

THE OCCURRENCE OF NON-OBLIGATE CAVE DWELLING BEETLES (INSECTA, COLEOPTERA) IN THE BIOSPELEOLOGICAL PROVINCES OF ROMANIA: A FAUNAL AND ZOOGEOGRAPHIC ANALYSIS

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Abstract. Beside 143 specialized (obligate) and other 85 non-obligate cave dwelling species of Coleoptera (also named troglobitic species), previously inventoried by us in the Romanian fauna, in this article we present a list of 156 of non-obligate cave dwelling species which occur in different associations in the Romanian caves, for the first time grouped on biospeleological provinces and zones. In the context of the new studies which showed that the “non-obligate” cave dwelling species do not occur randomly in the caves, but having a proved selectivity for caves, this study is focused on biogeographical aspects of non-specialized cave dwelling species. Our purposes were: (1) to update the inventory the non-obligate (troglaxene and troglophile species) from the caves in Romania, and (2) ordering them in the biospeleological provinces, to observe whether there it is a similarity with the distribution of obligate (troglobiont) beetle species, formerly identified as characteristic for each of five biospeleological provinces of Romania. We observed that the distributional pattern of non-obligate cave-dwellers differs by that of the obligate/specialized cave dwelling species of coleoptera and it was influenced in different ways by the geographical landscape. We emphasize here the ecological importance of the non-obligate cave dwelling species for ecosystems in karst areas – as most of them are detritivores or predators.

Key words: Coleoptera, zoogeography, Karst areas, non-obligate cave dwelling species, Romania.

1. INTRODUCTION

From the very beginning of biospeology, EMIL RACOVITZA, in his well-known work “*Essai sur les problèmes biospéologiques*” (1907) emphasized that “the cave fauna is an absolutely heterogeneous mixture of very different *forms* (species n.a.) – different in their origin, heredity, degree of colonization of the subterranean environment, the age of immigration into the caves...”. Analyzing the degree of adaptation of species to the underground environment and the dependence of some species on the cave environment, Racovitza established a first classification of cave-dwelling species in “*troglobionts*” (strictly dependent and adapted to underground habitats – which cannot survive outside this environment), “*troglophiles*”

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(species that are dependent in some ontogenetic phases on caves) and “*trogloxenes*” (usually epigeal or soil species that can sometimes visit vestibular (entrances) of caves. JEANNEL (1926) noted that it is not sufficient to designate a cave animal as troglaxene, troglophile or troglotic to define its ecology and consider its connections or relations with the subterranean environment to be resolved. He emphasized that habitats, species’ environmental specialization, and feeding preferences are essential in defining the relationships with subsurface environments for each species. On a larger scale, referring to the colonization of geographic areas, UDVARDY (1969) mentioned as elementary factors for the capacities of species to conquer new environments “the degree of vagility, nature of barrier which forms the limit of regular distribution of species, and chance”. The occurrence of species interpreted as “the frequency of incidence” of potential pioneers (“irregular visitors” – like the so called “*trogloxenes*”) is influenced by the factors enumerated above.

DECU AND NEGREA (1969), inspired by the previous principles of designating different biospeological areas for France JEANNEL (1926), for Barcelona (ESPANOL, 1961) or for Sweden (STRINATI, 1966), started a biogeographic study of cave species from Romania.

Analyzing the distribution of troglotic arthropods in Romanian caves, DECU AND NEGREA (1969) presented a map of 5 biospeological provinces including 25 areas for Romania. In the study and argumentation of the map of biospeological provinces, the mentioned authors took into account four major factors: 1) the geographical distribution of the karst areas; 2) the paleogeographical barriers that were decisive in the current range of distribution of the specialized species for caves in Romania; 3) paleoclimate and postglacial climate, and 4) the evolution of forests – the “arboreal element” (LATTIN, 1967), and the soil and endogenous fauna dependent on this habitat during the Tertiary and Quaternary geological periods.

To date, 143 species of specialized cave dwelling species of Coleoptera (troglotic species) have been inventoried for the Romanian fauna (NITZU ET AL., 2016; NITZU ET AL., 2018).

Many other faunal studies that have been conducted in karst landscapes have focused on species that are specialized and exclusive cave dwellers (troglotic species) (SKET, 2008; CULVER AND PIPAN, 2009, PIPAN AND CULVER, 2012; MAMMOLA AND ISAIA 2016; MAMMOLA AND LEROY, 2018).

Only a few studies have taken into consideration the influence of caves on the community structure of non-obligate cave dwellers (*trogloxene*) invertebrates in karst areas (species that normally live outside caves and in some periods of their life could be found in subterranean habitats without reproducing there) (SKET, 2008). PROUS ET AL. (2004) suggested that the cave entrance functions as a “membrane of selective permeability”, and most species of the epigeal and hypogean environment are not able to cross this “membrane” (ecotonal zone) located at the cave entrance (PROUS ET AL., 2015). LUNGI ET AL. (2014) have emphasized that the non-specialised cave dwelling species were frequent in caves, but they did not occur randomly at the entrance of caves. Furthermore, regardless

of the diversity of microhabitats and the faunal richness of soil/endogenous-species in a karst landscape, only a few of these species can distinctly colonize even the photic areas of caves (NITZU, 2021).

In this article, our purposes were: (1) to update of the inventory the non-obligate Coleoptera from the caves in Romania, showing their chorology, and (2) to order them in the biospeleological provinces, to observe that it is a similarity of their distributional pattern with the obligate (troglobitic) beetle species, formerly identified as characteristic for each of five biospeleological provinces of Romania.

2. MATERIAL AND METHODS

2.1. DATA PRESENTATION

Beside the data on the species identified by the author between the years 1990–2022 in the Romanian caves (the sampling date presented for each species as mm/dd/yy), we mentioned also the previous published records of species for each cave (IONESCU, 1912; DECOU, 1964; NITZU, 2001; NITZU ET AL., 2002; NITZU AND ILIE, 2004; NAE ET AL, 2006; NITZU ET AL., 2007; NITZU ET AL., 2011; NITZU, 2013; NITZU, 2021 – *online resource 1*) – mentioned in the checklist, after the name of the cave. These data are grouped on biospeleological provinces I–V and zones (1–25) described by DECOU AND NEGREA, (1969) (Fig. 1.) for each species.

The higher taxa with the rank of Family are presented in the systematic order, and genera and species in alphabetical order.

