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Ground-beetles (Coleoptera) diversity on Maleševo mountains (North Macedonia)

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Abstract
The paper provides first data on the ground-beetle fauna of the Macedonian part of Maleševo Mts. (eastern parts of North Macedonia) collected as a result of a long-term intensive research. The material was collected by hand searching and by pitfall traps in the period of 2010-2019, in different habitat types.
In total 685 specimens belonging to 74 species from 32 genera were registered. Among them, 7 Balkan endemic, 4 subendemic, 7 rare and 1 Corine species were registered, emphasizing conservational importance of Maleševo Mts. in North Macedonia.
The obtained results supplement the knowledge about the distribution of ground-beetles on the Macedonian side of Maleševo Mountains and emphasize the conservational importance of the mountain as well.

Key words: Carabidae, faunistic data, country records, Republic of North Macedonia.

INTRODUCTION

The recognition of the importance of ground-beetles in the biodiversity protection contributed to increased faunistic research. But, despite the significant role that beetles play in ecosystems, they were poorly studied in the past, especially this is the case for the beetle diversity of Maleševo Mts. (Vlaina, Bukovik and Maleševski Planini) which are recognized as protected area on a national and international level.

The review of published literature revealed only 8 species for the Macedonian part of Maleševo Mountains (Hieke and Wrase 1988; Brajković et al. 2004; Chehlarov et al. 2016; Hristovski and Guéorguiev 2015).

Fortunately, the authors' research on Maleševo Mts. over the past years yielded a sizable amount of previously unreported faunistic data of ground-beetles which are summarized in this paper and give more comprehensive review of the present level of faunistic knowledge in this region.

STUDY AREA

The study area is situated in the eastern border mountains with Bulgaria, and includes three mountains: parts of Vlaina mountain (Kadiica, 1932 m) in the north, parts of Maleševski Planini (Džami Tepe, 1803 m) in the southeast, and the small (volcanic) mountain Bukovik (Orlovec, 1723 m) in the west which is usually considered as a part of Vlaina (Melovski et al. 2013). The area to the west is confined by Berovo valley and to the north by Delčevo valley. Maleševski Planini are medium-high mountains occupying the southeastern part of the Maleševo Region, while Bukovik is a small mountain elevation on the western side of Vlaina Mts. The study area (Fig. 1) covers surface of 10.14 km^2 on Bukovik and 5.01 km^2 on Vlaina – the whole area of Vlaina is actually 163.11 km^2 (Melovski et al. 2013). The study area on Maleševski Planini covers surface of 158.16 km^2 out its total surface of 356.43 km^2 (Melovski et al. 2013).

The most widespread soils in the region are the rankers that occur on the higher parts of Vlaina and Maleševo Mountains, while brown forest soils are mainly distributed in dense forested mountain areas (Filipovski et al. 1996).

Lower parts of the mountain (at about 900-1100 m above sea level) are under cold continental climate, with an average annual temperature range of about 9-10^oC and the annual precipitation range of 800-850

mm. Higher parts are influenced by mountain climate with the average annual temperatures between 3.5-8.5°C and the annual precipitation range of 800-1000 mm (Lazarevski 1993).

