele tipuri de stres abiotic (secetă, salinitate, radiație, temperaturi înalte sau scăzute, inundație) și biotic (patogeni, competiția cu alte organisme), care modifică echilibrul plantă-mediu. În acest context au fost determinate două procese fiziologice și anume conținutul indexului clorofilian (CCI) Chlorophyll content index si AVG-ul, media mediei clorofiliene. S-au constatat variatii ale acestor procese regăsite și în intensitatea fotosintezei la *Sambucus ebulus, Rumexs anguineus, Solanum nigrum, Thuja occidentalis*, *Mirabilis jalapa* (între 100 – 607 CCI), plante rezistente la temperaturi ridicate și cu o radiație fotosintetic-activă semnificativă.

Cuvinte cheie: plante, indexul clorofilian - CCI, AVG, Oltenia.

INTRODUCTION

Plants are exposed throughout their life to numerous stress factors that cause changes in the normal physiological functioning of all species, especially of the cultivated ones (BEINŞAN et al., 2009). The terrestrial ecosystems situated in the south-west of Oltenia between the localities of Maglavit and Calafat are characterized by a flora specific to the Danube meadow.

From a phytogeographical and geobotanical point of view, the study area is included in the Central European Region, the Moesian Province (Banat-Oltenia), in the south-western silvo-steppe of the Romanian Plain (DRUGESCU, 1994; CIOBOIU C., 2005). Sedimentary formations, alluviums, accumulations of sands are present in this area, being given by particular characters, gleization, pseudogleization, salinization or alkalization, the appearance and degree of carbonates, which provide favourable conditions for the growth of spontaneous and cultivated plants (NĂSTASE & NĂSTASE, 2002).

The temperate-continental climate, with average annual temperatures around 11.7^{0}C, with relatively low rainfall (480 mm/year), influence the Danube's silvo-steppe vegetation, represented by oak forests, steppe meadows formed of xerophilous plants and xeromezophiles (*Euphorbia agraria, Tribulus terrestris, Verbascum blattaria, Elymus repens, Plantago scabra*) (MARINICĂ & MARINICĂ, 2016; VLĂDUŢ et al., 2017).

Fragments of natural vegetation are rarely found in the study area due to the active manmade intervention and domestic animals (especially sheep) through grazing. Many surfaces of sandy lands have been cultivated (NĂSTASE, 2004).

MATERIAL AND METHOD

Observations were made during the 2017-2018 period in order to determine some physiological processes in spontaneous and cultivated plants from the terrestrial ecosystems in the Maglavit - Calafat area, Dolj county (Fig. 1). The main characteristics of soils were determined pedologically and agrochemically using the analytical methods in force. Chlorophyll content index and the AVG were measured using CM 1000 TM, which estimates the concetration of chlorophyll in leaves between 700-840 nm wavelength. It detects the change of chlorophyll content in the real-time growth process (ROJANSCHI et al., 1992; BERCA, 2000, ŞUMĂLAN & DOBREI, 2002; BURESCU & TOMA, 2005; BUCUR, 2009; HUSSAIN et al., 2010).

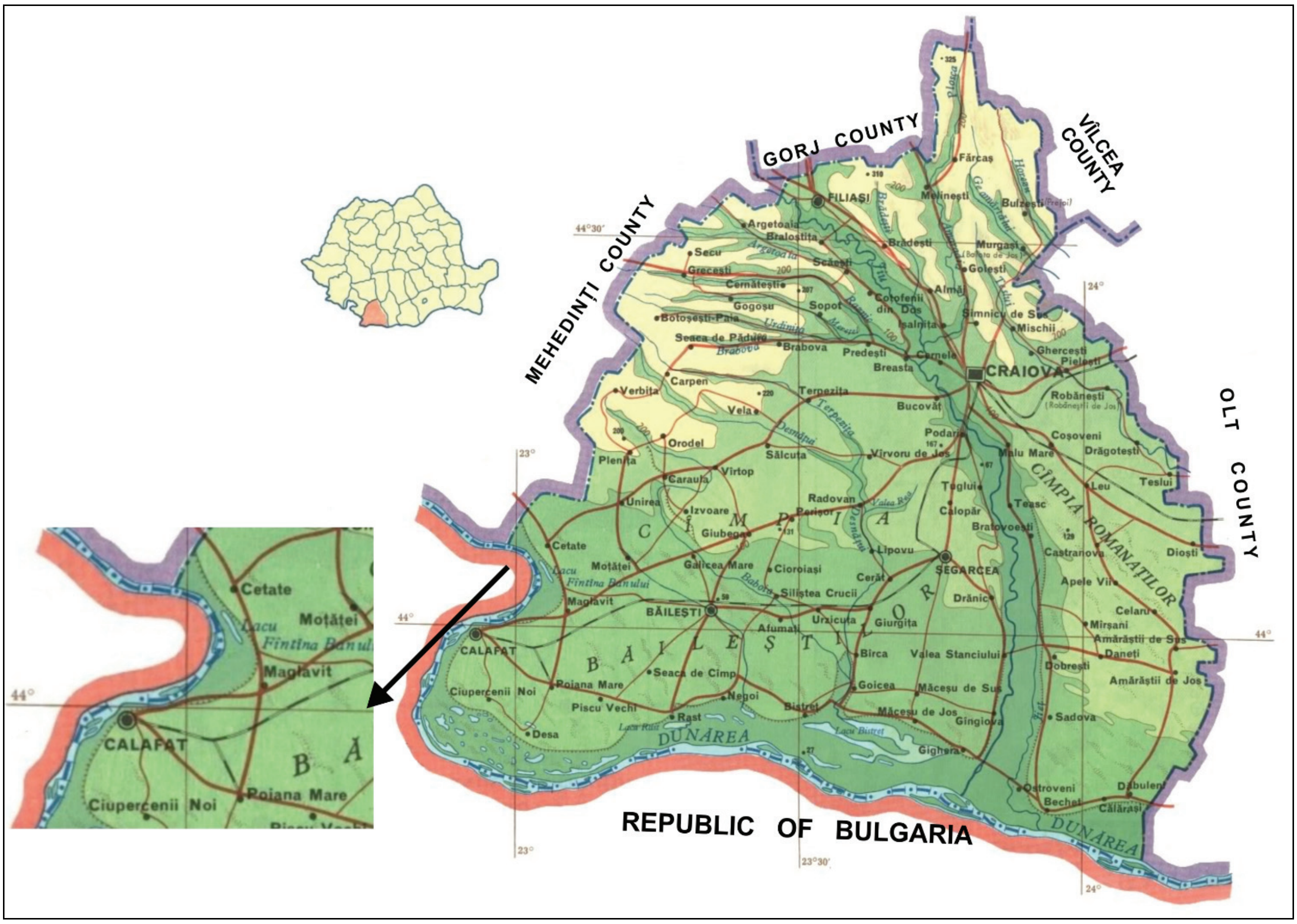


Figure 1. The localization of the study area in the south-west of Oltenia (Google Earth, accessed: March 5, 2019).

RESULTS AND DISCUSSIONS

The soils in the Maglavit - Calafat sector are characterized by sandy levigated chernozems, non-consolidated lands. There is a mosaic of soils on the lower terrace of the Danube meadow represented by sandy levigated chernozems and sands in different stages of solidification, alluvial solonetz soils, gleizated chernozems and even marshy soils (NĂSTASE, 2004; GAVRILESCU, 2013).