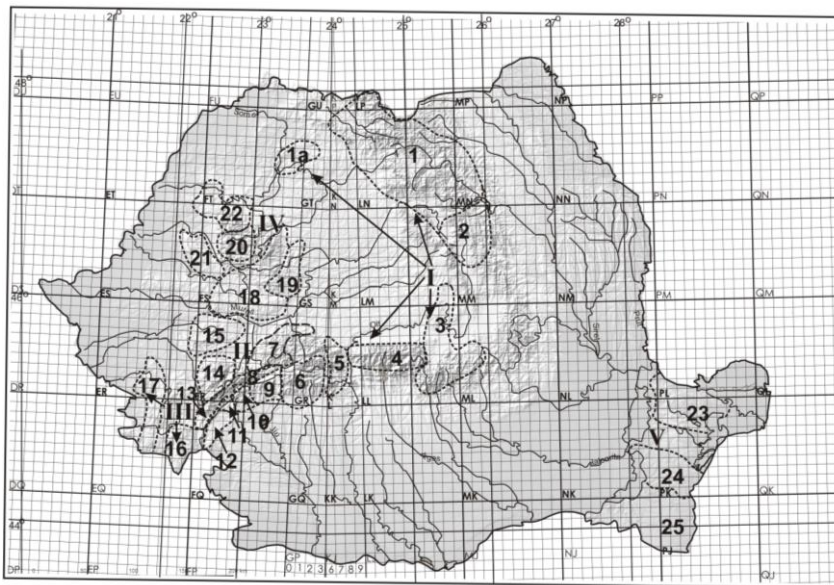


Fig. 1. The map of biospeleological provinces (I – V) and zones (1 – 25) of Romania (following DECOU AND NEGREA, 1969, modified).

2.2. BIOGEOGRAPHIC ANALYSIS

The biogeographic data of plants or animals have been presented over time, in three major types of classifications: 1) The simplest of all was the enumeration of the areas of their distribution (i.e. the Carpathians, the Balkans, the Mediterranean area, etc.) and frequently as presence or absence of species by country (LOBL AND SMETANA, 2003). 2) The second type was represented by the chorological pattern – An item of classification of geographical distribution of species, based on distribution patterns concept of “a recurrent type of merely geographic distribution” (TAGLIANTI ET AL., 1999). 3) The most “abstract” model is that “historic – eco – biogeographic” distribution (LATTIN, 1967) which tries to define the actual distribution of each species based on their actual habitat preferences (arboreal, eremial, oreo-tundral, etc.) and their glacial dispersal centers, but this presumes a great degree of interpretation (NITZU, 2001; CALAYAUD ET AL., 2016).

In this article, each species recorded from the Romanian caves is defined by corological and by its local distribution in the biospeleological provinces and zones of Romania (following DECOU AND NEGREA, 1969).

2.3. STATYSTICAL ANALISIS

The faunal differences between the investigated areas were analysed using cluster analysis based on species abundances (Bray-Curtis distance coefficient and complete linkage method) using the program “Biodiversity Pro V.2”, following the indication of clustering strategies given by LUDWIG AND REYNOLDS (1988) and KREBS (1989).

3. RESULTS AND DISCUSSIONS

The Checklist of Coleoptera species recorded in the Romanian caves, distributed on biospeleological provinces I–V and zones (1–25) (Fig. 1), and their chorotypes.

Terms and symbols used in the list of species: Chorotype: An item of classification of geographical distribution of species, based on distribution patterns concept of “a recurrent type of merely geographic distribution” (TAGLIANTI ET AL., 1999; NITZU, 2013). Records from caves: Records of species *per* biospeleological provinces (I–V) and zones, (1– 25) of Romania, according to the map presented in Fig. 1. *Example*: I (1) = Province I, zone 1; P. = Cave (RO. Pestera). Recording dates presented as month/day/year (unpublished data) or as cited source (i.e., Decou, 1964).

Fam. Carabidae**1. *Abax parallelepipedus* Piller and Mitterpacher, 1783**

Chorotype. European.

Records from caves: **I (3)** P. 1200/7; 1200/13 din Cheile Varghişului, 05/23/2002.
II (12) P. din Dealul Curecea, 08/2017.

2. *Abax parallelus* (Duftschmid, 1812)

Chorotype. European.

Records from caves: **I (3)** P. 1200/7; P. 1200/12 din Cheile Varghişului ?/05/2002.

3. *Abax carinatus* (Duftschmid, 1812)

Chorotype. European.

Records from caves: **I (3)** Cave in Bertea, 6/10/2001. **V (25)** Caves in Canaraua Fetei, 5/5/1998.

4. *Abax (Abacopercus) schuppeli* Palliardi, 1825

Chorotype. European.

Records from caves: **II (11)** P. cu Gheaţă, 6/22/2002, 6/23/2003.

5. *Bembidion (Trepanes) articulatum* (Panzer, 1796)

Chorotype. Transpalaeartic.

Records from caves: **I (3)** P. 1200/24 din Cheile Varghişului, 6/06/2004.

6. *Bembidion (Peryphanes) dalmatinum* Dejean, 1831

Chorotype. Turano-European.

Records from caves: **I (3)** P. S6 din Platoul Meledic, 6/12/2001. **IV (22)** P. Batranului, 7/05/2016, 10/24/2016; P. Meziad (Decou, 1964).

7. *Bembidion (Euperyphus) fluviatile* Dejean, 1831

Chorotype. Turano-European-Mediterranean.

Records from caves: **II (11)** P. Lazului, 6/26/2014.

8. *Carabus (Procerus) gigas* Creutzer, 1799

Chorotype. Central-E. European.

Records from caves: **II (11)** P. Lazului, 5/23/2013.

9. *Carabus (Pachystus) graecus morio* Mannerheim, 1830

Chorotype. Ponto-Mediterranean.

Records from caves: **V (25)** P. Movile, 5/10/1996.

10. *Laemostenus terricola punctatus* (Dejean, 1828)

Chorotype. Europeo-Mediterranean.

Records from caves: **III (16)** P. Gura Ponicevei, 2/27/2014. **III (17)** P. Şoimuş, 12/5/2008; P. cu Apă de la Gârlişte, 8/30/2017. **V (25)** Canaraua Fetei, 6/23/1998; P. de la Limanu, 7/15/2000.

11. *Molops piceus orthogonius* Chaudoir, 1868

Chorotype. Subspecies endemic for Romania.

Records from caves: **III (17)** P. de la Ponorul Drăgoina, 10/17/2005.

12. *Parophonus mendax* (Rossi, 1790)

Chorotype. Europeo-Centasiatic.

Records from caves: **V (25)** P. Movile, 8/17/1997.

13. *Patrobus styriacus* Chaudoir, 1871

Chorotype. Central-E. European.

Records from caves: **IV (18)** P. Neagră din Barsa (Decou, 1964).

14. *Porotachys bisulcatus* Nicolai, 1822)

Chorotype. Turano-Mediterranean.

Records from caves: **V (25)** P. Movile, 5/17/1995.

15. *Platynus (Batenus) banaticus* I. Frivaldszky, 1865

Chorotype. Endemic for Banat province.

Records from caves: **III (17)** P. de la Fagul Impreunat, 8/03/2005.

16. *Platynus glacialis* Reitter, 1877

Chorotype. Carpathian endemite.

Records from caves: **I (3)** P. Stanciului, 6/26/2009.

17. *Platynus scrobiculatus* (Fabricius, 1801)

Chorotype. European.

Records from caves: **III (17)** P. de la Ponorul Drăgoina, 7/13/2002, 10/17/2005. **IV (22)** P. Ciur-Ponor, 10/20/2015, 10/25/2016.

18. *Pterostichus (Argutor) strenuus* (Panzer, 1797)

Chorotype. Palaeartic.

Records from caves: **I (3)** P. din Satul Peştera, 7/09/2003.

