J. Entomol. Res. Soc., 20(2): 79-90, 2018 *ISSN:1302-0250*

Contributions to the Knowledge of Darkling Beetles (Coleoptera: Tenebrionidae) of Mount Davraz (Isparta): Along with Ecological and Zoogeographical Notes

Didem KORKMAZ* Ali GÖK

Suleyman Demirel University, Art and Science Faculty, Department of Biology, 32260 Isparta, TURKEY, e-mails: *ddm_korkmaz@hotmail.com, aligok32@gmail.com

ABSTRACT

The faunal composition, altitudinal distribution, habitat preferences, seasonal changes in abundance and chorology of darkling beetles of Mount Davraz were studied in 2014. A total of 15 species that belong to 13 genera in three subfamiles were found in the research area. *Dailognatha quadricollis*, *Pimelia subglobosa polita* and *Blaps tibialis* were the most common species. The highest number of species (12) was collected during June at the elevations of 1800-2100 m. It was determined that individual number of the beetles reach the highest level in the summer season and the lowest in the autumn. Also, the most diverse habitat type was the steppe environment. In terms of the zoogeographical composition, the two species (*Raiboscelis coelestinus* and *Blaps jeannei*) are endemic to the fauna of Turkey. Except for these species, it was found that the remaining species are commonly distributed in East Mediterranean part of West Palaearctic region.

Key words: Coleoptera, darkling beetles, fauna, Mount Davraz, Isparta.

INTRODUCTION

Darkling beetles occur in all major zoogeographic regions (Palaearctic, Nearctic, Neotropic, Oriental and Ethiopian etc.) (Fattorini, 2000). They are specially diverse and abundant in semi-arid or arid regions all over the world, and considered as biological indicators of these environments (de los Santos *et al*., 2000). Members of this family are also used as model organisms in areas of extraordinarily high biological diversity (biodiversity hotspots) (Fattorini, 2006; Papadopoulou *et al*., 2009). They live mostly in the soil, under logs and rocks, and in leaf litter (Mani, 1968; Borror *et al*., 1989; Daly *et al*., 1998; Wiggins *et al*., 2007; Ghahari *et al*., 2010; Thakare *et al*., 2012). Tenebrionids usually feed on plant parts, including decaying plant litter, dead wood, pollen, fungi and algae. Some of them are scavengers, myrmecophiles, predators and cannibalistic. Some tenebrionid species are associated with stored grain and considered as common pests of crops (Brendell, 1975; Borror *et al*., 1989; Booth *et al*., 1990; Daly *et al*., 1998; Fattorini, 2000; Lillig *et al*., 2012; Thakare *et al*., 2012).

The Turkish Tenebrionidae fauna contains about 543 species, including the recent contributions of Canpolat and Hasbenli (2012), Nabozhenko and Keskin (2014), Chigray *et al*. (2015a-b) and Keskin *et al*. (2017). Up to now, some important studies

on the Turkish Tenebrionidae fauna have been carried out by Ferrer and Soldati (1999), Tezcan *et al*. (2004a-b), Keskin and Çevik (2004), Keskin (2005), Keskin and Ferrer (2006), Nabozhenko and Tichy (2006), Keskin and Yağmur (2008), Nabozhenko and Keskin (2009-2010-2013-2014-2016), Keskin and Nabozhenko (2010-2011-2012-2015), Nabozhenko (2011), Chigray *et al*. (2015a-b), Keskin *et al*. (2017). Although the darkling beetle fauna of Turkey is relatively well studied, new species are still being discovered (e.g. Nabozhenko and Keskin 2014-2016, Keskin and Nabozhenko 2015, Chigray *et al*. 2015a-b, Nabozhenko *et al*. 2016).

Davraz Mountain which is an extension of the west Taurus Mountains constitutes one of the important highlands of Turkey because of its zoogeographical location. Although several works have reported presence of some tenebrionid species in the area (Ferrer and Soldati 1999, Grimm and Schawaller 2000, Leo and Fattorini 2000, Nabozhenko and Tichy 2006, Chigray *et al*. 2015a), there are no studies in detail describing the tenebrionid composition of Mount Davraz. Therefore, main objectives of the present study are to provide information on faunal composition, habitat preferences, altitudinal distribution, phenology and zoogeography of darkling beetles inhabiting Mount Davraz.

MATERIAL AND METHODS

This study was carried out at Mount Davraz (Isparta), located in Southern Turkey (37°43′N-37°47′N, 30°41′E-30°46′E). Mount Davraz (2637 m altitude) presents many different habitat types such as forest, shrub, steppe and meadow environments.

Field surveys were performed from April to November in 2014; the surveys in the remaining months were not carried out efficiently because of heavy snow. Darkling beetle sampling was performed between 8.00-18.00 h during each sampling visit, which was conducted every two weeks, and the entire altitudinal range (900-2400 m) was divided into five 300 belts. The specimens were collected using pitfall traps and by hand collecting under stones and on the ground. A total of 50 pitfall traps (10 per belts) were randomly placed with a minimum distance of 30 m between traps. Also, the first author spent one hour walking randomly throughtout each belt, sampled underneath the rocks and on the ground in the sampling areas. The collected specimens were preserved in ethylene glycol in storage boxes. GPS information on locality and altitude, date of collection, collecting method, vegetation on which species were found and number of species collected was recorded. Ecological and zoogeographical notes, habitat preference were also given for each species. Löbl and Smetana (2008) was followed for the classification, nomenclature and distributional data of darkling beetles. Specimens were examined using a stereomicroscope and species were determined taxonomically using the identification keys by Reitter (1892-1900-1903-1907-1915-1917-1920).