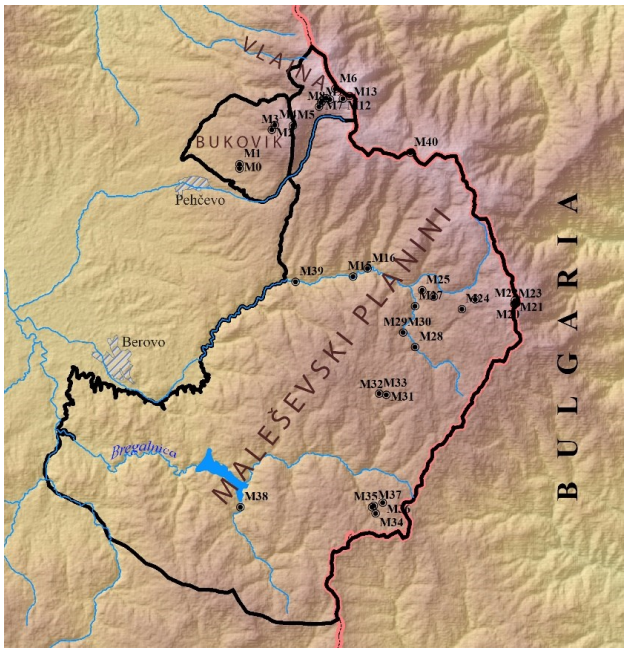

Fig. 1 Map of the studied area

MATERIAL AND METHODS

The material was collected manually and by pitfall traps during field trips on three mountains (Bukovik, Vlaina and Maleševo) in the Republic of North Macedonia, in the period 2010–2019. The research was conducted in different habitats and habitat types: wet meadows and riparian habitats (Strednjačka Reka), gravel banks of Kriva Reka, Strednjačka Reka and Zamenička Reka, wetlands (Ajdučki Kladenec, Tresčen Kamen, Čengino Kale peak), peatbogs, marshes (Tresčen Kamen - Kadiica, Elensko Blato), meadows (Mlečna, Klepalo and along Ravna Reka), cattle breeding farm (Tresčen Kamen), habitats with *Chamaecytisus* (Čengino Kale and Kadiica), hill pastures (Judovi Livadi), pastures (Mlečna, Kadiica, Tresčen Kamen and Čengino Kale peak), beech forests (Orlovec, Čengino Kale, Klepalo, Ravna Reka), *Salix caprea* stand (Čengino Kale peak), beech-fir-spruce forests (Murite), white pine-beech forest (Mlečna) and stands of *Betula pendula* (Čengino Kale).

The material is deposited in the personal collection of S. Hristovski. Sampled sites, habitats and sampling dates are presented below:

M0: **Bukovik**, Judovi Livadi, 1190 m a.s.l., peat bog, 24.06.2015, leg. S. Hristovski

M1: **Bukovik**, Judovi Livadi, hill pasture, 1210 m a.s.l., 22.91513 N 41.768136 E, 28.06.2018, leg. S. Hristovski

M2: **Bukovik**, Elensko Blato, peatbog, 1450 m a.s.l., 22.929399 N 41.779013 E, 28.06-15.08.2018, leg. S. Hristovski

M3: **Bukovik**, Elensko Blato, peatbog, 1450 m a.s.l., 22.929369 N 41.778965 E, 27.08.2019, leg. S. Hristovski

M4: **Bukovik**, Elensko Blato, peatbog, 1470 m a.s.l., 41.780519 N 22.930677 E, 28.06.2018, leg. S. Hristovski

M5: **Bukovik**, Orlovec, beech forest, 1690 m a.s.l., 41.780203 N 22.938527 E, 28.06–15.08.2018, leg. S. Hristovski

M6: **Vlaina**, Kadiica, Chamaecytisus, 1820 m a.s.l., 41.791748 N 22.957085 E, 28.06.-15.08.2018, leg. S. Hristovski

M7: **Vlaina**, Kadiica, pasture, 1820 m a.s.l., 41.787382 N 22.950874 E, 28.06.-15.08.2018, leg. S. Hristovski

M8: **Vlaina**, Tresčen Kamen, mandra, 1620 m a.s.l., 41.786072 N 22.949923 E, 13.07.2018, leg. S. Hristovski

M9: **Vlaina**, Tresčen Kamen, peatbog, 1630 m a.s.l., 41.787382 N 22.950874 E, 28.06-15.08.2018, leg. S. Hristovski

M10: **Vlaina**, Tresčen Kamen, peatbog, 1650 m a.s.l., 41.787974 N 22.951413 E, 28.06.2018, leg. S. Hristovski

M11: **Vlaina**, Tresčen Kamen, pasture, 1700 m a.s.l., 41.788832 N 22.953101 E, 28.06.2018, leg. S. Hristovski

M12: **Vlaina**, Tresčen Kamen, pasture, 1850 m a.s.l., 41.788451 N 22.960388 E, 24.06.2015, leg. S. Hristovski

M13: **Vlaina**, Tresčen Kamen, pasture, 1930 m a.s.l., 41.789329 N 22.963156 E, 24.06.2015, leg. S. Hristovski