Because of the varied pedoclimatic conditions, the flora of Oltenia includes over 2200 species of superior plants out of the 3868 species existing in Romania (CIOCÂRLAN, 2000). More than 750 species of vascular plants have been identified in the south-west of Oltenia, growing on the zonal soils in the Danube Meadow (NĂSTASE, 2004). Key factors in the evolution of the soils in the area are: the relief, rock solification, the depth of the ground water, the climate and microclimate. A great role in the formation and evolution of soils in this territory was played by the Danube. The dominant zonal soil in Calafat is cambic chernozem (CZ cb-K3-d5-LL42/UG(21)-Te-m/NB-A) which has a normal low modular aspect with level oscillations between 10-20 cm. The chemical characteristics are the pH between 6.4-7.6 upH, humus of 2.1%, total nitrogen of 0.120%, mobile phosphorus of 98 ppm, mobile potassium of 143 ppm and nitrogen index of 1.9.

As the soil reaction is poorly acidic, the total nitrogen content is low, the content in mobile phosphorus is very high, the mobile potassium content is moderate, the nitrogen index is low, the humus content is low.

The zonal soil prevailing in Maglavit is also cambic chernozem (CZ cb-G1-K3-d5-LL (42) / SG (31) -Te-m / NB-A) which has a normal low modular aspect with oscillation of level between 10-20 cm. The chemical characteristics are the pH between 6.3-8.2 upH, humus of 2.2%, total nitrogen of 0.121%, mobile phosphorus of 64 ppm, mobile potassium of 198 ppm, and nitrogen index of 1.9.

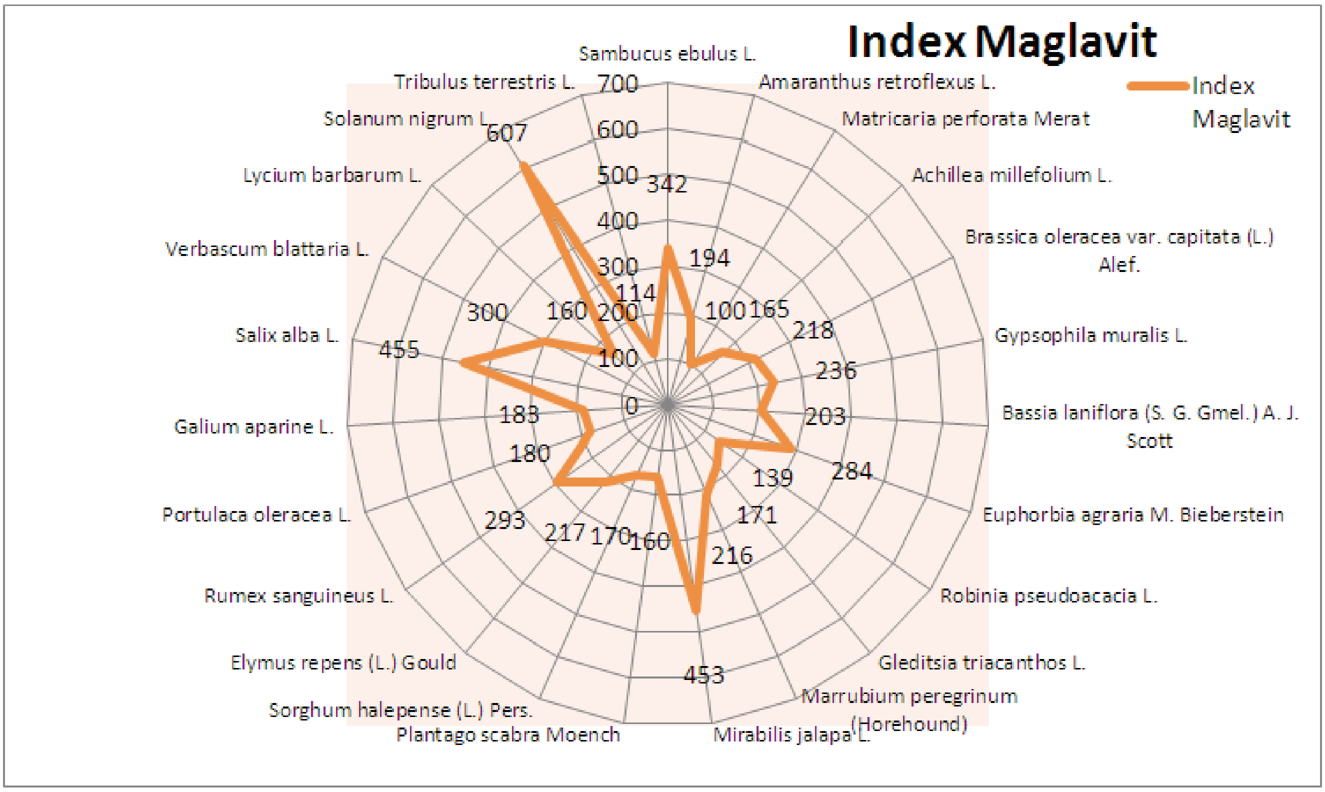
We note that in this area, the soil's reaction is poorly acidic - slightly alkaline, the total nitrogen content is low, the content of mobile phosphorus is very high, the mobile potassium content is moderate, the nitrogen index is low, the humus content is low.

In the study area, the influence of some physiological factors was evaluated on 38 spontaneous and cultivated species belonging to 30 families, characteristic of sandy soils in the Danube Meadow (Table 1).

Table 1. The taxonomic composition of the studied species from the Maglavit - Calafat sector.

Family	**Species**	**Maglavit**	**Calafat**
Cupressaceae	*Thuja orientalis* L.		_
	Thuja occidentalis L.		_
Berberidaceae	*Mahonia aquifolium* L.		_
Moraceae	*Ficus elastica* Roxb. ex Hornem.		_
Cannabaceae	*Celtis occidentalis* L.		_
Betulaceae	*Carpinus betulus* L.		_
Nyctaginaceae	*Mirabilis jalapa* L.	_	
Portulacaceae	*Portulaca oleracea* L.	_	
Caryophyllaceae	*Gypsophila muralis* L.	_	
Amaranthaceae	*Amaranthusretroflexus* L.	_	
Chenopodiaceae	*Bassia laniflora* (S. G. Gmel.) A. J. Scott	_	
Polygonaceae	*Rumex sanguineus* L	_	
Rosaceae	*Chaenomeles japonica* (Thunb.) Lindl. ex Spach		_
Fabaceae	*Cercis siliquastrum* L.		_
	Robinia pseudoacacia L.	_	
	Gleditsia triacanthos L.	_	
Hydrangeaceae	*Philadelphus coronarius* L.		_
Buxaceae	*Buxus sempervirens* L.		_
Euphorbiaceae	*Euphorbia agraria* M. Bieberstein	_	
Vitaceae	*Parthenocissus quinquefolia* (L.) Planch.		_
Zygophyllaceae	*Tribulus terrestris* L.	_	
Araliaceae	*Hedera helix* L.		_
Salicaceae	*Salix alba* L.	_	
Oleaceae	*Syringa vulgaris* Aiden C. Elharrar		_
Onagraceae	*Oenothera glazioviana*Micheli		_
Solanaceae	*Lycium barbarum* L.	_	
	Solanum nigrum L.	_	
Lamiaceae	*Marrubium peregrinum* (Horehound)	_	
Plantaginaceae	*Plantago lanceolata* L.		_
	*Plantago scabra*Moench	_	
Scrophulariaceae	*Verbascum blattaria* L.	_	
Rubiaceae	*Galium aparine* L.	_	
Adoxaceae	*Sambucus ebulus* L	_	
Asteraceae	*Matricaria perforata*Merat	_	
	Achillea millefolium L.	_	
	Sonchus oleraceus L. not Wall.		_
Poaceae	*Sorghum halepense* (L.) Pers.	_	
	Elymusrepens (L.) Gould	_	