19. *Trechus austriacus* Dejeanm 1831

Chorotype. European

Records from caves: **V (24)** Cheia-Dobrogea, 5/08/1998; P. Gura Dobrogei, 9/20/1999. **V (25)** Canaraua Fetei, 5/04/1998.

20. *Trechus latus* Putzeys, 1847

Chorotype. Carpathian endemite.

Records from caves: **I (1)** P. Izvorul Taușoarelor, 6/21/2006. **I (3)** P. Fundata, (Decou, 1964). **III (17)** P. Buhui, 8/31/2017. **IV (20)** Avenul Borțig (Decou, 1964). **IV (22)** P. Ciur-Ponor, 10/20/2015; P. Moanei; P. Poarta Bihariei (Decou, 1964).

21. *Trechus pulchellus* Putzeys, 1846

Chorotype. Central -E. European.

Records from caves: **II (8)** P. Dalma cu Brazi, (Decou, 1964). **IV (22)** P. Moanei, 7/05/2016.

22. *Trechus striatulus* Putzeys, 1847

Chorotype. Central -E. European.

Records from caves: **I (1)** P. Liliacilor de la Pietrele Doamnei, 6/29/2007.

Fam. Staphylinidae**23. *Acrolocha amabilis* (Heer, 1841)**

Chorotype. European.

Records from caves: **IV (22)** Betfia, 7/03/2019.

24. *Aleochara diversa* (Sahlberg, 1876)

Chorotype. European.

Records from caves: **II (5)** P. Liliacilor de la Mănăstirea Bistrița. **II (6)** P. Muierii de la Baia de Fier. **II (10)** P. Fușteica. (Decou, 1964). **III (17)** P. Rolului, 7/08/2009. **IV (20)** Corobana Mândruțului. **IV (22)** P. Meziad, P. Ungurului (Decou, 1964).

25. *Aleochara funebris* Wollaston, 1864

Chorotype. European.

Records from caves: **II (10)** P. Mare de la Balta, 7/25/2013. **II (11)** P. Lazului, 7/23/2013. **III (17)** P. cu Apă din Cheile Gârliștei, 08/2017.

26. *Aleochara milleri* Kraatz, 1862

Chorotype. Europeo-Centrosiatic.

Records from caves: **V (24)** Cheia-Dobrogea, 5/8/1998.

27. *Aleochara moesta* Gravenhorst, 1802

Chorotype. European.

Records from caves: **II (5)** P. Liliacilor de la Mănăstirea Bistrița (Decou, 1964).

28. *Aloconota currax* (Kraatz, 1856)

Chorotype. European.

Records from caves: **II (9)** P. de la Gârla Vacii (Decou, 1964).

29. *Aloconota insecta* (Thomson, 1856)

Chorotype. European.

Records from caves: **II (9)** P. de la Gârla Vacii. **IV (22)** P. din Valea Mierei (Decou, 1964).

30. *Anotylus sculpturatus* Gravenhorst, 1806

Chorotype. Palaeartic.

Records from caves: **I (3)** P. 1200/14 din Cheile Vârghișului, 5/24/2002. P. Dobreștilor, 8/01/2003.

31. *Anotylus tetracarinatus* (Block, 1799).

Chorotype. Holarctic.

Records from caves: **II (9)** P. Gârla Vacii (Decou, 1964). **II (11)** P. Lazului, 6/05/2014.

32. *Arpedium quadrum* (Gravenhorst, 1806)

Chorotype. Palaeartic.

Records from caves: **II (5)** P. Liliiecilor de la Mânăstirea Bistrița (Decou, 1964).

33. *Astrapeus ulmi* (Rossi, 1790)

Chorotype. Europeo-Mediterranean.

Records from caves: **V (23)** Popina I. (in diaclasis) 6/11/2000. **V (25)** Obantul Mare 5/17/1997 (in microcave).

34. *Atheta contristata* (Kraatz, 1856)

Chorotype. European.

Records from caves: **II (11)** P. Lazului, 5/23/2013, 7/23/2013, 6/26/2014, 9/06/2017; P. Balta, 9/04/2017. **II (13)** P. Bobot (Decou, 1964). **IV (20)** P. Ghețarul de la Barsa; P. Pereții Corlatului (Decou, 1964).

35. *Atheta crassicornis* (Fabricius, 1792)

Chorotype. European.

Records from caves: **II (11)** P. Lazului, 6/26/2014; P. Closani, 6/26/2014.

36. *Atheta ermishi* Benik, 1934

Chorotype. European.

Records from caves: **V (24)** P. Casian, 5/31/2000.

37. *Atheta hygrotopora* (Kraatz, 1856)

Chorotype. European.

Records from caves: **III (17)** P. cu Apă de la Gârliște, 8/29/2017.

38. *Atheta incognita* (Sharp, 1869)

Chorotype. Europeo-Mediterranean.

Records from caves: **I (3)** P. 1200/24 din Cheile Vârghişului, 5/24/2002.

39. *Atheta sodalis* (Erichson, 1837)

Chorotype. European.

Records from caves: **II (11)** P. Lazului, 6/26/2014.

40. *Atheta spelaea* Erichson, 1840

Chorotype. Ponto-European.

Records from caves: **III (17)** P. cu Apă de la Gârlişte, 8/29/2017; P. Liliacilor, 10/17/2017. **IV (19)** P. din Cheile Ampoiţei. **IV (20)** P. Magura (Decou, 1964).

IV (22) P. Ungurului (Decou, 1964 as *macroptera*). **V (24)** P. X din Cheia Dobrogea 5/27/200; P. Casian, 5/28/2000. **V (25)** P. Limanu, 9/18/1997; P. de la Hagieni, 5/05/1992; P. de la Gura Dobrogei, 9/20/1999.

41. *Bryaxis glabricollis* (Reichenbach, 1816)

Chorotype. European.

Records from caves: **I (3)** P. 1200/12 din Cheile Vârghişului, 6/07/2004.

42. *Bryaxis goliath* (Jeannel, 1922).

Chorotype. Carpathian endemite.

Records from caves: **IV (20)** P. de la Corobana Mândruţului (Decou, 1964).

43. *Bryaxis nodicornis* (Aube, 1833)

Chorotype. European.

Records from caves: **III (17)** P. de după Cârşă, 7/26/2002.

44. *Bryaxis ruthenus* (Saulcy, 1877)

Chorotype. Carpathian endemite.

Records from caves: **I (3)** P. 1200/10 din Cheile Vârghişului, 6/23/2004.

45. *Carpelimus bilineatus* (Stephens, 1834)

Chorotype. Palaearctic.

Records from caves: **V (24)** Casian; 5/17/1958. **V (25)** Movile (Obanul Mare); 6/25/1998.

46. *Carpelimus elongatulus* (Erichson, 1839)

Chorotype. European.

Records from caves: **I (3)** Cave in gypsum- Berteia, 6/20/2001. **IV (22)** P. din Valea Mierei (Decou, 1964).

47. *Carpelimus lindrothi* Palm, 1943

Chorotype. European.

Records from caves: **V (24)** Casian; 5/17/1958.