RESULTS AND DISCUSSION

A total of 1650 specimens that belong to 15 species in 13 genera were collected. Ecological and zoogeographical remarks of collected species are briefly presented below.

***Zophosis punctata* Brulle, 1832**

Zophosis punctata is a psammophilic, geophilic and eurytopic species. It is an uncommon species in Mount Davraz, where it was found in steppe habitats. This Mediterranean species has a continous distribution from Spain and Morocco to Kazakhstan.

***Dailognatha quadricollis* (Brulle, 1832)**

Dailognatha quadricollis is a xerophilic, geophilic and myrmecophilous species. It is a very common species in the study area and was often found under *Astragalus microcephalus* shrubs in Mount Davraz. The distribution of the species is restricted to the Balkans and Anatolia.

***Tentyria rotundata mittrei* Solier, 1835**

It is a geophilic, psammophilic and stenotopic species often collected from areas where steppe and shrub vegetation were dominant. It is a rare speices in Mount Davraz where it prefers sandy and sandy-clay soil. It was also collected under *Astragalus microcephalus* in the subalpine area. The subspecies is confined to Greece and Turkey.

***Pimelia subglobosa polita* Solier, 1836**

Pimelia subglobosa polita is a geophilic and eurytopic subspecies. It is a very common taxon generally found in diverse habitat types such as steppe, shrub and forest. The samples were more frequently observed in moist and sun-exposed areas than in dry areas. It was also more common in areas with brown forest soil. The subspecies is distributed in Turkey, Bulgaria, Greece and Romania, Macedonia, Ukraine, the Southern European region of Russia and Kazakhstan.

***Pachyscelis quadricollis* Brulle, 1832**

It is a xerophilic, geophilic, myrmecophilous and detritivorous species. It is a relatively rare species generally found in steppe and shrub vegetation. This species was generally observed in arid areas associated to ant nests belonging to *Messor* sp. This species is only distributed in Turkey and Greece.

***Gnaptor prolixus* Fairmaire, 1866**

Gnaptor prolixus is a geophilic and detritivorous species. It is uncommon species generally collected in subalpine steppe and alpine rocky-open habitats. This species was often found under *Astragalus microcephalus* shrubs and *Verbascum* spp. leaf-litter in the colder months, especially in October-November. It is endemic to Turkey.

***Blaps tibialis* Reiche and Saulcy, 1857**

Blaps tibialis is a geophilic and detritivorous species. It is a very common species generally found in diverse habitat types such as meadow, steppe and forest in Mount Davraz. The species was also collected under *Astragalus microcephalus* and *Verbascum* spp. leaf-litter in the colder months. This species has a continous distribution along the Balkans, Anatolia, and the Southern European Region of Russia.

***Blaps jeannei* Ferrer and Soldati, 1999**

Blaps jeannei is a geophilic and detritivorous species. This species is relatively common in Mount Davraz, where it was collected in meadow, steppe and forest environments. Specimens were often found under *Astragalus microcephalus* and *Verbascum* spp. leaf litter. It is endemic to Turkey.

***Dendarus tenellus* (Mulsant and Rey, 1854)**

Dendarus tenellus is a geophilic and psammophilic species mostly collected in steppe environments in the semi-arid subalpine area. It is a common species and often found under *Astragalus microcephalus* and dead leaves of *Verbascum* spp. in the colder months. The distribution of this species is limited to Iraq, Turkey and Greece.

***Dendarus coelatus* Brulle, 1832**

Dendarus coelatus, is an uncommon geophilic and psammophilic species collected only in subalpine steppe environments at 1215 m in April. This species has a limited distribution in the South-east of the Western Palaearctic.The species is distributed in Italy, Albania, Greece and Turkey.

***Pedinus strabonis* Seidlitz, 1893**

This is a relatively common species in Mount Davraz. It is a geophilic species mostly collected from subalpine steppe environments and under stones in the alpine area. It is a typical Caucassian species distributed in Azerbaijan, Armenia, Turkey and Iran.

***Gonocephalum granulatum pusillum* (Fabricius, 1791)**

G. granulatum pusillum is a geophilic, xerophilic and detritivorous subspecies mostly collected from steppe habitats and areas with reddish-brown Mediterranean soils. It is an uncommon subspecies in Mount Davraz, where it is more frequently observed in arid areas than moist areas. This subspecies is widely distributed in the Western and Central Palaearctic.

***Opatrum alternatum* Küster, 1849**

Opatrum alternatum, is a common geophilic, psammophilic species mostly collected in steppe habitats and dominant in areas with reddish-brown Mediterranean soils. This species was also collected from soils burrowed by moles and under stones. *Opatrum alternatum* has a distribution confined to Greece, Romania and Turkey.