Out of the 36 species identified in the terrestrial ecosystems in the Maglavit area, 8 species have a CCI ranging from 100 - *Gypsophila muralis* to 139 - *Euphorbia agraria*, species characteristic for the flora of sands; 18 species have a CCI ranging between 171 - *Gleditsia triacanthos* and 300 - *Verbascum blattaria* and the others between 400 - *Solanum nigrum* and 800 - *Tribulus terrestris*, species characteristic of sand dunes. Concerning the AVG (the average of mean of the chlorophyll index), significant values are found in all 36 species, with the highest values recorded by *Bassia laniflora* - 346, *Euphorbia agraria* - 363, *Marrubium peregrinum* - 451, *Salix alba* - 469, *Solanum nigrum* - 513, *Sambucus ebulus* - 800 (Fig. 2). Most species respond actively to dry conditions and temperature variations (over 40^0C during summer and - 20^0C during winter), specific to the Oltenia Plain (MARTA et al., 2011; ILIE et al., 2018).



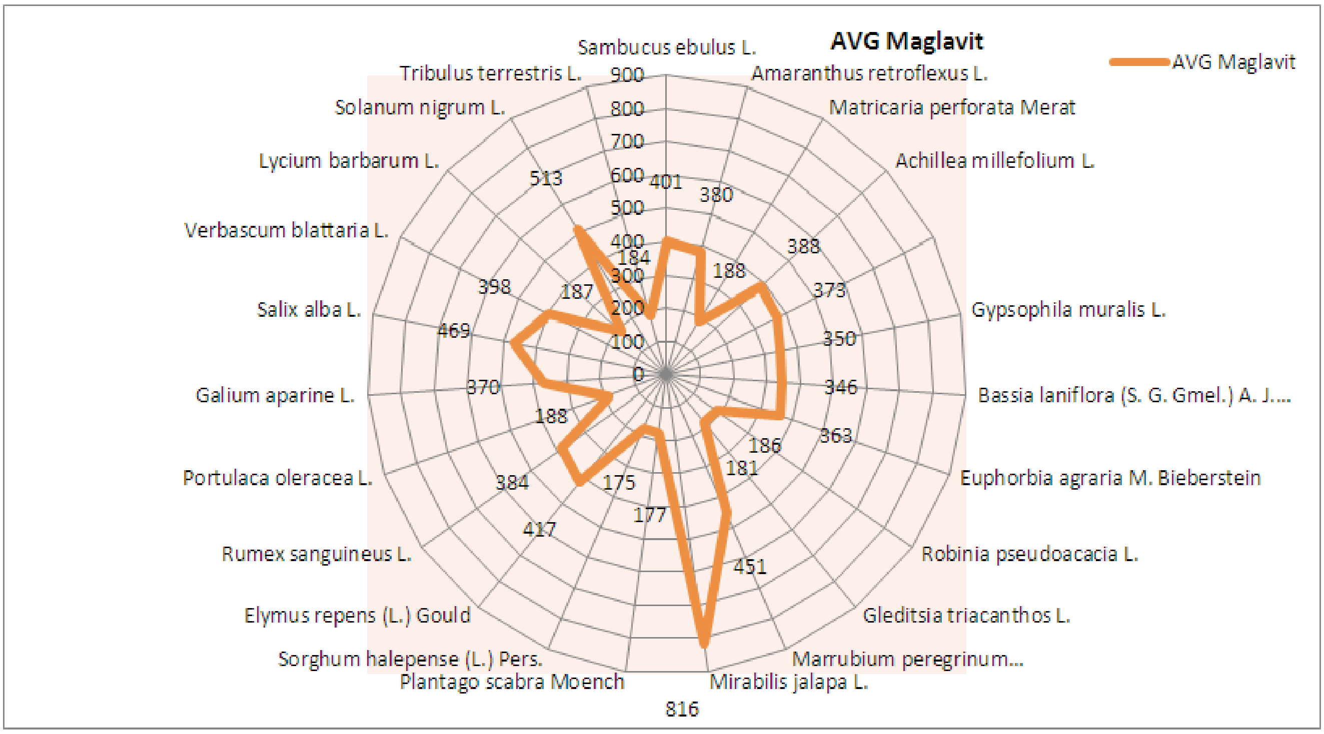


Figure 2. The values of the CCI and AVG in species of the Maglavit area.

Out of the 17 species identified in the area of Calafat, it is observed that 7 species are trees with a high CCI, ranging from 226 - *Carpinus betulus* to 300 - *Thuja occidentalis*; 6 species are shrubs with a CCI ranging between 206 - *Mahonia aquifolium* and 211 - *Syringa vulgaris*, and 2 species have the highest values - *Parthenocissus quinquefolia* (250) and *Hedera helix* (300). Concerning the AVG (the average of mean of the chlorophyll index), the average values range between 116 - *Sonchus oleraceus* and 198 - *Cercis siliquastrum* (Fig. 3) (NĂSTASE, 2004; GAVRILESCU, 2010).