48. *Coprophilus striatulus* (Fabricius, 1793)

Chorotype. Holarctic.

Records from caves: **II (11)** P. Lazului, 5/23/2013.

49. *Creophilus maxillosus* (Linnaeus, 1758)

Chorotype. Holarctic.

Records from caves: **II (5)** P. Liliecilor de la Mănăstirea Bistrița (Ionescu, 1912; Decou, 1964). **II (10)** P. Fușteica, 7/23/2007.

50. *Deleaster dichrous* (Gravenhorst, 1802)

Chorotype. Holarctic.

Records from caves: **IV (22)** P. din Valea Mierei (Decou, 1964).

51. *Dinaraea arcana* (Erichson, 1839)

Chorotype. European.

Records from caves: **I (3)** P. 1200/10 din Cheile Vârghișului, 5/23/202. **III (17)** P. Liliecilor, 8/31/2017.

52. *Drusilla, canaliculata* (Fabricius, 1787)

Chorotype. Europeo-Siberian.

Records from caves: **IV (22)** P. de la Cugliș (Decou, 1964). **V (24)** Cheia Dobrogea, 5/08/1998. **V (25)** P. din Canaraua Fetei, 5/04/1998.

53. *Gabrius nigrutilus* (Gravenhorst, 1802)

Chorotype. Palaeartic.

Records from caves: **IV (22)** P. din Valea Mierei (Decou, 1964).

54. *Geostiba circellaris* (Gravenhorst, 1806)

Chorotype. Turano-European.

Records from caves: **I (3)** P. 1200/24 din Cheile Vârghișului, 6/23/2004.

55. *Gnypeta carbonaria* (Mannerheim, 1830)

Chorotype. European.

Records from caves: **IV (22)** P. din Valea Mierei (Decou, 1964).

56. *Heterotops dissimilis* (Gravenhorst, 1802)

Chorotype. Palaeartic.

Records from caves: **V (24)** Cheia-Dobrogea; 5/8/1998.

57. *Lesteva longoelytrata* (Goeze, 1777)

Chorotype. Palaearctic.

Records from caves: **II (5)** P. Liliacilor de la Mănăstirea Bistrița, (Decou, 1964). **IV (20)** P. Corobana Mandruțului, P. de la Alun, P. Tărtăroaia. **IV (22)** P. de la Vadul Crișului (Decou, 1964), P. Ponor Plopa, 5/04/2002.

58. *Lesteva monticola* Kiesenwetter, 1847

Chorotype. European.

Records from caves: **IV (22)** P. Osoi, 7/06/2016, P. Toplița de la Vida, 10/08/2018.

59. *Medon dilutus* (Erichson, 1839)

Chorotype. European.

Records from caves: **III (17)** P. cu Apa de la Gârliște, 8/29/2017.

60. *Medon fuscus* (Mannerheim, 1830)

Chorotype. Europeo-Mediterranean.

Records from caves: **V (24)** P. Casian, V/27/2000. **V (25)** P. din Canaraua Fetei, 4/4/1998; P. Movile, 5/17/1997; 11/6/1997.

61. *Medon ripicola* (Kraatz, 1854)

Chorotype. Europeo-Mediterranean.

Records from caves: **III (17)** P. Cârneală, 8/16/2006.

62. *Metopsia clypeata* (Muller, 1821)

Chorotype. Europeo-Mediterranean.

Records from caves: **III (17)** P. cu Apă de la Gârliște, 8/29/2017.

63. *Mycetoporus bimaculatus* Lacordaire, 1835

Chorotype. Turano-European.

Records from caves: **I (3)** P. 1200/13 din Cheile Vârghișului, 6/23/2004.

64. *Mycetoporus clavicornis* (Stephens, 1832)

Chorotype. W-Palaearctic.

Records from caves: **IV (20)** P. din Pereții Corlatului (Decou, 1964).

65. *Neohilara subterranea* Mulsant and Rey, 1853

Chorotype. European.

Records from caves: **I (3)** Cave in gypsum at Berteia, 6/17/2001.

66. *Ocalea picata* (Stephens, 1832)

Chorotype. Palaearctic.

Records from caves: **II (7)** P. Gura Cetății (Decou, 1964).

67. *Ocalea rivularis* Miller, 1851

Chorotype. European.

Records from caves: **II (9)** P. Garla Vacii (Decou, 1964).

68. *Ochthephilus brachypterus* Jeanel and Jarrige, 1949

Chorotype. Central-European.

Records from caves: **II (9)** P. Gârla Vacii (Decou, 1964).

69. *Ousipalia caesula* (Erichson, 1839)

Chorotype. Europeo-Mediterranean.

Records from caves: **II (12)** P. Sfodei, 10/04/2017.

70. *Omalium caesum* Gravenhorst, 1806

Chorotype. Holarctic.

Records from caves: **II (11)** P. Lazului, 7/23/2013.

71. *Omalium rivulare* (Paykull, 1789)

Chorotype. Holarctic.

Records from caves: **II (11)** P. Lazului, 7/23/2013.

72. *Omalium validum* Kraatz, 1858

Chorotype. Central-E. European.

Records from caves: **I (3)** P. Dobreștilor, 3/11/2000. **II (11)** P. Lazului, 5/23/2013. **IV (22)** P. Toplița de la Vida, 10/8/2018.

73. *Othius angustus* Stephens, 1833

Chorotype. W-Palaeartic.

Records from caves: **I (3)** P. Dobreștilor, 7/01/2003.

74. *Phyllodrepa nigra* (Gravenhorst, 1806)

Chorotype. Palaeartic.

Records from caves: **IV (19)** P. din Cheile Ampoitei, (Decou, 1964).

75. *Philonthus corvinus* Erichson, 1839

Chorotype. Europeo-Siberian.

Records from caves: **III (17)** P. cu Apă de la Gârliște, 8/29/2017.

76. *Philonthus scribai* Fauvel, 1867

Chorotype. European.

Records from caves: **V (25)** Obanul Mare, 5/17/1997, 6/25/1998; P. Movile, 12/03/1994.

77. *Plataraea spaethi* (Bernheim, 1898)

Chorotype. S-E-European.

Records from caves: **V (24)** P. de la Cheia-Dobrogea, 5/8/1998.

78. *Platystethus alutaceus* Thomson, 1861

Chorotype. Palaearctic.

Records from caves: **IV (22)** P. din Valea Mierei (Decou, 1964).**79. *Platystethus capito* Heer, 1839**

Chorotype. Palaearctic.

Records from caves: **IV (22)** P. din Valea Mierei (Decou, 1964).**80. *Proteinus brachypterus* (Fabricius, 1792)**

Chorotype. Holarctic.

Records from caves: **IV (20)** P. de la Alun (Decou, 1964).**81. *Proteinus laevigatus* Hochhuth, 1872**

Chorotype. Palaearctic.

Records from caves: **I (3)** P. Dracilor, 8/01/2003. **II (11)** P. Lazului, 7/23/2013.**82. *Proteinus longicornis* Doderò, 1923**

Chorotype. Central European.