***Raiboscelis coelestinus* (Waltl, 1838)**

Raiboscelis coelestinus is a geophilic species mostly collected under stones in a stony mixed grassland area. It is an uncommon species in Mount Davraz. The species has a limited distribution including Turkey and Greece.

***Omophlus turcicus* Kirsch, 1869**

It is an uncommon phytophagous species collected from moist areas where grassland is dominant. This species is confined to Greece, Macedonia, and Turkey.

Faunistic remarks

As a result of collections in the study area, we found 15 species that belong to 13 genera (Table 1). Four taxa, although having previously been reported from the Mount Davraz (Ferrer and Soldati, 1999; Grimm and Schawaller, 2000; Nabozhenko and Keskin, 2017), were not found in this study: *Probaticus tenebricosus* (Brulle, 1832), *Helops glabriventris glabriventris* Reitter, 1885, *Colpotus vogti* Koch, 1944 and *Odocnemis perarmatus* Nabozhenko and Tichý, 2006.

Table 1. Number of species, dominance percentages, habitat preference and altitudinal distribution (TN: Total Number, D(%): Dominance percentages, A: 900-1200 m, B: 1200-1500 m, C: 1500-1800 m, D: 1800-2100 m, E: 2100-2400 m).

SpecieS	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	TN	D(%)	Shrub	Forest	Meadow	Steppe	Altitude
Blaps tibialis	14	54	55	13	16	57	3	5	217	13,15		+	+	+	A, C, D, E
B. jeannei	6	18	50	17	8	43	3	2	147	8,91		+	+	+	A, C, D, E
Dendarus tenellus	15	48	8	6	3	55	-	3	138	8,36				+	C, D
D. caelatus	1	-	-	-	-	-	-	-	1	0,06				+	B
Dailognatha quadricollis	-	1	86	150	219	19	-	-	475	28,78	+		+	+	A, C, D, E
Gnaptor prolixus	2	1	3	-	1	2	-	-	9	0,54				+	C, D
Gonocephalum granulatum pusillum	-	4	3	2	-	1	-	-	10	0,6		+		+	D
Omophlus turcicus	-	-	2	-	-	-	-	-	2	0,12			+		D
Opatrum alternatum	82	17	6	17	-	4	3	-	129	7,81				+	B, C, D
Pachyscelis quadricollis	-	18	2	-	3	-	-	-	23	1,39	+			+	A, D
Pedinus strabonis	2	2	1	4	9	5	36	-	59	3,57			+	+	A, B, C, D
Pimelia subglobosa polita	15	173	82	70	18	35	1	6	425	25,75		+	+	+	A, B, C, D, E
Raiboscelis coelestinus	-	-	2	-	-	2	-	-	4	0,24			+		C, D
Tentyria rotundata	4	2	-	-	1	2	1	-	10	0,6	+			+	A, B, C, D
Zophosis punctata	1	-	-	-	-	-	-	-	1	0,06				+	B
TOTAL	142	338	300	279	278	225	47	16	1650						

Habitat preferences

Results show that steppe and meadow habitats were inhabited by a higher number of darkling beetle species (13 and 7 species, respectively) than forest and shrub habitats (3 species in each habitat type) in Mount Davraz (Table 1). Crawford (1981) has reported that tenebrionids are abundant in steppe and grassland environments. Anastasiou *et al*. (2002) reported that the tenebrionids prefer the subaplin areas where the bush-steppe vegetation predominates, while the areas with coniferous trees prefer the least. Our results are consistent with the mentioned literature.

Among the Tenebrionidae species collected from Mount Davraz, *Blaps tibialis*, *B. jeannei*, *Dendarus tenellus* and *Dailognatha quadricollis* were found under *Astragalus microcephalus*, a small shrub, especially during the autumn season at 1500 m. These species were also collected under leaves of *Verbascum* spp. Shrubs provide both protection from insolation, predators (Ayal and Merkl, 1994) and cold weather conditions, as well as detritus that accumulate under the shrub canopies which constitute the main food supply for beetles (Krasnov and Shenbrot, 1997).

Dailognatha quadricollis and *Pachyscelis quadricollis* were collected from the vicinity of *Messor* sp. nests in arid areas. Crawford (1981), Rogers *et al*. (1988),

Sanchez-Pinero and Gomez (1995) similarly reported that tenebrionids are observed in nests of *Messor* sp. It is believed that the reason for observing these species in nests of *Messor* sp. is that they feed on seeds and debris accumulated around the nests. In addition, Sanchez-Pinero and Gomez (1995) also pointed out that feeding on ant-nest debris by darkling beetles expand their trophic ranges and reduce competition with other species. Furthermore, these authors consider that ant nests are preferred by some tenebrionid species because they also lay their eggs nears the nests during oviposition period.