M14: **Vlaina**, Tresčen Kamen, wetland, 1730 m a.s.l., 41.78829 N 22.954767 E, 24.06.2015, leg. S. Hristovski

M15: **Maleševski Planini**, Ravna Reka, h. Idila, beech forest, 1080 m a.s.l., 41.731107 N 22.962995 E, 29.07.2018, leg. S. Hristovski

M16: **Maleševski Planini**, Ravna Reka, meadow, 1100 m a.s.l., 41.733537 N 22.969311 E, 27.10.2014, leg. S. Hristovski

M17: **Maleševski Planini**, Čengino Kale, beech forest, 1575 m a.s.l., 41.722816 N 23.0152 E, 29.06.-28.07.2018, leg. S. Hristovski

M18: **Maleševski Planini**, Čengino Kale, Betula pendula stand, 1740 m a.s.l., 41.722134 N 23,032275 E,

28.08.-21.09.2019, leg. S. Hristovski

M19: Maleševo Mts., Čengino Kale peak, wetland, 1748 m a.s.l., 41.721288 N 23,032901 E, 29.06.-28.07.2018, leg. S. Hristovski

M20: **Maleševski Planini**, Čengino Kale peak, wetland, 1748 m a.s.l., 41.721326 N 23,032867 E, 29.06.2018, leg. S. Hristovski

M21: **Maleševski Planini**, Čengino Kale peak, pasture, 1748 m a.s.l., 41.721154 N 23,032588 E, 29.06.2018, leg. S. Hristovski

M22: **Maleševski Planini**, Čengino Kale, *Chamaecytisus* shrubland, 1750 m a.s.l., 29.06.-28.07.2018, 41.721083 N 23,032199 E, leg. S. Hristovski

M23: **Maleševski Planini**, Čengino Kale peak, *Salix caprea* stand, 1750 m a.s.l., 41.72099 N 23,032037 E, 29.06.2018, leg. S. Hristovski

M24: **Maleševski Planini**, Čengino Kale, Mlečna, pasture, 1510 m a.s.l., 41.719735 N 23,009416 E, 29.06.2018, leg. S. Hristovski & A. Cvetkovska-Gjorgjievska

M25: **Maleševski Planini**, Mlečna, *Fago-Pinetum sylvestris*, 1385 m a.s.l., 41.726058 N, 22.992221 E, 28.06.-15.08.2018, leg. S. Hristovski

M26: **Maleševski Planini**, Mlečna, meadow, 1450 m a.s.l., 41.724009 N 22.997397 E, 29.06.2018, leg. S. Hristovski

M27: **Maleševski Planini**, Kriva Reka - grip, beech forest, 1240 m a.s.l., 41.72103 N, 22.989257 E, 29.06.2018, leg. S. Hristovski

M28: **Maleševski Planini**, Kriva Reka, gravel bank, 1320 m a.s.l., 41.707865 N 22.988946 E, 21.08.2010, leg. S. Hristovski

M29: **Maleševski Planini**, Strednjačka Reka, gravel bank, 1298 m a.s.l., 41.712641 N 22.983953 E, 29.06.2018, leg. S. Hristovski

M30:**Maleševski Planini**, Strednjačka Reka, wet meadow, 1300 m a.s.l., 41.712651 N 22.983951 E, 28.06.-15.08.2018, leg. S. Hristovski

M31: **Maleševski Planini**, Murite, beech-fir-spruce forest, 1350 m a.s.l., 41.692676 N 22.976071 E, 26.10.2014, leg. S. Hristovski

M32: **Maleševski Planini**, Murite, beech-fir-spruce forest, 1350 m a.s.l., 41.692676 N 22.976071 E, 12.07.2015, leg. S. Hristovski

M33: **Maleševski Planini**, Murite, near road, 1350 m a.s.l., 41.693148 N 22.973046 E, 12.07.2015, leg. S. Hristovski

M34: **Maleševski Planini**, Klepalo, beech forest, 1250 m a.s.l., 41.654588 N 22.970262 E, 12.06.2015, leg. S. Hristovski