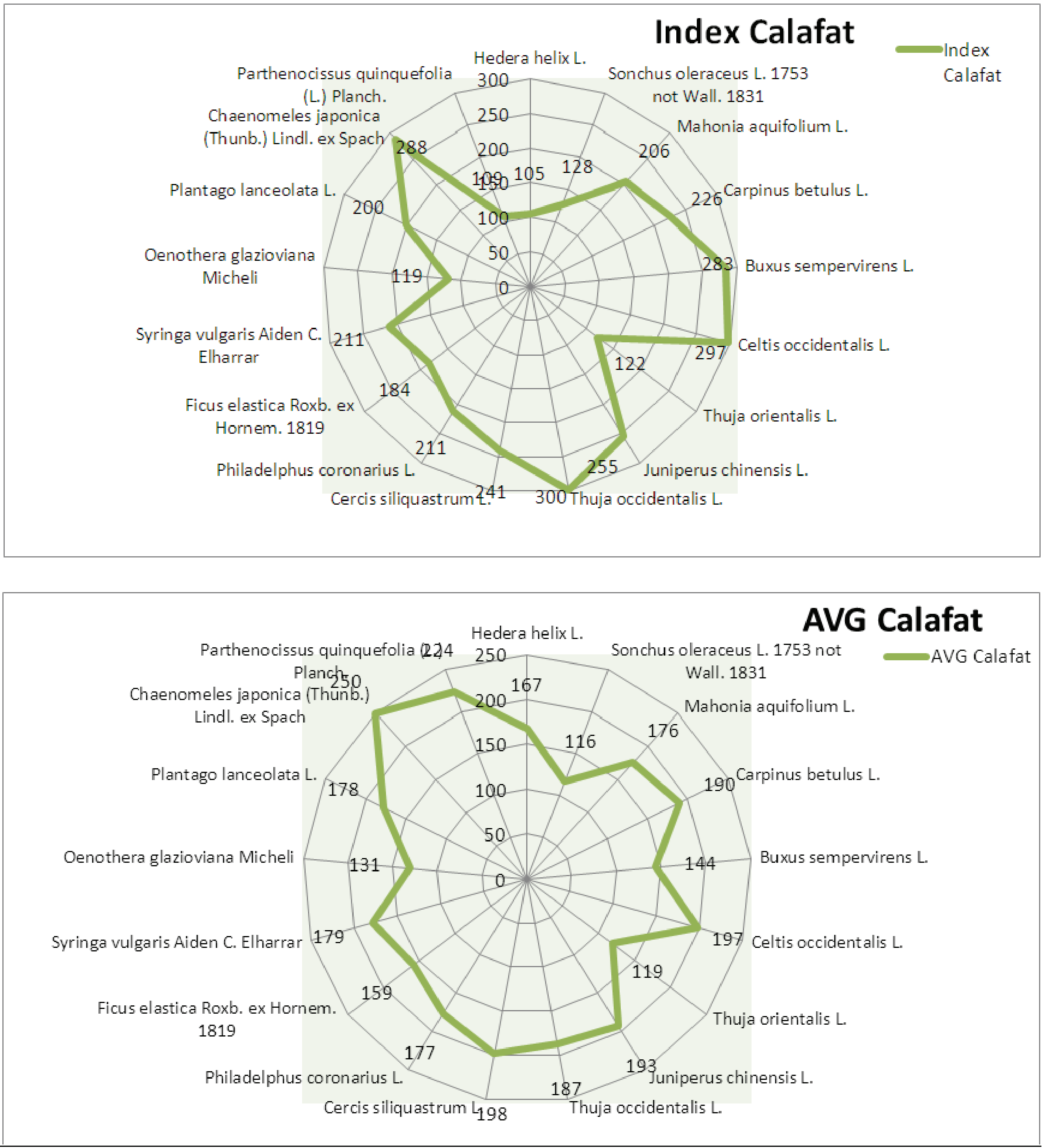


Figure 3. The values of the CCI and AVG in the species from Calafat.

CONCLUSIONS

The soils in the study area are characterized by sandy levigated chernozems and non-consolidated lands, to which there are added the alluvial solonetz, gleizated chernozems and even marshy soils from the Danube meadow. The soils are poorly supplied in macroelements, so that nitrogen and phosphorus fertilizers must be applied where necessary.

Out of the 750 species of vascular plants in the south-west of Oltenia, some physiological factors were assessed in 38 spontaneous and cultivated species belonging to 30 families, characteristic of the sandy soils in the Danube meadow. CCI ranged between 100 - *Gypsophila muralis* and 800 - *Tribulus terrestris*, in the Maglavit area, respectively 226 - *Carpinus betulus* and 300 - *Thuja occidentalis*, *Hedera helix* in the Calafat area. In terms of AVG, the values ranged between 346 - *Bassia laniflora* and 800 - *Sambucus ebulus* for the Maglavit area, and between 116 - *Sonchus oleraceus* and 198 - *Cercis siliquastrum* for Calafat. The evaluation of these physiological factors is closely related to the nitrogen demand, i.e. the rational use of fertilizers for adequate soil dosing in order to protect the environment (GAVRILESCU, 2013; ROŞESCU, 2018).

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Gavrilescu Elena, Mărăcineanu Liviu Cristian

University of Craiova, Faculty of Horticulture, Biology and Environmental Engineering Department,
A. I. Cuza Street 13, Craiova, 200585, Romania.
E-mail: gavrilescu_elena@yahoo.com

Cioboiu Olivia, Năstase Adrian

The Oltenia Museum, Craiova, Str. Popa Șapcă, No. 8, 200422, Craiova, Romania.
E-mails: oliviacioboiu@gmail.com; cioboiu.olivia@yahoo.com

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HOW EFFICIENT IS THE PROTECTION OF BIODIVERSITY THROUGH NATURAL PROTECTED AREAS IN ROMANIA?

PETRIŞOR Alexandru-Ionuţ, ANDREI Mădălina Teodora

Abstract. Natural protected areas are an important component of sustainability, aimed at preserving a part of the current biodiversity for the future generations. Romania has declared numerous protected areas during the process of joining the European Union, particularly NATURA 2000 sites, but the question is: How effective is the management of sites declared under the pressure of time? In order to answer the question, this study uses data from the competent authorities on the presence of a custodian (with or without a management contract) and of a management plan for each natural protected area. After processing the data to answer each question in a binary manner, the results were mapped and synthesized. Our findings indicate that roughly 50% of the Romanian natural protected areas of benefit upon an effective protection, suggesting that little progress was achieved in the decade succeeding their declaration. Therefore, much hope is placed in the newly created Agency for the future.

Keywords: custodian, management plan, management contract, sustainable development, conservation.

Rezumat. Cât este de eficientă protecţia biodiversităţii prin arii naturale protejate în România? Ariile naturale protejate sunt o componentă importantă a dezvoltării durabile, având ca scop conservarea unei părţi a biodiversităţii actuale pentru generaţiile viitoare. În procesul de aderare la Uniunea Europeană România a declarat numeroase arii naturale protejate, în special situri NATURA 2000, dar se pune problema cât este de eficientă administrarea acestor arii declarate sub presiunea timpului? Pentru a răspunde la întrebare, acest studiu foloseşte date de la autorităţile competente privind prezenţa custozilor, a contractelor şi planurilor de management pentru fiecare arie naturală protejată. După procesarea datelor, menită să asigure prezenţa unui răspuns binar la fiecare întrebare, acestea au fost cartografiate şi sintetizate. Rezultatele arată că cca. 50% din ariile naturale protejate din România beneficiază de o protecţie efectivă, arătând că procesul înregistrat după declararea lor este nesemnificativ. Astfel, aşteptările faţă de nou înfiinţata agenţie a ariilor naturale protejate sunt mari.

Cuvinte cheie: custode, plan de management, contract de management, dezvoltare durabilă, conservare.

INTRODUCTION

Sustainable development involves, from a practical perspective, the restoration of degraded ecosystems, assessing the impact of current activities and internalizing the social and environmental externalities, as well as preserving a part of the current biodiversity for the future generations (PETRIŞOR & PETRIŞOR, 2014); the third goal is achieved by declaring natural protected areas (MÜCHER et al., 2009; KATI et al., 2014; STAN et al., 2014; OPRŠAL et al., 2018). For this purpose, the European Union created a transnational network of natural protected areas starting from two directives, Birds and Habitats; the aim is not a strict preservation of biodiversity, but a sustainable management involving the local communities in the process of drafting effective plans (STĂNCIOIU et al., 2010; SINGH et al., 2014). The network consists of Areas of Special Conservation Interest created in relationship to the Habitat Directive, Special Protection Areas under the Birds Directive (SPAs) and sites connecting the first two (PĂTROESCU et al., 2007; MÜCHER et al., 2009; EVANS, 2012; STRINGER & PAAVOLA, 2013).