Altitudinal preference

In this study, the highest number of individuals (1164 specimens) was collected in meadow and steppe environments at 1800-2100 m elevation, while the lowest number of beetles was collected in alpine areas at 2100-2400 m elevation (47 specimens) (Fig. 1). Higher elevations of mountains are unsuitable due to influence of various environmental factors (air temperature, carbon dioxide and oxygen levels, water vapor pressure, ultraviolet radiation, vegetation structure, etc.) (Mani, 1968; Daly *et al*., 1998). Konstantinov *et al*. (2009) have reported that mountains in the Palearctic region are rich in terms of insect diversity, but their diversity decreases towards higher altitudes. Similarly, Anastasiou *et al*. (2002) have emphasized a reduction in the number of individuals of Tenebrionidae in alpine areas compared to subapline areas because the alpine zone of the mountains, like the polar tundra regions, is a zone in which few plants can survive and the extinction rate of immigrant species is likely to be high (Cox *et al*., 2016).

Altitudinal distributions of species were evaluated according to elevation ranges (vertical intervals) which were determined as 300 meters (A: 900-1200 m, B: 1200-1500 m, C: 1500-1800 m, D: 1800-2100 m, E: 2100-2400 m). When the species were analyzed with respect to vertical distributions (Table 1), interval D has the most number of species with 13 species, followed by intervals C with 11 species, A and B with 7 species, E with 4 species (Fig. 2). Among them, *Pimelia subglobosa polita* is the only species found in all altitude ranges. The most widely distributed species following that are *Blaps tibialis*, *Blaps jeannei*, *Dailognatha quadricollis*, *Pedinus strabonis* and *Tentyria rotundata mittrei*.

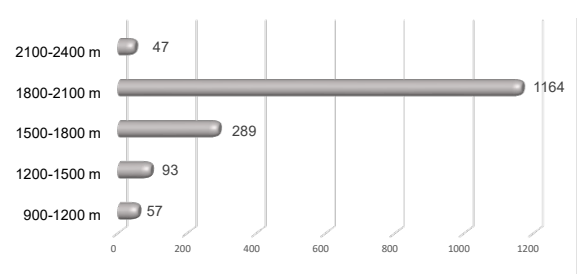

Fig. 1. Individual numbers on Mount Davraz with respect to different altitude ranges.

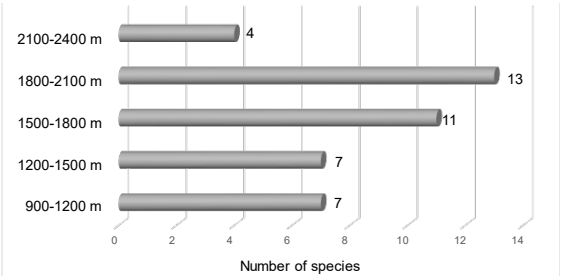

Fig. 2. Number of collected species according to vertical distribution in research area.

Phenology

The species composition and abundance of the tenebrionids are seasonally variable (Pierre, 1958; Rickard, 1970; Holm and Edney, 1973; Nepesova, 1980). Most tenebrionids are active only in spring and summer, passing the winter as larvae or as hibernating adults (Fattorini, 2008). This pattern of life history might explain the tolerance to winter length and very low winter temperatures (Fattorini and Ulrich, 2012). Also, Doyen and Lawrence (1979), Watt (1992) and Ghahari *et al*. (2010) have reported that tenebrionids can hide in soil and in nests of other animals during winter. Our field data showed that the activity period of specimens was mainly concentrated between spring and summer season. Fattorini (2008) and Ghahari *et al*. (2010) reported that tenebrionids are active in the spring and summer season. Also, Krasnov and Ayal (1995), Anastasiou *et al*. (2002) and Li *et al*. (2013) have found that tenebrionids showed the highest abundances in spring, and the lowest number of individuals in autumn. When the phenology of the species was analyzed, *Pimelia subglobosa polita* and *Opatrum alternatum* were the dominant species in spring, *Dailognatha quadricollis* and *Pimelia subglobosa polita* in summer, and *Blaps tibialis* and *Dendarus tenellus* in autumn (Fig. 3). The number of collected species was the highest in June (12 species) while the lowest number of species corresponded to November (4 species) (Fig. 4).

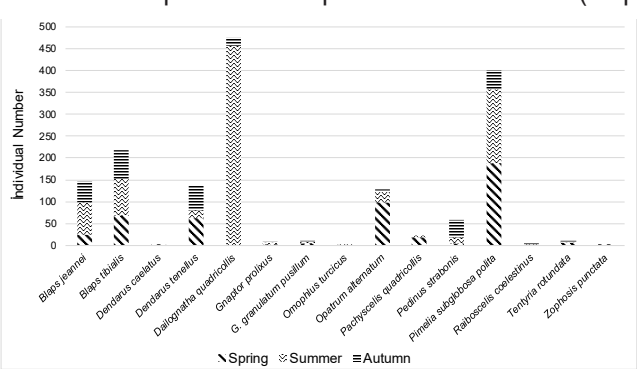

Fig. 3. Seasonal phenology of the species.

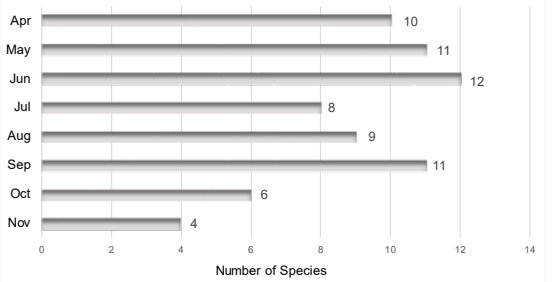

Fig. 4. Number of species according to collecting months.