Records from caves: **II (11)** P. Lazului, 8/06/2014. **IV (22)** P. Toplița de la Vida, 10/08/2018.**83. *Proteinus ovalis* Stephens, 1834****Chorotype. European.**Records from caves: **IV (22)** P. Osoi, 7/06/2016.**84. *Pycnota paradoxa* Mulsant et Rey, 1861**

Chorotype. European.

Records from caves: **V (25)** Obantul Mare (microcave) 5/17/1997, 8/16/1997, 6/25/1998.**85. *Quedius (Quedionuchus) cinctus* (Paykull, 1790)**

Chorotype. Europeo-Mediterranean.

Records from caves: **II (11)** P. Lazului, 6/03/2014.**86. *Quedius (Raphirus) cincticollis carpaticola* Roubal, 1924**

Chorotype. Carpathian endemite.

Records from caves: **III (17)** Avenul cel Nou din Valea Golumbului, 5/03/2002.**87. *Quedius fulgidus* (Fabricius, 1787)**

Chorotype. Europeo-Siberian.

Records from caves: **I (3)** P. Urșilor din Piatra Craiului, 2/05/2003. **V (25)** Obantul Mare, 7/17/1998; P. Limanu; 9/18/1999.

88. *Quedius humeralis* Stephens, 1832

Chorotype. Palaearctic.

Records from caves: **III (17)** P. Caprioarei (Decou, 1964). **IV (22)** P. Moanei, (Decou, 1964).

89. *Quedius invreae* Gridelli, 1924

Chorotype. European.

Records from caves: **IV (22)** P. Betfia, 8/03/2019.

90. *Quedius lateralis* (Gravenhorst, 1802)

Chorotype. European.

Records from caves: **II (11)** P. Lazului, 6/26/2014.

91. *Quedius maurorufus* (Gravenhorst, 1806)

Chorotype. European.

Records from caves: **IV (20)** P. Tărtăroaia (Decou, 1964).

92. *Quedius mesomelinus* (Marsham, 1802)

Chorotype. Cosmopolitan.

Records from caves: Widespread in caves from all biospeleological provinces (I–V) of Romania. **I (1)** P. Mare din Dealul Repedea, 7/06/2012. **II (5)** P. Liliacilor de la Mănăstirea Bistrița. **II (10)** P. Fușteica, 7/23/2013. **II (11)** P. Lazului 05/23/2013, 7/03/2013, 10/05/20014; P. Grammei, 5/27/2013, 9/08/2014; P. Balta, 7/25/2013; P. Cloșani, 9/18/2013. **II (12)** P. Topolnița, 7/25/2013. **II (13)** P. Hoților de la Băile Herculane; P. Mare de la Soroniște (Decou, 1964). **III (17)** Gaura Turcului, P. Boilor din Cheile Nerei, 7/21/2009; P. Gaura cu Muscă (Decou, 1964). **IV (19)** P. din Valea Bibarțului. **IV (20)** Coderinca lui Putui (Decou, 1964); P. Ferice, 9/11/2014. **IV (21)** P. de la Boiu (Decou, 1964). **IV (22)** P. Gruiețului, 7/04/2016; P. Moanei, 10/24/2016; P. Doboș, 10/22/2016, 8/31/2017, P. Betfia, 7/03/2019; P. Bătrânului (Decou, 1964). **V (24)** P. de la Gura Dobrogei, and more other (Decou, 1964).

93. *Quedius picipes* (Mannerheim, 1831)

Chorotype. European.

Records from caves: **III (17)** Avenul din Padina Seacă, 8/07/2007.

94. *Quedius umbrinus* Erichson, 1839

Chorotype. W-Palaearctic.

Records from caves: **IV (20)** P. Ghetarul de la Focul Viu (Decou, 1964). **V (24)** P. Casian, 5/31/2000.

95. *Stenus coarcticollis* Eppelsheim, 1890

Chorotype. E-European.

Records from caves: **IV (20)** P. din Pereții Corlatului (Decou, 1964).

96. *Stilicus rufipes* Germar, 1836

Chorotype. European.

Records from caves: **I (3)** P. Mare din Satul Peștera, 7/9/2003.**97. *Tachinus humeralis* Gravenhorst, 1802**

Chorotype. European.

Records from caves: **II (11)** P. Lazului, 5/23/2013.**98. *Tachinus lignorum* (Linnaeus, 1758)**

Chorotype. Europeo-Mediterranean.

Records from caves: **II (11)** P. Lazului, 6/03/2014.**99. *Tachinus rufipennis* (Gyllenhal, 1810)**

Chorotype. Palaearctic.

Records from caves: **IV (20)** P. din Pereții Corlatului, (Decou, 1964).**100. *Tachinus subterraneus* (Linnaeus, 1758)**

Chorotype. European.

Records from caves: **II (11)** P. Lazului, 5/23/2013. **IV (20)** P. din Pereții Corlatului (Decou, 1964).**101. *Tasgius winkleri* (Bernhauer, 1906)**

Chorotype. European.

Records from caves: **I (3)** P. 1200/12 din Cheile Vârghișului, 05/23/2002.**102. *Zyras (Pella) himeralis* (Gravenhorst, 1802)**

Chorotype. European.

Records from caves: **III (17)** P. de dupa Cârșă, 4/18/2004.**Fam. Pselaphidae****103. *Rybaxis longicornis* (Leach, 1817).**

Chorotype. Europeo-Mediterranean.

Records from caves: **V (24)** Cheia-Dobrogea, 5/8/1998.**Fam. Leiodidae****104. *Apocatops nigrita* (Erichson, 1837)**

Chorotype. European.

Records from caves: **I (1)** P. Liliștilor de la Pietrele Doamnei, 6/29/2007. **I (3)** P. 1200/24 din Cheile Vârghișului (Nitzu et al., 2007). **III (17)** P. cu Apă de la Gârliște, 8/29/2017. **IV (20)** P. de la Pîrâul Budu (Decou, 1964).

105. *Catops coracinus* Kellner, 1846

Chorotype. Palaearctic.

Records from caves: **IV (19)** P. din Valea Bibarțului (Decou, 1964).

106. *Catops fuliginosus* Eerichson, 1837.

Chorotype. European.

Records from caves: **II (11)** P. Lazului, 5/23/2013. **V (24)** P din Cheia-Dobrogea, 5/31/2000.

107. *Catops fuscus* (Panzer, 1794)

Chorotype. Europeo-Siberian.

Records from caves: **I (3)** P. Dobreștilor, 8/01/2003; P. 1200/13 din Cheile Vârghișului (Nitzu et al., 2007). **II (10)** P. Muierilor din Pârgavu (Decou, 1964). **V (24)** P. Casian, 5/28/2000.

108. *Catops nigircans* (Spence, 1815)

Chorotype. Turano-European.

Records from caves: **II (13)** P. de sub Șerban (Decou, 1964). **V (24)** P. Casian, 5/28/2000; Cheia-Dobrogea, 5/31/2000.

109. *Catops longulus* Kellner, 1846

Chorotype. European.

Records from caves: **I (3)** P. 1200/45 din Cheile Vârghișului, 6/07/2004. **IV (22)** P. Ungurului (Decou, 1964).

