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Orijinal araştırma (Original article)

Notes on the seasonal dynamics of some coprophagous Scarabaeoidea (Coleoptera) species in Manisa province, western Anatolia

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Summary

The seasonal activity of the adult Scarabaeid (Laparosticti) beetles was monitored in 2004 and 2006 in two locations situated in different altitudes (600 m and 900 m) near Dagmarmara, Manisa province, western Turkey. Totally 33 species belonging to the families Aphodiidae, Geotrupidae and Scarabaeidae of coprophagous Scarabaeoidea are recorded in cow dung in the two localities. In the first four species with the following numbers as percentage of the total catch: *Aphodius* (s. str.) *fimetarius* (Linnaeus, 1758), 19.2 %; *Onthophagus* (*Palaeonthophagus*) *ruficapillus* Brullé, 1832, 18.8 %; *Onthophagus* (s. str.) *taurus* (Schreber, 1759), 12 % and *Onthophagus* (*Palaeonthophagus*) *medius* (Kugelann, 1792), 8.7 %. Seasonal dynamics of these recorded species are evaluated and compared with published results from mainly Europe.

Key words: Coleoptera, Aphodiidae, Geotrupidae, Scarabaeidae, coprophagous, seasonal dynamics, faunistics, Turkey, phenology

Anahtar sözcükler: Coleoptera, Aphodiidae, Geotrupidae, Scarabaeidae, koprofag, mevsimsel aktivite, faunistik, Türkiye, fenoloji

Introduction

The super-family Scarabaeoidea comprises worldwide more than 35.000 species (Ratcliffe & Paulsen, 2008). Dung-beetles, once known as Laparosticti, mainly characterized by their abdominal spiracles situated in a line on the membrane uniting sternites and tergites, including in the Palaearctics Aphodiidae, Geotrupidae, Glaresidae, Hybosoridae, Ochodaeidae, Orphnidae,

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Scarabaeidae and Trogidae represents some 15.000 species. Nearly 700 species are reported from Turkey, 350 of them being Laparosticti (Carpaneto et al., 2000; Löbl & Smetana, 2006). Only 20 % of the Laparosticti and more than 50 % in Pleurosticti are considered endemic to Turkey (Carpaneto et al., 2000; Löbl & Smetana, 2006). Pleurosticti included primarly the plant feeders and chafers and were characterized by most of the abdominal spiracles located on the upper portion of the sternites. Although the division into Laparosticti and Pleurosticti is untenable, those terms are here used for convenience.

Dung beetles feed mainly on droppings of mammals. Doing this, they decompose dung, thus benefiting both to pasture and animal health. Dung beetle activity is meant to be of crucial importance in nutrient cycles. They compete with pestiferous flies and parasitic nematodes, enrich the soil by burying large quantities of nutrient-rich dung, and effectively mix and aerate soil through tunneling (Bertone, 2004; Bertone et al., 2005).

Aphodiidae species, unlike other coprophaga, feed directly on the dung without constituting reserves for the adults or the larvae in a burrow or a gallery outside the mass: such coprophaga are called endocoprids or dwellers (Bornemissza, 1969; 1976) Food-location as in almost other groups is done by olfaction, the dung being randomly distributed on the ground. On the reverse, other coprophaga, called paracoprids or tunnelers, like Geotrupidae or Scarabaeidae, constitute reserves for themselves or their larvae in burrows or galleries under or near the dung pad (Bornemissza, 1969; 1976). A third category of dung beetles consists in the so called telecoprids or rollers, like Scarabaeinae of the genera *Sisyphus* Latreille, 1807*, Gymnopleurus* Illiger, 1803 or *Scarabaeus* Linnaeus, 1758 which pack dung into balls and roll them away from the original location for burial (Halffter & Matthews, 1966; Halffter & Edmonds, 1982).