Zoogeographic remarks

Each species in the faunistic list is assigned to one of the chorotypes proposed by Vigna Taglianti *et al*. (1999) and also distribution in Turkey is presented in Table 2. When the identified species are assessed as per their zoogeographical regions, it is observed that 13% of species (2 species) are endemic to the fauna of Turkey. Among the remaining species, 60% are (9 species) present in East Mediterranean, 7% in Centralasiatic-Europeo-Mediterranean, Turanian, Turano-Mediterranean and South European zoogeographical regions (1 species for each) (Fig. 5). In addition to this, most of the species collected from Mount Davraz are Mediterranean faunal elements with distributions in East Mediterranean countries. When *Zophosis punctata* and *Gonocephalum granulatum pusillum* are compared with other species, they attract attention as species having the widest distribution in the Palaearctic Region.

Table 2. Distributions in Turkey: 1, Marmara Region (MAR); 2, Aegean Region (AEG); 3, Mediterranean Region (MED); 4, Central Anatolian Region (CAR); 5, Black Sea Region (BSR); 6, Eastern Anatolian Region (EAR); 7, Southeastern Anatolian Region (SAR). Zoogeographical distributions: ETr, endemic for Turkey; SEU, South European; EME, East Mediterranean; CEM, Centralasiatic-Europeo-Mediterranean; TUR, Turanian; TUM, Turano-Mediterranean

Species	SAR	MR	AR	EAR	BR	MDR	CA
Blaps tibialis	+	+	+	+	-	+	+
B. jeannei	+	+	+	+	-	+	+
Dendarus tenellus	+	-	+	+	+	+	+
D. caelatus	-	-	+	-	-	+	+
Dailognatha quadricollis	+	+	+	+	+	+	+
Gnaptor prolixus	+	-	+	+	+	+	+
Gonocephalum granulatum pusillum	+	-	+	+	+	+	+
Omophlus turcicus	-	+	+	-	+	+	-
Opatrum alternatum	-	+	+	-	+	+	-
Pachyscelis quadricollis	-	-	+	-	-	+	-
Pedinus strabonis	+	+	+	+	+	+	+
Pimelia subglobosa polita	-	-	+	-	-	+	-
Raiboscelis coelestinus	-	-	+	-	-	+	+
Tentyria rotundata	+	+	+	+	+	+	+
Zophosis punctata	-	-	+	+	-	+	+

In order to evaluate the collected species, with respect to the regions of Turkey, 21% of species are distributed in the Mediterranean and Aegean Regions (15 species), followed by

16% in the Central Anatolian Region (11 species), 13% in Eastern Anatolian (9 species), 10% in Southeastern Anatolian and Marmara (7 species), and 9% in Black Sea regions (6 species) (Fig. 6). Also, the four species in the assemblage show two different patterns: while *Pachyscelis quadricollis* and *Pimelia subglobosa polita* are restricted to AEG and MED regions, *Dailognatha quadricollis* is found in all the regions of Turkey (Table 2).

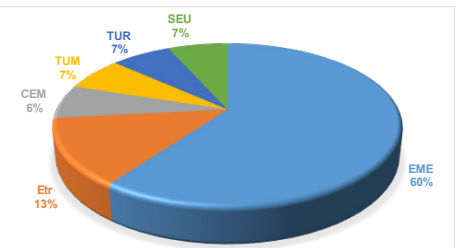

Fig. 5. Zoogeographical composition of Tenebrionidae species.

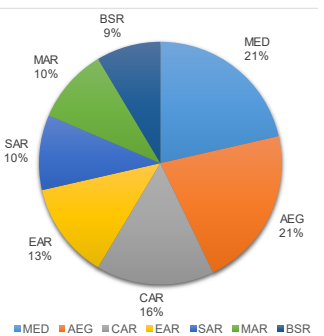

Fig. 6. Distriburion of species according to different geographical regions of Turkey.

Results presented here establish baseline data for faunistic composition and some ecological characteristics of darkling beetles of Mount Davraz and can serve as a reference study for future research. Also, the study contribute to biological richness of the Mediterranean Region of Turkey. We strongly suggest similar studies to investigate darkling beetles existence in different regions of Turkey.

ACKNOWLEDGEMENTS

We thank the Department of Scientific Research Project Management of Süleyman Demirel University (SDUBAP) for the financial supports to project number 3762-YL-213. We are also very grateful Dr. Bekir Keskin (Ege University, Biology Department, Turkey) for his contribution in species identification.

REFERENCES

Anastasiou, I., Papadopoulou, A., Legakis, A., 2002, Relationships between the Diversity of Epigean Coleoptera (Carabidae, Tenebrionidae) on Habitat Characteristics Mountain Taygetos. Book of abstracts, 9th International Congress on the Zoogeography and Ecology of Greece and Adjacent Regions, 22-25.05.2002, Thessaloniki, Greece, 5.