110. *Catops picipes* (Fabricius, 1792)

Chorotype. European.

Records from caves: **I (3)** P. 1200/10 din Cheile Vârghișului (Nitzu et al., 2007); P. Mare din Satul Peștera, 10/15/2003. **II (11)** P. Cloșani (Nitzu and Ilie, 2004); P. Lazului, 5/23/2013, 9/18/2013, 4/28/2014. **II (13)** P. Imbre (Elmer, 1921). **IV (20)** P. Mare Dâmbău; Huda de la Portiță; P. Fânațe (Decou, 1964). **IV (22)** P. Moanei, 7/05/2016.

111. *Catops subfuscus* Kellner, 1846

Chorotype. Turano-European.

Records from caves: **I (3)** P. 1200/10 din Cheile Vârghișului (Nitzu et al., 2007). **II (11)** P. Lazului, 5/23/2013.

112. *Catops tristis* (Panzer, 1794)

Chorotype. European.

Records from caves: **I (1)** P. Cobășel, 6/21/2006. **II (11)** P. cu Gheață, 7/27/2003.

113. *Choleva angustata* (Fabricius, 1781)

Chorotype. Central - S- European.

Records from caves: **II (11)** P. Lazului, 5/23/2013; P. din Valea Lupșei (Decou, 1964). **IV (22)** P. Gălășeni, 10/22/2016, Lazuri, 11/18/2016.

114. *Choleva cisteloides dacica* Jeannel, 1922

Chorotype. Carpathian endemite.

Records from caves: **IV (22)** P. Osoi, 5/18/2012; P. Viduța II, 10/22/2015; P. Meziad, 10/22/2015; P. Moanei, 7/05/2016; P. Doboș, 10/22/2016; P. II din V. Vizu; P. Vadu Crișului; P. Ferice (Decou, 1964); P. Toplița de la Vida, 10/08/2018.

115. *Choleva glauca* Britten, 1918

Chorotype. Central-E-European.

Records from caves: **I (3)** P.1200/9 Cheile Vârghișului (Nitzu, 2013). **II (7)** P. Ponorici-Cioclovina. **II (8)** P. Alunii Negri (Decou, 1964). **IV (20)** Corobana Mândruțului (Decou, 1964). **IV (22)** P. Gruiețului, 7/04/2016; P. Doboș, 7/04/2016.

116. *Choleva* (s. str.) *nivalis* (Kraatz, 1856)

(= *Choleva biharica* Fleischer, 1888)

Chorotype. European.

Records from caves: **IV (20)** P. Padiș (Elmer, 1921); P. de la Sohodolul Cicerei (Decou, 1964). **IV (21)** P. de la Boiu (Decou, 1964); **IV (22)** P. No. I-II in the Vizu Valley (Nitzu, 2013).

117. *Choleva oblonga* Latreille, 1807

Chorotype. European.

Records from caves: **II (7)** P. Piatra Barișorului. **II (11)** P. 6 din Valea Lupșei (Decou, 1964). **IV (22)** P. II de la Vizu (Decou, 1964). **V (24)** Cheia-Dobrogea, 5/8/1998.

118. *Choleva spadicea* (Sturm, 1839)

Chorotype. European.

Records from caves: **II (13)** P. de sub Șoim (Decou, 1964). **IV (20)** P. de la Alun; P. din Dealul Vârseci (Decou, 1964).

119. *Fissocatops westi* (Krogerus, 1931)

Chorotype. European.

Records from caves: **II (11)** P. Lazului, 7/23/2013; Pestera cu Gheață, 7/22/2003.

120. *Leptinus testaceus* Muller, 1817

Chorotype. European.

Records from caves: **II (8)** P. din Piatra Topliței. **II (11)** P. din Valea Lupșei; P. 11 din Valea Motrului Sec (Decou, 1964). **IV (20)** P. de la Fânațe (Decou, 1964).

121. *Liodes cinnamomea* (Panzer, 1793)

Chorotype. European.

Records from caves: **V (24)** P. Casian, 5/31/2000.**122. *Nargus badius* (Sturm, 1839)**

Chorotype. European.

Records from caves: **II (11)** P. din Valea Lupșei (Decou, 1964). **II (12)** P. Sfodei, 9/07/2014; P. din Valea Părului (Decou, 1964). **IV (20)** P. Corbeasca (V.Sighiștel), 7/03/2014. **IV (22)** P. Toplița de la Vida, 10/08/2018.**123. *Nemadus colonoides* (Kraatz, 1851)**

Chorotype. Turano-European.

Records from caves: **III (17)** Avenul de la Padina Seacă, 8/07/2007.**124. *Ptomaphagus variicornis* (Rosenhauer, 1847)**

Chorotype. Turano-European.

Records from caves: **IV (20)** P. de la Poarta Bihariei (Decou, 1964).**125. *Sciodreporides watsoni* (Spence, 1815)**

Chorotype. Europeo-Siberian.

Records from caves: **I (3)** Berteia (Cave in gypsum) 6/20/2001. **II (11)** P. Cloșani (Nitzu and Ilie, 2004), 7/26/2013. **III (17)** Microcave in Cheile Carasului, 6/01/2003.5/13/2014. **V (25)** P. Hagieni; 6/22/1998.**Fam. Silphidae****126. *Silpha carinata* Herbst, 1783**

Chorotype. European.

Records from caves: **I (3)** P. 1200/8 din Cheile Vârghișului, 6/23/2004. **V (25)** P. din Canarua Fetei; 6/23/1998.**127. *Silpha tristis* Illiger, 1798**

Chorotype. European.

Records from caves: **V (23)** P. Casavet; 5/2/1993.**Fam. Histeridae****128. *Epiurus comptus* Erichson, 1834**

Chorotype. European.

Records from caves: **IV (22)** P. Betfia, 7/03/2019.**129. *Gnathoncus nannetensis* (Marseul, 1862)**

Chorotype. European.

Records from caves: **III (17)** P. cu Apă de la Gârliște, 8/29/2017.

130. *Gnathoncus nanus* (Scriba, 1790)

Chorotype. Cosmopolitan.

Records from caves: **II (12)** P. Topolnița, 7/25/2013; 9/01/2017. **V (25)** Microcave in Obantul Mare, 5/17/1997; 6/17/1998.

131. *Pholioxenus quedenfeldti schatzmayri* (J. Muller, 1910)

Chorotype. Europeo-Mediterranean.

Records from caves: **V (25)** Microcave in Obantul Mare, 5/17/1997; 5/21/1998.

132. *Saprinus semistriatus* (Scriba, 1790)

Chorotype. W-Palaeartic.

Records from caves: **II (11)** P. Cloșani, 6/26/2014.

Fam. Trogidae**133. *Trox hispidus* Pontopidan, 1763**

Chorotype. Europeo-Centralasiatic.

Records from caves: **II (11)** P. Cloșani, 6/04/2014. **II (13)** P. Hoților de la Băile Herculane (Decou, 1964 – as *T. scaber*). **V (23)** P. Tunel de la Nufăru, 5/30/1993.