M35: **Maleševski Planini**, Klepalo, meadow, 1250 m a.s.l., 41.65665 N 22.968773 E, 11.07.2015, leg. S. Hristovski

M36: **Maleševski Planini**, Klepalo, meadow, 1270-1350 m a.s.l., 41.657963 N 22.973427 E, 11.07.2015, leg. S. Hristovski

M37: **Maleševski Planini**, Klepalo, meadow, 1270 m a.s.l., 41.657027 N 22.969582 E, 16.08.2017, leg. S. Hristovski

M38: **Maleševski Planini**, Berovsko Ezero, Zamenička River, gravel bank, 990 m a.s.l., 41.657551 N 22.9122 E, 28.08.2019, leg. S. Hristovski

M39: **Maleševski Planini**, meadow, 1020 m a.s.l., 41.729816 N 22.938199 E, 13.06.2018, leg. S. Hristovski

M40: **Maleševski Planini**, Ajdučki Kladenec, wetland, 1660 m a.s.l., 41.770572 N 22.988737 E, 15.08.2018, leg. S. Hristovski

RESULTS AND DISCUSSION

In total 685 specimens belonging to 74 species from 32 genera were registered (Tab. 1). *Amara* (10), *Bembidion* (8), *Carabus* (6), *Harpalus* (6) and *Pterostichus* (6) had the highest species richness, while other genera were registered with 3 to 1 species. The most abundant species was *Tapinopterus balcanicus belasicensis* (118 specimens), followed by *Calathus melanocephalus melanocephalus* (82), *Poecilus versicolor* (68) and *Carabus violaceus azurescens* (45), representing about 45.75% of total abundance.

Among species with conservation importance, the endemics are represented with the highest share (11 species), while only the species *Carabus convexus dilatatus* is noted on the CORINE list.

Pterostichus vecors, Pterostichus bruckii, Tapinopterus balcanicus belasicensis, Carabus violaceus azurescens, Carabus gigas gigas, Cyhrus semigranosus balcanicus, Zabrus balcanicus rhodopensis are Balkan endemics**,** while four species: *Xenion ignitum, Molops rufipes denteletus, Molops piceus osogovensis, Platynus scrobiculatus bulgaricus* are recognized as subendemics, with populations outside the boundaries of the researched area. Until recently we considered *Platynus scrobiculatus bulgaricus* and *Molops rufipes denteletus* as local endemics for the Osogovo Mountains, but with their discovery on Maleševo Mts, their known range of distribution has been expanded. *Amara lunicollis, Notiophilus laticollis, Pterostichus apfelbecki*,

Pterostichus diligens, Bembidion stephensii, Bembidion brunnicorne, Bradycellus caucasicus have restricted distribution and narrower habitat tolerances, therefore are considered as rare. Of these, special attention deserve *Pterostichus apfelbecki* a species with a disjunct distribution (which indicates its relictness), registered only at the locality Judovi Livadi (Chehlarov et al. 2016) and *Pterostichus diligens*, a rare species in North Macedonia, associated with peatlands and other wet habitats.

All above presented species mostly belong to Palearctic or European/Eurosiberian complexes. All of the records are from different habitat types harboring rich carabid diversity, with highest species diversity registered in wet meadows (22), habitats with *Chamaecytisus* (17), peatbogs (16), meadows (15) and wetlands (14). The refugial sites provide presence of endemic and rare species as well, highlighting the well

Table 1. A list of recorded ground-beetle species on the Maleševo Mts. [abbreviations of localities M1-M40 are presented in the Materials and Methods chapter].