The Romanian protected areas were conceived from the very beginning according to the guidelines of the International Union for the Conservation of Nature, with slight variations (MUNTEANU & SEVIANU, 2014). Nevertheless, the declaration of new areas, performed at a very fast pace in relationship to the accession of the country to the European Union, was not an easy process (VANONCKELEN & VAN ROMPAEY, 2015), generating overlapping categories (IOJĂ et al., 2010) and a consequent lawsuit from the European Union (COJOCARIU et al., 2010). Currently, natural protected areas cover 18% of the national territory (STĂNCIOIU et al., 2010), a share in line with other European countries (KATI et al., 2014).

Previous studies carried out in Romania assessed the efficiency of the national system of natural protected areas by looking at the overlap of categories (IOJĂ et al., 2010), the coverage of biogeographical regions (PETRIŞOR, 2008; PETRIŞOR & PETRIŞOR, 2017) or priority habitats (PETRIŞOR, 2016a), landform diversity (PETRIŞOR, 2009), coverage of wetlands (PETRIŞOR, 2010) or evidence of environmental impacts within their perimeter (PETRIŞOR, 2016a, b; 2018a, b). Most studies employed the Geographical Information Systems (GIS) in conjunction with spatial indicators (PĂTROESCU et al., 2007).

The present study aims at assessing the efficiency of Romanian natural protected areas based on the presence of a custodian (with or without a management contract) and of a management plan, using data from the authorities in charge.

DATA AND METHODS

The study used spatial data on Romanian Natural Protected areas, freely available on the Internet page at http://www.mmediu.ro/beta/domenii/protectia-naturii-2/arii-naturale-protejate/ and a consolidated file with information on their management: custodians, management contract, and management plan. The file contained detailed information, but we converted all the details to a binary format (presence/absence), considering the information from the perspective of the moment. For example, if the custodian declared that the procedure for drafting the management plan was initiated, but not completed, we considered that the area did not have a plan, excepting for the cases where an ongoing project is directed at drafting the plan; if the management contract was expired, we considered it did not exist; and if no information was available, we assimilated it to the lack of existence of plans or contracts.

The file was merged with the official database, using the unique identification code for matching the two; the information in the new file was reviewed and completed (for example, by assimilating the Administration of Danube Delta Biosphere Reserve to a custodian with a management contract, and the law of the Reserve with a management plan). The revised file was used to produce the maps presented in the article.

RESULTS AND DISCUSSION

The results are presented as maps; for a better visualization separate maps were produced to display the status of custodians, with or without a management contract (Fig. 1) and of the management plans (Fig. 2). Fig. 1 shows that more than half of the natural protected areas have a custodian, but very few of them have a management contract. Similarly, Fig. 2 indicates that more than half of the protected areas have a management plan.

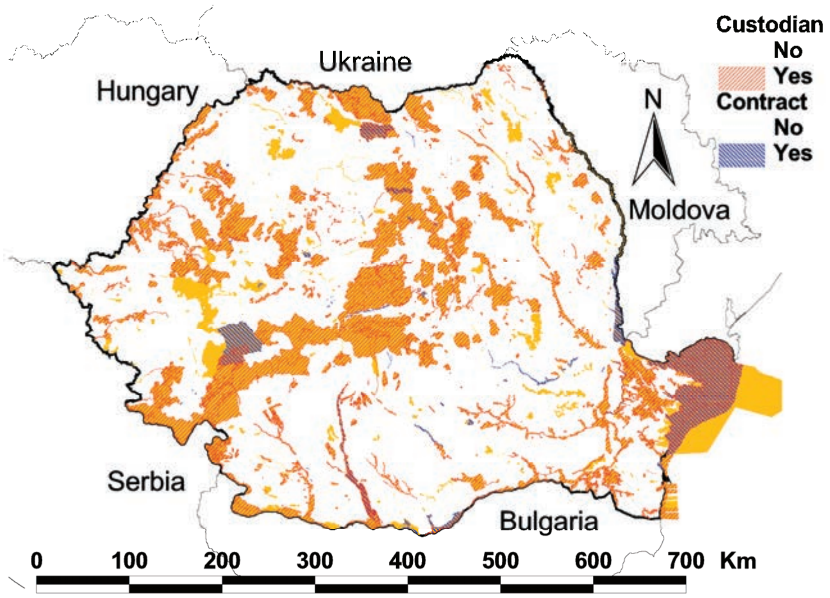

Figure 1. Spatial distribution of the Romanian natural protected areas with an assigned custodian, who has or not a management contract for his/her activity. The yellow background indicates a natural protected area (original).

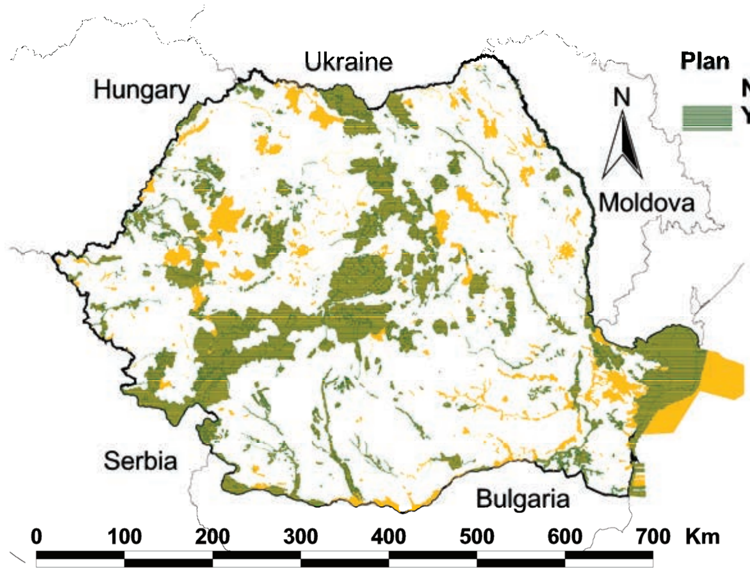

Figure 2. Spatial distribution of the Romanian natural protected areas with a management plan. The yellow background indicates a natural protected area (original).

The joint information is displayed in Fig. 3 and Table 1. The table confirms the previous findings, but there are slight differences; the differences are explained by the size of the area. Most of the small ones lack a custodian and/or a management plan. The table indicates that very few areas – the largest ones – have a custodian with a management contract. The shares of areas with a custodian who has a management contact and also a management plan or not are both below 1%, suggesting that the process of assigning custodians and contracting them is only in its very beginning. The shares of natural protected areas with a management plan and with or without a custodian, safeguarding their effective administration, are roughly around 50% ± 5%.

Provided that the process of declaring natural protected areas had its peak in Romania around 2005-2007, related to the accession of the country to the European Union, which required, among others, the implementation of natural protected areas under the Natura 2000 program (Areas of Special Conservation Interest and Special Protection Areas), it can easily been noticed that little progress was achieved in the following decade. It can be only hoped that the creation of a special dedicated Agency could help reducing the gap between the declared level of protection (20% of the national territory covered by natural protected areas) and the effective protection.