Ayal, K., Merkl, O., 1994, Spatial and temporal distribution of tenebrionid beetles (Coleoptera) in the Negev Highlands, Israel. *The Journal of Arid Environments,* 27: 347-361.

Booth, R. G., Cox, M. L., Madge, R. B., 1990, *The Guides to Insects of Importance to Man. 3. Coleoptera*. International Institute of Entomology, the Natural History Museum, Wallingford, UK, 384.

Borror, D. J., Triplehorn, C. A., Johnson, N. F., 1989, *Study of İnsects: Families of Coleoptera.* Thomson Learning, USA, 445-446.

Brendell, M. J. D., 1975, Handbooks for the Identification of British Insects Coleoptera (Tenebrionidae). *Royal Entomological Society of London*, London, 22.

Canpolat, D., Hasbenli, A., 2012, New Records of Tenebrioninae and Pimeliinae (Coleoptera: Tenebrionidae) from Turkey. *Journal Entomology Research Society*, 14(1): 15-20.

Chigray, I. A., Nabozhenko, M., V., Keskin, B., 2015a, A Review of the Genus *Gnaptor* Brullé, 1832 (Coleoptera, Tenebrionidae) with Description of a New Species from Turkey. *Entomological Review*, 95(8): 1131-1136.

Chigray, I. A., Nabozhenko, M., V., Keskin, B., 2015b, A New Species of the Genus *Blaps* Fabricius, 1775 (Coleoptera: Tenebrionidae) From Western Turkey. *Vestnik Yuzhnogo Nauchnogo Tsentra*, 11(2): 63-65.

Crawford, C. S., 1981, *Biology of Desert Invertebrates*. Springer-Verlag, New York, 314.

Cox, C. B., Moore, P. D., Ladle R., 2016, *Biogeography: An Ecological and Evolutionary Approach*, 9th edn. Wiley-Blackwell, John Wiley and Sons Ltd, West Sussex, 482.

Daly, H. V., Doyen, J. T., Purcell, A. H. I., 1998*, Introduction to Insect Biology and Diversity,* 2nd edn. Oxford University Press, New York, USA, 680.

de los Santos, A., Go´mez-Gonza´lez, L. A., Alonso, C., Arbelo, C. D., de Nicolas, J. P., 2000, Adaptive trends of darkling beetles (Col. Tenebrionidae) on environmental gradients on the island of Tenerife (Canary Islands). *Journal of Arid Environments*, 45: 85-98.

Doyen, J. T., Lawrence, J. F. 1979, Relationships and higher classification of some Tenebrionidae and Zopheridae (Coleoptera). *Systematic Entomology*, 4: 333-377.

Fattorini, S., 2000, Dispersal, vicariance and refuges in the Anatolian Pimeliinae (Coleoptera, Tenebrionidae): remarks on some biogeograpichal tenets. *Biogeographia*, 21: 355-398.

Fattorini, S., 2006, Detecting biodiversity hotspots by speciesarea relationships: a case study of Mediterranean beetles. *Conservation Biology*, 20: 1169-1180.

Fattorini, S., 2008, A multidimensional characterization of rarity applied to the Aegean tenebrionid beetles (Coleoptera Tenebrionidae). *Journal of Insect Conservation*, 12: 251-263.

Fattorini, S., Ulrich, W., 2012, Drivers of species richness in European Tenebrionidae (Coleoptera). *Acta Oecologica*, 43: 22-28.

Ferrer, J., Soldati, L., 1999, Contribution a l'etude des Tenebrionidae de Turquie (Insecta, Coleoptera). *Entomofauna*, 20: 53-92.

Ghahari, H., Bunalski, M., Tabari, M., Ostovan, H., 2010, Contribution to the Knowledge of Darkling Beetles (Coleoptera: Tenebrionidae) from Iranian Rice Fields and Surrounding Grasslands. *Polish Journal of Entomology*, 79: 81-90.

Grimm, R., Schawaller, W., 2000, The Genus *Colpotus* Mulsant and Rey (Coleoptera: Tenebrionidae) in the Eastern Mediterrenean Region, with Descriptions of Two New Species. *Stuttgarter Beiträge zur Naturkunde Serie A (Biologie)*, 615: 1-15.

Holm, E., Edney, E. B., 1973, Daily activity of Namib Desen arthropods in relation to climate. *Ecology*, 54: 45-56.

Keskin, B., Çevik, İ. E., 2004, *Dichomma dardanum* (Steven, 1829) (Coleoptera: Tenebrionidae) Türü İçin İki Yeni Ege Populasyonu. *Türkiye Entomoloji Dergisi*, 28(3): 207-208.

Keskin, B., 2005, A new record for the Tenebrionidae (Coleoptera) fauna of Turkey: Mesostena puncticollis Solier, 1835 (Pimeliinae: Tentyriini), *Zoology in the Middle East*, 34(1): 119-120.

Keskin, B., Ferrer, J., 2006, First record of *Xanthomus cf. ovulus* Seidlitz, 1895 (Coleoptera: Tenebrionidae) from Turkey. *Zoology in the Middle East*, 39(1): 114-116.