Fam. Dermestidae**134. *Dermestes (Montandonia) latissimus* Bielz, 1852**

Chorotype. Carpathian endemite.

Records from caves: **I (3)** P. Dobreștilor, 8/01/2003.

Fam. Ptinidae**135. *Ptinus dubius* Sturm, 1833**

Chorotype. W-Palaeartic.

Records from caves: **IV (20)** P. Urșilor de la Chișcău, 11/30/2011.

136. *Ptinus fur* (Linnaeus, 1758)

Chorotype. Palaeartic.

Records from caves: **I (3)** P din Satul Peștera, 10/15/2003. **V (24)** Cheia-Dobrogea, 5/27/2000.

137. *Ptinus testaceus* (Olivier, 1790)

Chorotype. Europeo-Mediterranean.

Records from caves: **V (24)** Cheia-Dobrogea, 5/27/2000.

138. *Tipnus unicolor* (Piller and Mitterpacher, 1783)

Chorotype. Holarctic.

Records from caves: **I (3)** P. de la Schitul Ialomitei (Decou, 1964 as *Niptus crenatus* Fabr.).

Fam. Salpingidae**139. *Aglenus brunneus* (Gyllenhal, 1813)**

Chorotype. European.

Records from caves: **V (25)** P. Limanu 6/23/1998.**Fam. Anobiidae****140. *Anobium punctatum* (De Geer, 1774)**

Chorotype. Cosmopolitan.

Records from caves: **III (17)** P. cu Apă de la Gârliște, 8/29/2017.**Fam. Monotomidae****141. *Rhizophagus puncticollis* C.R. Sahlberg, 1837**

Chorotype. Palaeartic.

Records from caves: **II (11)** P. Lazului, 8/06/2014; P. Cloșani, 5/13/2014.**Fam. Cryptophagidae****142. *Atomaria gibbula* Erichson, 1846**

Chorotype. European.

Records from caves: **IV (20)** P. din Pereții Corlatului (Decou, 1964).**143. *Atomaria pusilla* (Paykull, 1798)**

Chorotype. Palaeartic.

Records from caves: **IV (20)** P. din Pereții Corlatului (Decou, 1964).**144. *Cryptophagus axillaris* Reitter, 1875**

Chorotype. E – European.

Records from caves: **II (13)** P. din Plaiul Băniții (Decou, 1964). **IV (22)** P. Ungurului (Decou, 1964).**145. *Cryptophagus cylindricus* Kiesenwetter, 1858**

Chorotype. European.

Records from caves: **I (3)** P. din Satul Peștera, 10/15/2003.**146. *Cryptophagus montanus* C. Brisout de Barneville, 1863**

Chorotype. European.

Records from caves: **I (1)** P. cu Trei Intrări din Dealul Repedea, 7/06/2012. **I (3)** P. 1200/12; 1200/19 din Cheile Vârghișului, 5/23/2002; Berteza (cave in gypsum), 21/6/2001. **II (11)** P. Lazului, 9/13/2014; P. Cloșani, 9/18/2013, 3/24/2014. **III (17)** P. cu Apă de la Gârliște, 8/29/2017.

147. *Cryptophagus nitidulus* Miller, 1858

Chorotype. Central – E-European.

Records from caves: **II (13)** P. din Plaiul Banitii (Decou, 1964).

148. *Cryptophagus quercinus* Kraatz, 1852

Chorotype. Palaeartic.

Records from caves: **II (11)** P. Lazului, 5/23/2013; P. Cloșani, 9/18/2013.

149. *Cryptophagus schmidti* Sturm, 1845

Chorotype. Turano-European.

Records from caves: **V (25)** Microcave in Obantul Mare, 5/25/1998; P de la Canaraua Fetei, 5/5/1998.

150. *Cryptophagus scutellatus* Newman, 1834

Chorotype. Palaeartic.

Records from caves: **IV (22)** P. Moanei, P. Ungurului, (Decou, 1964).

Fam. Nitidulidae**151. *Amphotis marginata* (Fabricius, 1781)**

Chorotype. Turano-European.

Records from caves: **III (17)** P. Liliacilor, 8/31/2017.

152. *Eपुरaea neglecta* (Heer, 1841)

Chorotype. European.

Records from caves: **III (17)** P. Cârneală, 8/16/2006.

153. *Soronia punctatissima* (Illiger, 1794)

Chorotype. Palaeartic.

Records from caves: **III (17)** Liliacilor, 8/31/2018.

Fam Endomychidae**154. *Mycetaea subterranea* (Fabricius, 1801).**

Chorotype. Holarctic.

Records from caves: **II (11)** P. Lazului, 3/24/2013, 5/23/2013. **III (17)** P. Liliacilor, 8/31/2017; P. cu Apă de la Gârliște, 8/30/2017; P. de după Cârșă, 4/02/2002.

155. *Hylaia rubricollis* (Germar, 1843)

Chorotype. S- E-European.

Records from caves: **II (11)** P. Cloșani, 5/13/2014; P. CSER, 2002.

Fam. Tenebrionidae**156. *Blaps lethifera* Marsham, 1802**

Chorotype. Centralasiatic-European.

Records from caves: **V (25)** P. de la Canaraua Fetei; 6/23/1998; P. de la Hagieni, 5/5/1993.

157. *Blaps mortisaga* (Linnaeus, 1758)

Chorotype. Palaearctic.

Records from caves: **V (23)** P. Casavet, 5/2/1993. **V (24)** P. Casian; 5/28/2000; Cheia-Dobrogea; 5/27/2000. **V (25)** Obanul Mare, 5/10/1996; P. de la Canaraua Fetei; 6/23/1998.

158. *Blaps mucronata* Latreille, 1804.

Chorotype. European.

Records from caves: **IV (22)** P. Betfia, 7/03/2019.

159. *Scaphidema metallicum* (Fabricius, 1792)

Chorotype. European.

I (1) P. Mare din Dealul Repedea, 7/06/2012.

Fam. Lathridiidae**160. *Corticaria serrata* (Paykull, 1798).**

Chorotype. Europeo-Mediterranean.

Records from caves: **IV (20)** P. din Pereții Corlatului (Decou, 1964).

Fam. Alexiidae**161. *Sphaerosoma globosum* (Sturm, 1807)**

Chorotype. European.

Records from caves: **III (17)** P. cu Apă de la Gârliște, 8/29/2017.

Fam. Chrysomelidae**162. *Oomorplus concolor kolbei* (Scholz, 1926)**

Chorotype. Central-European.

Records from caves: **III (17)** P. cu Apă de la Gârliște, 8/29/2017.

163. *Sclerphaedon orbicularis* (Suffrian, 1851)

Chorotype. Central-European.

Records from caves: **III (17)** P. cu Apă de la Gârliște, 8/29/2017.

Fam. Curculionidae

164. *Stomodes gyrosicollis* Boheman, 1843

Chorotype. Holarctic.

Records from caves: **III (17)** P. cu Apă de după Cârșă; P.Lilieciilor, 8/31/2017.