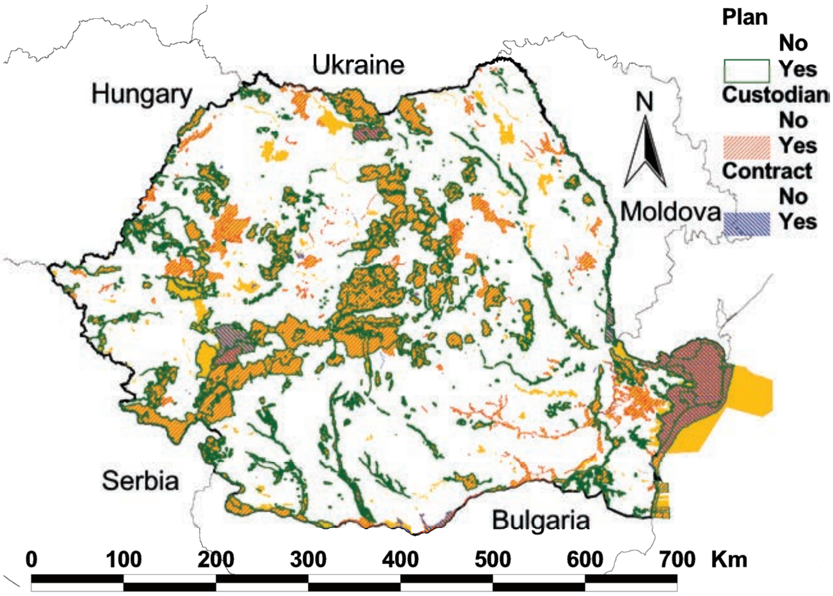

Figure 3. Spatial distribution of the Romanian natural protected areas with an assigned custodian, who has or not a management contract for his activity, and a management plan. The yellow background indicates a natural protected area (original).

Table 1. Overall status of the Romanian natural protected areas: presence of custodians, management contract and plans.

Protected areas with:	Custodian	Management contract	Management plan	Custodian and management contract	Custodian and management plan	Custodian, management contract and plan
No.	987	102	862	7	734	6
% (of 1572)	62.79	6.49	54.83	0.45	46.69	0.38

CONCLUSION

The findings indicate that roughly 50% of the natural protected areas of Romania benefit from effective protection, measured by the existence of a management plan and a custodian. It appears that little progress was achieved in the decade succeeding the peak of declaring new protected areas, especially NATURA 2000 sites. Nevertheless, the creation of the new dedicated Agency could substantially contribute to a better management of the Romanian natural protected areas.

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Petrişor Alexandru-Ionuţ
Doctoral School of Urban Planning, "Ion Mincu" University of Architecture and Urbanism,
Str. Academiei, no. 18-20, sector 1, cod 010014 Bucharest, Romania.
E-mail: alexandru_petrisor@yahoo.com, Internet: www.environmetrics.ro

Andrei Mădălina Teodora
National Agency for Natural Protected Areas, Piaţa Valter Mărăcineanu, no. 1-3, sector 1, cod 010155 Bucharest, Romania.
E-mail: madalinaa71@yahoo.com

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LUDOVIC MRAZEC (1867-1944): FOUNDER OF MODERN ROMANIAN GEOLOGY

POPESCU C. Gheorghe, DINCĂ George

Abstract. Ludovic Mrazec is one of the most important Romanian geologists because of his fundamental contributions to mineralogy, petrology and tectonics of the Romanian Carpathians and of the Dobrogea Units. He was the founder of the Department of Mineralogy at University of Bucharest (1894) and the founder and organizer of the Geological Institute of Romania (1906), where he started the activity of drawing up the geological map of Romania, scale 1: 500,000. He had fundamental contributions in deciphering the tectonics of the Romanian Subcarpathians by discovering the phenomenon of diapirism and its role in defining the petroleum structures. In the history of Romanian geology, he is well known for his view of the relations between the two groups of crystalline schists in the Southern Carpathians and East Carpathians, through the theory of organic petroleum origin and by organizing the research activity and capitalizing on the Romanian mineral resources, following the elaboration of the first mine laws (1924).

Keywords: Mrazec, salt diapirism, petroleum, mineralogy, metamorphic petrology.

Rezumat. Ludovic Mrazec (1867-1944): fondatorul geologiei româneşti moderne. Ludovic Mrazec este unul dintre cei mai importanti geologi români datorită contribuţiilor sale fundamentale la mineralogia, petrologia si tectonica Carpaţilor româneşti şi a unităţilor dobrogene. El a fost fondatorul Catedrei de Mineralogie de la Universitatea Bucureşti (1894) şi fondatorul şi organizatorul Institutului Geologic al Romaniei (1906), unde a demarat activitatea de întocmire a hărţii geologice a României, scara 1 :500.000. A avut contribuţii fundamentale în descifrarea tectonicii Subcarpaţilor româneşti, prin descoperirea fenomenului de diapirism şi al rolului său în definirea structurilor petrolifere. In istoria geologie româneşti a rămas prin concepţia sa privind relaţiile dintre cele doua grupuri de şisturi cristaline din Carpaţii Meridionali, prin teoria genezei organice a petrolului şi prin organizarea activităţii de cercetare şi valorificare a resurselor minerale ale României, urmare a elaborării primei legi a minelor (1924).

Cuvinte cheie: Mrazec, diapirism, petrol, mineralogie, petrologia şisturilor cristaline.

INTRODUCTION

Ludovic Mrazec was the third great Romanian geologist, after Grigore Cobâlcescu and Gregoriu Ştefănescu, whose name is related to the birth of various sub-domains in Romanian geology. He was also one of the most prominent European geologists at the turn of the 20th century and throughout the first few decades of the 1900s. He was also an efficient manager (administrator); he founded the Department of Crystallography, Mineralogy and Petrography of the University of Bucharest in 1894. Later in 1906, he founded the Geological Institute of Romania, whose director he was until 1927 (Fig. 1).

Figure 1. Ludovic Mrazec (1867-1944).

His fundamental scientific discoveries were diverse. Firstly, he was an important contributor to the recognition of the Alpine fold and thrust tectonics in the Southern Carpathians. The discovery of the Getic shear zone with his close collaborator Gheorghe Munteanu Murgoci (MUNTEANU-MURGOCI, 1905). His efforts then focused on fundamental research in petroleum geology and was one of the first promoters of the concept of diapirism in general and diapirism of salt in particular. Salt diapirism in particular and buoyancy-driven ductile deformation in general (in the lithosphere and asthenosphere) are important concepts in modern tectonics. Ludovic Mrazec was concerned about the economic aspect of geology, coining the economic geology in Romania.

EARLY DAYS

Initially Mrazec attended pharmacy courses, first in Bucharest and then at the University of Geneva, following the wish of his father Ludovic Valeriu Severin, who was an apothecary (pharmacist) in Craiova. In Geneva, he obtained a degree in physical-chemical sciences and a doctorate in mineralogy, with Professor of Mineralogy Louis Duparc as advisor, whom he trusted with a strong friendship and to whom he dedicated his fundamental work "The General Mineral Course and Year (1938). His doctoral dissertation was « La Protogine du Mont-Blanc et les roches éruptives qui l'accompagnent. Pétrographie » (1892), where he examined the petrography of the Mont Blanc granite massif (Fig. 2) and clarified the magmatic origin of the granite known as the protogene; he also studied the fan-like structure of the granite massif, which is an example of magmatic diapirism.