Keskin, B., Yağmur, E. A., 2008, A new record for the Tenebrionidae fauna of Turkey: Akis subtricostata Redtenbacher, 1850 (Coleoptera: Tenebrionidae). *Zoology in the Middle East*, 43(1): 113-114.

Keskin, B., Nabozhenko, M. V., 2010, A New Species and New Records of the Genus *Nalassus* Mulsant, 1854 (Coleoptera: Tenebrionidae: Helopini) from Turkey. *Annales Zoologici*, 60(1): 23-28.

Keskin, B., Nabozhenko, M. V., 2011, Review of the Genus *Odocnemis* Allard, 1876: *O. korbi* Species-Group (Coleoptera: Tenebrionidae: Helopini). *Annales Zoologici (Warszawa)*, 61(2): 339-354.

Keskin, B., Nabozhenko, M. V., 2012, *Idahelops alpagutae* (Coleoptera: Tenebrionidae: Helopini): A new genus and species from the Aegean region of Turkey. *Zootaxa*, 3207: 63-67.

Keskin, B., Nabozhenko, M. V., 2015, The New Genus Taurohelops (Coleoptera: Tenebrionidae) From Anatolia, Turkey. *The Coleopterists Society Monograph*, 14: 83-92.

Konstantinov, A. S., Korotyaev, B. A., Volkovitsh, M. G., 2009, *Insect Biodiversity in Palearctic Region*. *In*: Foottit, R. G., Adler, P. H. (Eds). İnsect Biodiversity: Science and Society. Wiley-Blackwell, UK, 107-162.

Krasnov, B., Shenbrot, G., 1997, Seasonal Variation in Spatial Organization of a Darkling Beetle (Coleoptera: Tenebrionidae) Community. *Enviromental Entomology*, 26(2): 178-190.

Krasnov, B., Ayal, Y., 1995, Seasonal changes in darkling beetle communities (Coleoptera: Tenebrionidae) in the Ramon erosion cirque, Negev Highlands, Israel. *Journal of Ad Environments*, 31: 335-347.

Leo, P., Fattorini, S., 2000, The zoogeographical composition and distribution of the Anatolian Pimeliini (Coleoptera, Tenebrionidae). *Biogeographia*, 21: 399-427.

Li, F. R., Liu, J. L., Liu, C. A., Liu, Q .J., Niu., R. X., 2013, Shrubs and species identity effects on the distribution and diversity of ground-dwelling arthropods in a Gobi desert. *Journal of İnsect Conservation*, 17: 319-331.

Lillig, M., Barthet, H. B., Mifsud, D., 2012, An Identification and Informative Guide to the Tenebrionidae of Malta (Coleoptera). *Bulletin of the Entomological Society of Malta*, 5: 121-160.

Löbl, I., Smetana, A., 2008, *Catalogue of Palaearctic Coleoptera*. Tenebrionidae. Apollo Books, Stenstrup, 5: 670.

Mani, M. S., 1968, *Ecology and Biogeography of High Altitude Insects*. The Hague: W. Junk N. V., Agra, 527.

Nabozhenko M. V., Tichy, V., 2006, A new species of the genus *Odocnemis* Allard, 1876 (Coleoptera, Tenebrionidae) from Turkey. *Caucasian Entomological Bull*, 2(2): 183-185.

Nabozhenko, M. V., Keskin, B., 2009, Two new species of the genus Gunarus Des Gozis, 1886 (Coleoptera: Tenebrionidae: Helopini) from Southern Turkey. *Zootaxa*, 2170: 53-60.

Nabozhenko, M. V., Keskin, B., 2010, A New Genus and Species of Darkling Beetles of the Tribe Helopini (Coleoptera, Tenebrionidae) from Turkey. *Entomological Review*, 90(9): 1215-1218.

Nabozhenko, M. V., 2011, Two new Species of the Genus *Nalassus* Mulsant, Subgenus *Helopondrus* Reitter (Coleoptera: Tenebrionidae) from Turkey. *Stuttgarter Beiträge zur Naturkunde A*, 4: 263-267.

Nabozhenko M. V., Keskin, B., 2013, Disjunctive distribution of Odocnemis protinus (Reitter, 1900), the first representative of the genus (Coleoptera: Tenebrionidae: Helopini) in Iran. *The South of Russia: ecology, development*, 3: 66-72.

Nabozhenko, M. V., Keskin, B., 2014, New Data About 'Nalassoid' Genera from South-Eastern Anatolia with Description of A New Species of *Zophohelops* (Coleoptera: Tenebrionidae). *Acta Entomologica Musei Nationalis Pragae*, 54(1): 243-249.

Nabozhenko, M. V., Keskin, B., 2016, Revision of the genus *Odocnemis* Allard, 1876 (Coleoptera: Tenebrionidae: Helopini) from Turkey, the Caucasus and Iran with observations on feeding habits. *Zootaxa*, 4202(1): 1-97.

Nabozhenko, M. V., Keskin, B., Keskin, N. A., 2016, Taxonomic review of the genus *Armenohelops* Nabozhenko, 2002 (Coleoptera: Tenebrionidae) with additional support of the mitochondrial COI gene sequences. *Caucasian Entomological Bulletin*, 12(2): 255-268.