Species/subspecies	Localities (number of specimens)	Specimens
1. Abax ovalis (Duftschmid, 1812)*	M25 (2), M31 (1)	3
2. Agonum sexpunctatum (Linnaeus, 1758)**	M19 (2)	2
3. Agonum viduum Panzer, 1796**	M19 (7)	7
4. Amara aenea (DeGeer, 1774)*	M1 (1)	1
5. Amara aulica (Panzer, 1796)**	M30 (1)	1
6. Amara communis (Panzer, 1797)**	M30 (13), M35 (1)	14
7. Amara convexior Stephens, 1828*	M30 (3), M39 (1)	4
8. Amara curta Dejean, 1828*	M22 (1), M30 (1), M35 (1)	3
9. Amara equestris (Duftschmid, 1812)*	M22 (2), M30 (7), M6 (4), M7 (6)	19
10. Amara littorea C. G. Thomson, 1857*	M30 (2), M9 (1)	3
11. Amara lunicollis Schiødte, 1837**	M22 (1), M6 (1)	2
12. Amara nitida Sturm, 1825**	M19 (1), M22 (1), M30 (26), M6 (1)	29
13. Amara similata (Gyllenhal, 1810)**	M19 (2)	2
14. Anchomenus dorsalis (Pontoppidan, 1763)*	M16 (2)	2
15. Anisodactylus binotatus (Fabricius, 1787)*	M30 (1)	1
16. Bembidion brunnicorne Dejean, 1831**	M3 (3)	3
17. Bembidion dalmatinum Dejean, 1831*	M14 (1), M2 (1)	2
18. Bembidion deletum Audinet-Serville, 1821*	M14 (1), M25 (1)	2
19. Bembidion geniculatum geniculatum Heer, 1837**	M3 (4), M31 (1), M4 (1)	6
20. Bembidion lampros (Herbst, 1784)*	M14 (1), M25 (7), M29 (1), M37 (1), M4 (5)	15
21. Bembidion properans (Stephens, 1828)*	M35 (2)	2
22. Bembidion stephensi Crotch, 1866**	M2 (1), M28 (2), M3 (1), M4 (2)	6
23. Bembidion tibiale (Duftschmid, 1812)*	M16 (1), M28 (7), M29 (1), M38 (5)	14
24. Brachinus explodens Duftschmid, 1812*	M16 (1)	1
25. Bradycellus caucasicus (Chaudoir, 1846)**	M20 (1)	1
26. Calathus distinguendus distinguendus Chaudoir, 1846**	M18 (1)	1
27. Calathus fuscipes (Goeze, 1777)*	M19 (1), M24 (1), M30 (2), M36 (4), M8 (1)	9
28. Calathus melanocephalus melanocephalus (Linnaeus, 1758)*	M16 (1), M18 (28), M22 (27), M24 (6), M30 (13), M36 (2), M40 (1), M6 (2), M7 (1)	81
29. Carabus convexus dilatatus Dejean, 1826*	M30 (2)	2