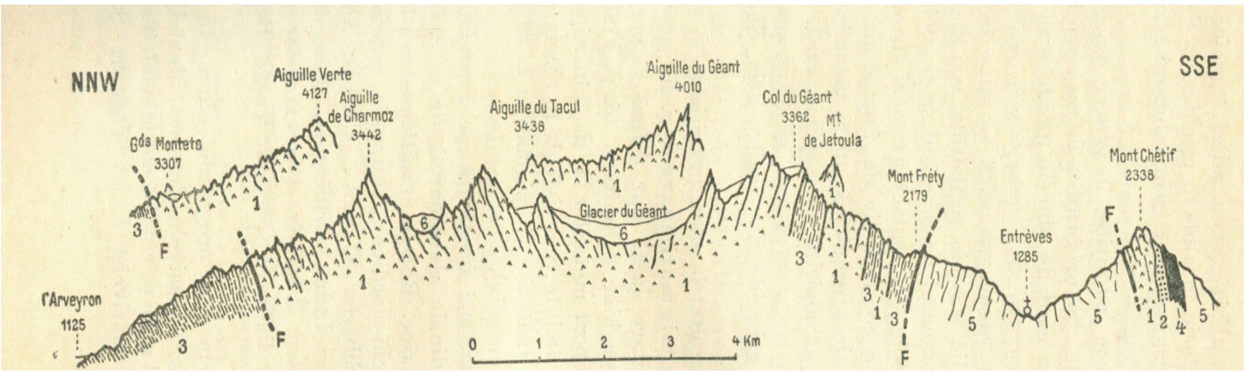

Figure 2. Profile of the central area of the Mont Blanc granite massif (MRAZEC, 1892).

FROM STUDENT TO PROFESSOR

Similar to his mentor L. Duparc, Mrazec started his career by solving physical-chemical problems in the study of minerals, rocks and ores, only to follow later in his career with a shift to tectonics and structural geology. After returning to Romania upon completing his doctoral degree, Ludovic Mrazec was hired as professor of the newly founded department of Mineralogy, whose leadership he held until 1937. Apart from teaching the courses, Mrazec took care of organizing and endowing the laboratory with mineral collections and rocks and analytical equipment. He also organized a specialized library within the department that included fundamental treatises and periodical collections (American Mineralogist, Economic Geology, etc.). The quintessence of his experience in teaching mineralogy courses and practical works is his "General Course of Minerals and Rocks'' (1938). The importance of mineralogy as a science could be illustrated through the words of professor Ludovic Mrazec: "We must not forget that the only purpose followed through mineralogic instruction is to know the minerals and their associations, their occurrence as well as their role in our economic life" (1938).

YEARS OF RESEARCH

The research directions approached by Professor Ludovic Mrazec covered a broad spectrum: Mineralogy, Magmatic and Metamorphic Petrology, Structural Cartography and Geology, Oil Geology, Sedimentary Petrology, Ore deposits. His first field campaigns and studies took place between 1893 and 1900 in the various areas of the Carpathian Mountains and Dobrogea and focused primarily but not exclusively on basement rocks. Highlights were studies of the ortho-gneisses at Cozia and of the coal deposits in the Jiu Valley.

The second stage of his research carried out between 1900 and 1930 concerned the Sub-Carpathian hills rich in salt and crude oil. In 1900, at the Paris International Exhibition, he presented the first map of salt formations in Romania. This was a result of the extensive field work he and a prominent Polish geologist, Wawrzyniec Teisseyre (1860-1939), carried out in the diapir fold zone, and it is regarded as his first major contribution to the study of Romanian salt (MRAZEC & TEISSEYRE, 1902).

MRAZEC & TEISSEYRE (1902) were the first to discuss the depositional environment, the age, the internal structures, the chemistry, and also the tectonics of the salt in the Romanian Carpathians. They also described the unconformity between the salt core and the adjacent layers with the notion that salt is mostly found associated with anticlines (Fig. 3).

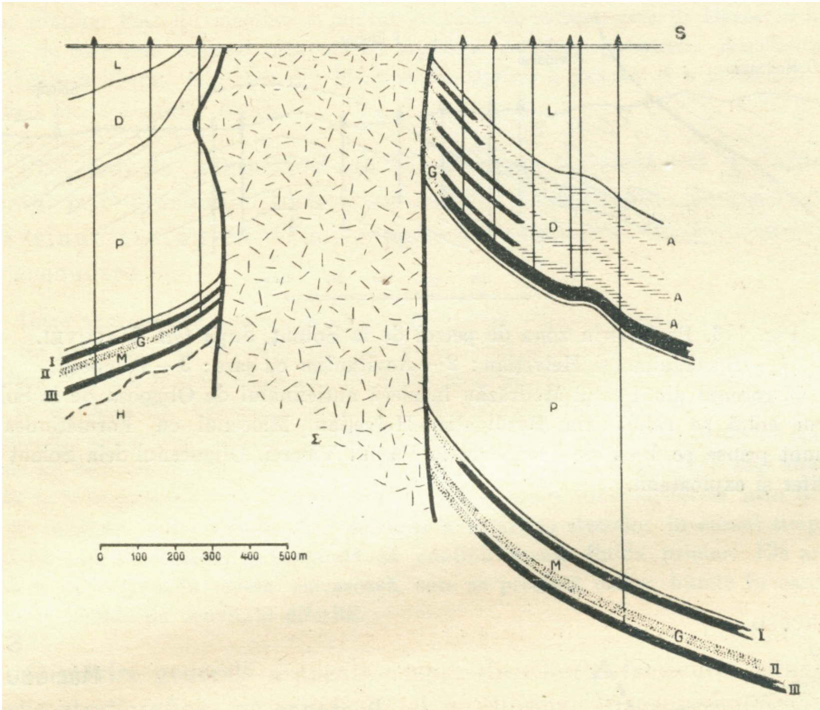

Figure 3. Cross-section of the Moreni-Tuicani anticline, a perfect example of a salt diapir (MRAZEC & ATANASIU, 1927).

Mrazec referred to these structures as “anticlines with salt core” or “folds with piercing core”. He coined the term “diapir” and the phenomenon of “diapirism” (plastic deformations and salt lifting by breaking up the formations above the deposit) for raw salt, demonstrating that they can provide an effective trap for oil and gas pools. Salt diapirism was firstly mentioned by Ludovic Mrazec at the Third International Petroleum Conference, in 1907 (MRAZEC, 1910).

Following the Third International Petroleum Congress, Mrazec summarized his theories in a paper in 1915, which issued in print in 1926. In this context, Ludovic Mrazec explained the distribution of hydrocarbon accumulations in the sub-Carpathian Neogene area. Given the limited data sets (wells and outcrops) of the time, it is remarkable that Mrazec put forward an internally coherent salt tectonics model and that some aspects of his model are still valid. Furthermore, he explained the appearance of petroleum in organic matter, demonstrating that the organic raw material the oil originated from was the plankton of the sea.

MODERNIZING THE ROMANIAN GEOLOGY

On June 19, 1906, the Geological Institute of Romania was established by Royal Decree, the first Director being Ludovic Mrazec, one of the initiators. He led this institute from 1906 until 1930, succeeding in imposing a climate of collaboration and understanding. Under his leadership, the first geological map of Romania was developed in 1920, and the oil and gas fields of Transylvania were evaluated. In 1924, Ludovic Mrazec proposed that the geological maps made on scales 1: 1,000,000 and 1: 500,000 should represent deep structures using the borehole data. Also, on his own initiative, one of the topics discussed at the International Drilling Congresses held between 1925 and 1939 should concern the methodology of using drilling data for the study of the lithosphere. In 1926, under Mrazec’s coordination, the geological map of Romania, scale 1: 1,500,000 (printed in 1927), was made and exhibited at the International Geological Congress in Madrid.