Nabozhenko, M. V., Keskin, B., 2017, Taxonomic review of the genus *Helops* Fabricius, 1775 (Coleoptera: Tenebrionidae) of Turkey. *Caucasian Entomological Bulletin*, 13(1): 41-49.

Nepesova, M. G., 1980, *Tenebrionid beetles of Turkmenia (Biology and Ecology)*. Ashkhabad Publication, Russia, 211.

Papadopoulou, A., Anastasiou, I., Keskin, B., Vogler, A. P., 2009, Comparative phylogeography of tenebrionid beetles in the Aegean archipelago: the effect of dispersal ability and habitat preference. *Moleculer Ecology*, 18: 2503-2517.

Pierre, F., 1958, Écologie et peuplement entomologique des sables vifs du Sahara nord-occiental. Publications du Centre de Recherches Sahariennes (Série Biologie). *Centre National de la Recherche Scientifique*, Paris, 1: 342.

Reitter, E., 1892, Bestimmungs-Tablle der unecheten Pimeliden aus der Palaearktischen Fauna. *Verhandlungen der Naturforschenden Vereins in Brünn*, 31: 201-250.

Reitter, E., 1900, Bestimmungs-Tablle der Tenebrioniden-Abtheilungen: Tentyrini und Adelostomini. *Verhandlungen der Naturforschenden Vereins in Brünn*, 36: 82-197.

Reitter, E., 1903, Bestimmungs-Tablle der Tenebrioniden-Unterfamiliae: Lachnogyini, Akidini, Pedinini, Opatrini und Trachyscelini. *Verhandlungen der Naturforschenden Vereins in Brünn*, 39: 25-189.

Reitter, E., 1907, Nachtraege zur Bestimmungs-Tablle der unechten Pimeliiden aus der Palaearktischen Fauna. *Wiener Entomologische Zeitung*, 26(3): 81-92.

Reitter, E., 1915, Bestimmungs-Tablle der echten Pimeliiden aus der Palaearktischen Fauna. *Wiener Entomologische Zeitung*, 34(1-2): 1-63.

Reitter, E., 1917, Bestimmungs-Schlüssel für die Unterfamiliae und Tribus der Palaearktischen Tenebrionidae. *Wiener Entomologische Zeitung*, 36(3-5): 51-66.

Reitter, E., 1920, Bestimmungs-Tablle der unterfamilien: Belopinae, Borinae, Tenebrioninae und Coelometopinae der Tenebrioniden. *Wiener Entomologische Zeitung*, 1-24.

Rickard, W. H., 1970, The distribution of ground dwelling beetles in relation to vegetation, season, and topography in the Rattlesnake Hills, southeastern Washington. *Northwest Science*, 44: 107-113.

Rogers, L. E., Woodley, N. E., Sheldon, J. K., Beedlow, P. A., 1988, Diets of darkling beetles (Coleoptera; Tenebrionidae) within a shrub-steppe ecosystem. *Annals of the Entomological Society of America*, 81: 782-791.

Sanchez-Pinero, F., Gomez, J. M., 1995, Use of ant-nest debris by darkling beetles and other arthropod species in an arid system in south Europe. *Journal of Arid Environments*, 31(1): 91-104.

Tezcan, S., Karsavuran, Y., Pehlivan, E., Keskin, B., Ferrer, J., 2004a, Contributions to the knowledge of the Tenebrionidae (Coleoptera) From Turkey Part I. Lagriinae, Pimeliinae, Bolitophaginae, Diaperinae. *Turkish Journal of Entomology*, 28(2): 99-114.

Tezcan, S., Karsavuran, Y., Pehlivan, E., Keskin, B., Ferrer, J., 2004b, Contributions to the knowledge of the Tenebrionidae (Coleoptera) From Turkey Part II. Opatrinae, Tenebrioninae, Adeliinae. *Turkish Journal of Entomology*, 28(3): 163-180.

Thakare, V. G., Zade, V. S., Hegde, V. D., 2012, Darkling Beetles (Coleoptera: Tenebrionidae) of Melghat Tiger Reserve, Central India. *Journal on New Biological Reports*, 1(1): 29-32.

Vigna Taglianti, A., Audisio, P. A., Biondi, M., Bologna, M. A., Carpaneto, G. M., De Biase, A., Fattorini, S., Piattella, E., Sindaco, R., Venchi, A. and M. Zapparoli., 1999, A proposal for a chorotype classification of the Near East fauna, in the framework of the Western Palaearctic Region. *Biogeographia*, 20: 31-59.

Watt, J. C., 1992, *Fauna of New Zealand*: Tenebrionidae (Insecta: Coleoptera): *catalogue of types and keys to taxa***.** DSIR Plant Protection/Te Wāhanga Manaaki Tupu Auckland, New Zealand, 70.

Wiggins, G. J., Grant, J. F., Lambdin, P. L., 2007, Diversity of Darkling Beetles (Coleoptera: Tenebrionidae) from Arnold Air Force Base in the Barrens of the Eastern Highland Rim, Tennessee. *Natural Areas Journal*, 27(1): 66-71.

Received: March 10, 2017 *Accepted: January 19, 2018*