DECOU (1964), in addition to the list of specialized cave beetles (troglobitic species), inventoried 85 non-specialized cave dwellers (troglophiles and troglonexes) registered until then in Romanian caves. In this paper, we have updated the list of non-obligate cave-dwelling beetles to **164** species. Of these, 54 species (32.9%) were recorded in caves located in at least two biospeleological provinces. To date, no species of non-obligate cave-dwelling Coleoptera have been recorded in zones I (2), II (14), II (15). It should be noted that even DECOU AND NEGREA (1969) did not mention any troglobitic species for these biospeleological zones designated by them. The identified species belong to 13 chorotypes (Fig. 2).

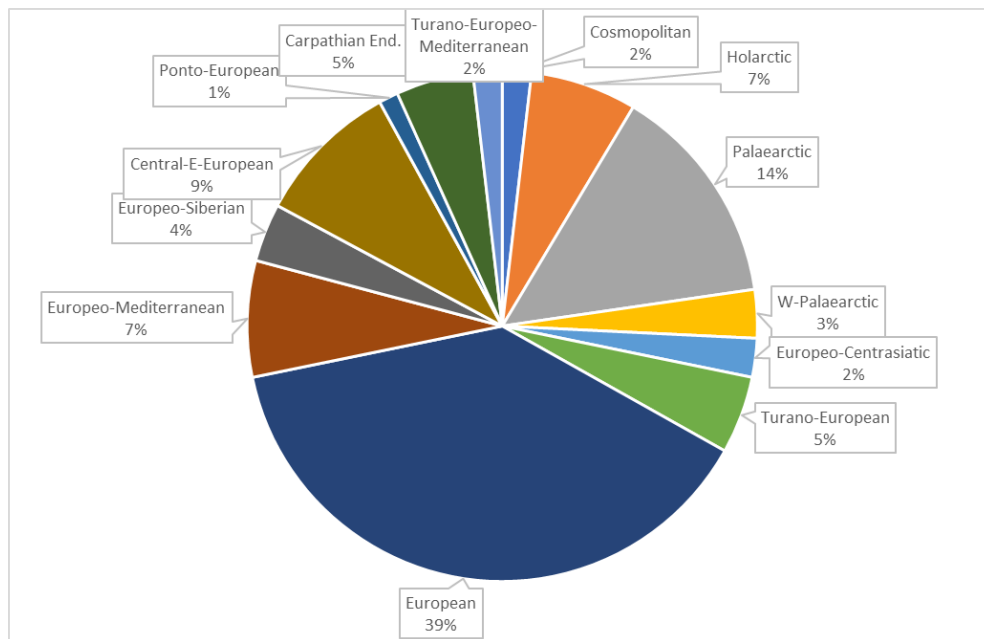


Fig. 2. Proportion of chorotypes for non-obligate cave dwelling species of Coleoptera identified in Romania.

Cluster analysis of the biospeleological provinces and zones, based on the number of caves populated by each species, in each zone, showed a large difference between most areas (Fig. 3). The observed differences between the biospeleological zones suggest an appreciable heterogeneity of the faunal associations of non-obligate cave-dwelling species between them. This contrasts with the distribution

of obligate (specialist) cave-dwelling species (troglobitic sp.), which have been shown to be characteristic of each biospeleological province (DECOU AND NEGREA, 1969) and strictly confined to these geographic areas (NITZU ET AL., 2016).

Bray-Curtis Cluster Analysis (Complete Link)

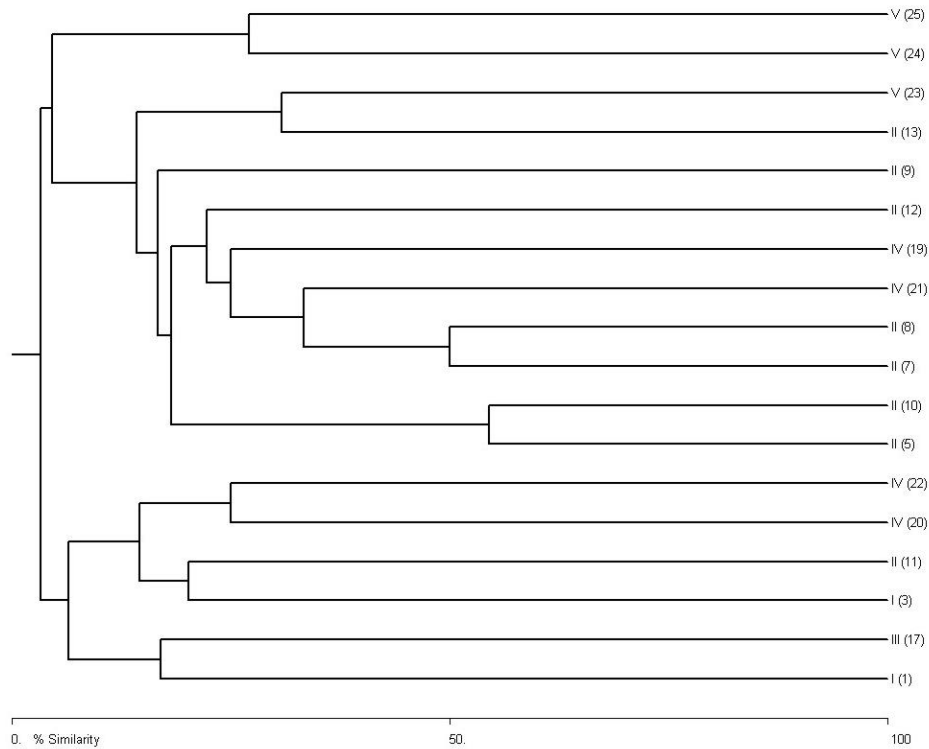


Fig. 3. The dendrogram of biospeleological zones of Romania, based on the non-obligate cave dwelling species of Coleoptera.

Unlike troglobitic species, for which the main hydrographic basins represented a true natural barrier in their geographical spreading (DECOU AND NEGREA, 1969), the non-specialist cave dwellers used these basins/ valleys to colonize new karst areas, as suggested by the results presented here. (Figs. 1 and 3). In this context, it should be mentioned here that, according to POVOLNY (1966), the species of the genus *Abax* evolved and spread in Europe from the karst “Hercynian refuge” located in the Bohemian massif. For the Romanian caves, we mentioned in this article four *Abax* species, all of them with European chorotype.

The non-specialized cave species, most of them detritivores or predators (NITZU, 2021), more vagile than troglobitic ones, have used the corridors of the main hydrographic basins to spread between regions, following the direction of valleys and water courses, in the karst landscape.

3. CONCLUSIONS

The present study, far to be exhaustive, brings important data on diversity of non-obligate cave dwelling Coleoptera in the Romanian karst landscape. More studies, based on more intensive capture effort will be necessary in biospeleological zones I (2), I (4), II (6), II (14), II (15), III (16) and IV (18) in order to have a real evaluation of the presence of Coleoptera in the Romanian caves.

Our study exemplifies, for the Romanian subterranean environments, and emphasizes the importance of the subterranean environment in preserving and spreading of the epigaeic, soil and subterranean species.

The karst areas could offer extra information in monitoring the dynamic ecological equilibrium and managing the natural areas on the Earth.

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