LEGACY FOR FUTURE GEOLOGISTS

Ludovic Mrazec retired at the age of 63, in 1930, despite his contributions and his ability to conduct new research. In the remaining years of his life, he devoted his energy to the organization of scientific meetings, the publishing of a scientific bulletin, actions that have led to the increase of Romania’s scientific prestige. Subsequently, he held conferences on topics related to the gold mines in Romania, the classification of the Carpathian flysch, the sulphur deposits in Romania, the origin of the salt lakes, the loess origin, etc. Every scientific community, including the

Romanian geosciences has an iconic father figure, responsible for placing geology on the map of that country. Ludovic Mrazec through his own work and dedication succeeded in writing a golden page in the history of the Romanian geology and worldwide petroleum geology.

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Popescu C. Gheoghe
University of Bucharest, Faculty of Geology and Geophysics,
Department of Geology, 1 N. Bălcescu Ave, 010041, Bucharest, Romania.
E-mail: gheorghec.popescu@yahoo.com

Dincă George
University of Bucharest, Faculty of Geology and Geophysics,
Department of Geology, 1 N. Bălcescu Ave, 010041, Bucharest, Romania.

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NEW RECOVERIES OF COLOR MARKED EURASIAN SPOONBILLS (*Platalea leucorodia*), WITH LONGEVITY RECORDS AND SIGNS OF HIGH TERRITORIAL FIDELITY

KISS J. Botond, MARINOV E. Mihai, SÁNDOR D. Attila

Abstract. The authors add new information to the previously published information on the recovery of the rings of the 219 spoonbills (*Platalea leucorodia* Linnaeus, 1758), marked in the north of Sinoie lagoon, Romania, in 2003-2005. Up to now 33 individual birds were resighted (15.7%). One of the marked birds was observed 5 times at a breeding colony ca 75 km to the north to its hatching site, while another was observed 17 km from its hatching area after 5813 days. These new observations and especially the longevity records show the importance of colour marking in large wading birds and would serve as justification for the continuation of the project.

Keywords: breeding, Danube Delta, migration, ringing, Romania.

Rezumat. Recapturi noi de lopătar (*Platelea leucorodia*), cu un record de longevitate și fidelitate teritorială accentuată. Autorii adaugă informații noi la cele publicate anterior cu privire la recuperarea inelelor de pe cei 219 lopătari (*Platalea leucorodia* Linnaeus, 1758), marcați în nordul lagunei Sinoie, România, în 2003-2005. Până în prezent s-au obținut date despre 33 de păsări (15.7%). Unul dintre lopătari a fost regăsit în cursul anilor, a patra și a cincea oară, la o colonie de cuibărit la 75 km de la locul inelării. Al doilea prezintă recordul de până acuma a supraviețuirii, fiind regăsit după 5813 zile de la data inelării, la 17 km de la colonia de origine. Recordurile de longevitate și fidelitate teritorială obținute ar justifica continuarea acțiunilor de marcare al lopătarilor, cu inele de plastic color.

Cuvinte cheie: lopătari, marcări, fidelitate teritorială, longevitate.

Post-breeding dispersal of the Eurasian spoonbill (*Platalea leucorodia* Linnaeus, 1758) is largely unknown in Romania, with only a handful of ringing recoveries using metal rings being published earlier: two recoveries in Egypt and one each in the Republic of Moldova, Sudan and Kenya (CĂTUNEANU 1999; SMART et al., 2007). In the meantime, more and more diverse data is provided by the use of the color rings on spoonbills breeding in the lagoons of the Danube Delta Biosphere Reserve. A total of 219 nestlings were marked with individual color rings in the period 2003-2005, thus marking ca. 5-7 % of the nestlings of the of 1100-1500 pairs of spoonbills breeding in Romania in that period. Altogether 33 individual birds (15.7% of all ringed) were recovered over the years, mostly by resightings (photos or visual observations), but also as reports of birds shot or found dead, with most individuals seen on multiple dates and countries. Recoveries were reported from ten countries, geographically falling into an irregular polygon, with peaks in Italy, Croatia, Hungary, Romania, Ukraine, Bulgaria, Cyprus, Turkey, Oman, Israel and Tunisia. The longest distance an individual bird travelled was 3814 km from the breeding colony, and the longest period of ring-bearing was 3651 days (KISS et al., 2007, 2019).

Here we intend to report three new recoveries, which considerably extend the longevity records of the species in Romania and highlight the territorial fidelity of the species. The bird marked with the UX - UX color plastic ring, identified earlier in three occasions, was also photographed twice in the area of its former resightings (in each case at a distance of ca. 75 km from the ringing site, here it was observed yearly from 2014). This individual was ringed in 2004, thus bearing the color marks for more than 5430 days (Fig. 1a, b). However, the longevity record is held by another individual observed on 15 May 2019 at a distance of 17 km from its hatching island and 5813 days after its ringing.

Overall, the above observations – in addition to their record character – highlight the utility of color marking method and advocate for further continuation of individual color ringing, especially in the case of long legged species (including the spoonbill). The continuation of ringing is also important, as the chance of new recoveries to be made (and new information provided) drastically decreases after an initial period.

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[1]Kiss J. Botond, [1]Marinov Mihai, [2]Sándor D. Attila
1. Danube Delta National Institute for Research and Development, Str. Babadag 165, Tulcea 820112, Romania.
2. University of Agricultural Sciences and Veterinary Medicine, Faculty of Veterinary Medicine, Department of Parasitology and Parasitic Diseases, Calea Mănăștur 3-5, Cluj-Napoca 400372, Romania
Author responsible for correspondence: Kiss J. Botond, E-mail: jbkiss03@yahoo.com

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a.


b.

Figure 1a, b. Specimen of Spoonbill (*Platalea leucorodia*) – remarkable territorial fidelity (Photo. Sigrid Lange).

RECOMMENDATIONS
regarding the elaboration of the papers for the scientific journal
"Oltenia. Studii şi comunicări. Ştiinţele Naturii"

The journal is edited by the Oltenia Museum Craiova and it publishes original papers in the fields of vegetal and animal biology, ecology-environment protection, mineralogy-palaeontology, as well as scientific reports, reviews, anniversary or commemoration papers.

It appears annually, it is ISI indexed (http://science.thomsonreuters.com/cgi-bin/jrnlst/jlresults.cgi?PC= MASTER &Word=oltenia**) and accredited by CNCSIS as a B+ Journal.**

I. Structure (format) for original papers, scientific reports and reviews:

A	***Original papers***	will be structured according to the information rendered in the Table 1.
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STRUCTURE OF THE PAPER	CHARACTERISTICS	OBSERVATIONS
TITLE	capital letters, 12 pt., bold, centred	
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AHMADJIAN V. 1967. *The Lichen Symbiosis*. Blaisdell Publishing Company. Massachusetts. Available from: http://books.google.ro/books?id=at7uXMn8iMC&printsec=frontcover&hl=ro&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false. 152 pp. (accessed: January 15, 2013).
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