Species/subspecies	Localities (number of specimens)	Specimens
30. Carabus coriaceus cerisyi Dejean, 1826*	M23 (1)	1
31. Carabus gigas gigas Creutzer, 1799*	M15 (1)	1
32. Carabus hortensis Linnaeus, 1758*	M17 (1), M18 (28), M22 (1), M23 (1), M25 (5)	36
33. Carabus montivagus Palliardi, 1825*	M18 (1)	1
34. Carabus violaceus azurescens Dejean, 1826	M17 (2), M2 (1), M22 (7), M25 (5), M30 (17), M34 (2), M6 (6), M7 (3), M9 (2)	45
35. Cicindela campestris campestris Linnaeus, 1758*	M33 (1)	1
36. Cychrus semigranosus balcanicus Hopffgarten, 1881*	M17 (1), M5 (2)	3
37. Cymindis humeralis (Geoffroy, 1785)**	M36 (1)	1
38. Harpalus affinis (Schrank, 1781)	M8 (5)	5
39.Harpalus latus (Linnaeus, 1758)**	M30 (13), M6 (1)	14
40. Harpalus rufipalpis Sturm, 1818*	M2 (1), M6 (1)	2
41. Harpalus rufipes (DeGeer, 1774)*	M8 (2)	2
42. Harpalus subcylindricus Dejean, 1829*	M1 (2)	2
43. Harpalus tenebrosus Dejean, 1829**	M17 (1), M22 (1), M6 (1)	3
44. Laemostenus terricola punctatus (Dejean, 1828)**	M22 (1), M6 (3)	4
45.Leistus spinibarbis rufipes Chaudoir, 1843**	M13 (1)	1
46. Molops piceus osogovensis B. V. Guéorguiev, 1997*	M38 (2)	2
47. Molops rufipes denteletus B. V. Guéorguiev, 1997*	M17 (2), M23 (1), M6 (1)	4
48. Nebria brevicollis (Fabricius, 1792)*	M10 (1), M23 (1)	2
49. Notiophilus laticollis Chaudoir, 1850**	M6 (1)	1
50. Notiophilus substriatus C. R. Waterhouse, 1833**	M17 (1), M18 (1), M25 (5)	7
51.Ophonus azureus (Fabricius, 1775)**	M35 (2)	2
52. Panagaeus bipustulatus (Fabricius, 1775)**	M30 (2)	2
53. Paranchus albipes (Fabricius, 1796)*	M38 (1)	1
54. Platynus scrobiculatus bulgaricus Schmidt, 2009*	M32 (1), M38 (2)	3
55. Poecilus lepidus (Leske, 1785)*	M30 (3)	3
53. Poecilus versicolor (Sturm, 1824)*	M12 (1), M21 (1), M30 (61), M36 (5)	68
57. Pterostichus apfelbecki Csiki, 1908	M0 (1)	1
58. Pterostichus bruckii Schaum, 1859*	M27 (1)	1
59. Pterostichus diligens (Sturm, 1824)**	M19 (2), M2 (1), M9 (3)	6
60. Pterostichus niger (Schaller, 1783)*	M2 (16), M30 (1), M4 (1)	18
61. Pterostichus nigrita (Paykull, 1790)*	M19 (5), M9 (2)	7
62. Pterostichus strenuus (Panzer, 1796)*	M29 (1), M30 (2), M40 (1)	4
63. Pterostichus vecors (Tschitschérine, 1897)*	M17 (4), M2 (2), M25 (4), M4 (1), M5 (1), M6 (2), M9 (1)	15
64. Sinechostictus millerianus Heyden, 1883*	M28 (1), M38 (3)	4
65. Syntomus obscuroguttatus (Duftschmid, 1812)**	M30 (1)	1
66. Syntomus truncatellus (Linnaeus, 1761)**	M22 (2), M30 (2)	4
67. Synuchus vivalis (Illiger, 1798)*	M30 (4)	4

Species/subspecies	Localities (number of specimens)	Specimens
68. Tapinopterus balcanicus belasicensis Mařan, 1933*	M17 (43), M22 (5), M23 (3), M25 (48), M26 (1), M5 (2), M6 (7), M7 (8), M9 (1)	118
69. Trechus obtusus obtusus Erichson, 1837*	M30 (1)	1
70. Trechus quadristriatus (Schrank, 1781)*	M16 (1)	1
71. Trechus gr. subnotatus Dejean, 1831*	M13 (1), M40 (5)	6
72. Xenion ignitum (Kraatz, 1875)*	M17 (9), M2 (1), M22 (17), M25 (6), M27 (1), M32 (1), M6 (1)	36
73. Zabrus balcanicus rhodopensis Apfelbeck, 1904*	M11 (1)	1
74. Zabrus tenebrioides (Goeze, 1777)**	M2 (1)	1

* First records for the Macedonian part of Maleševo mountains; ** First records for Maleševo mountains (both Macedonian and Bulgarian parts)

preserved nature and conservation importance of the mountain massif.

Overall, 71 species were recorded for the first time for the Macedonian part of Maleševo mountains. The following five species known from the literature were not confirmed: *Acinopus ammophilus* Dejean, 1829, *Amara kulti* Fassati, 1947, *Lebia cyanocephala* (Linnaeus, 1758), *Pedius longicollis* (Duftschmid, 1812) and *Stenolophus teutonus* (Schrank, 1781). Thus, the total number of species for the Macedonian part of Maleševo mountains is 79.

For comparison, during a faunistic study of the ground-beetle fauna on the Bulgarian side of the Maleševo Mts, relatively high species diversity of 125 species was registered, with 11 species of conservation importance among which the above-mentioned Balkan endemics dominate (Guéorguiev and Ljubomirov 2009). Our research contributed with 25 first species records for the whole Maleševo mountains in both Macedonian and Bulgarian parts. As a result of the studies in Bulgarian and Macedonian part of Maleševo Mt. the total number of ground beetle species is 153.

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