Aphodius (s. l.) species are sometimes very numerous in the same dung-pad and a severe competition may take place for the access to food (Hirschberger, 1998), for some species even for the access to the best breeding-sites, generally located at the interface ground / dung. Due to the constraints of the dung-mass which may loose most of its properties of the fresh state in a short period, those species are rather small, have a fast larval development and sexual maturity and a reduced longevity. Paracoprids on the contrary show low fecundity, slow larval development, late sexual maturity and brood care, by building pedotrophic nests, dung-balls as food-reserves for their larvae.

Lodos et al. (1978, 1999), Carpaneto et al. (2000) and later Löbl & Smetana (2006) provide complete bibliographic references on the known faunistic, systematic, taxonomy and chorology of Turkish Scarabaeoidea. Later works to add to those bibliographies are: Alpanssèque & Tauzin (2006), Keith (2006, 2008), Nikodym & Keith (2007), Pittino (2006, 2007), Pittino & Shokhin (2006), Ziani (2006, 2009), Ziani & Gudenzi (2006, 2007, 2009).

Tezcan & Pehlivan (2001) focused their study on Scarabaeoidea occurring in ecological cherry orchads in Izmir and Manisa, including some Laparosticti. Nevertheless, up to now, no study focusing ecology of dung-inhabiting Scarabaeoidea of any part of Turkey has been published, and the only published scarce data concern taxonomic and/or faunistic problems. In previous papers, dung-inhabiting Histeridae (Anlaş et al., 2007) and Hydrophilidae (Anlaş et al., 2008) species have been evaluated.

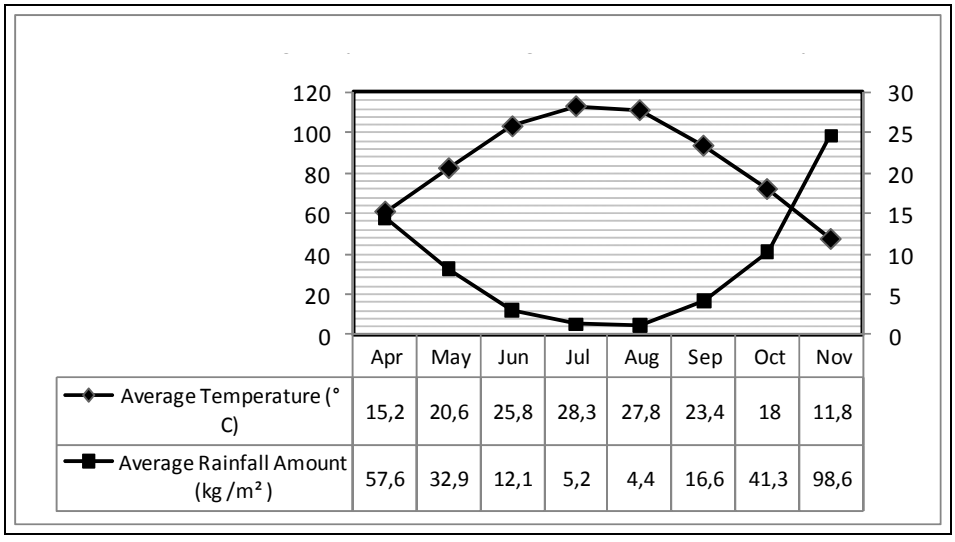
The aim of this study is to evaluate the Scarabaeoidea fauna of cow dung at two locations at different altitudes in Manisa province, western Anatolia. The results provide the first data on seasonal dynamics of these beetles in Turkey.

Material and Methods

The seasonal activity of the adult Scarabaeid (Laparosticti) beetles was monitored in 2004 and 2006 in two locations (ca 3 ha each) situated in different altitudes (600 m a.s.l. and 900 m a.s.l.) near Dagmarmara, Manisa province, Western Turkey. The coordinates of the localities are 38°23′37′'N, 27°49′09′'E and 38°20′09′'N, 27°50′47′'E, respectively (Figure 1). The location at 600 m a.s.l. is situated about 2 km north of Dagmarmara village within farm lands. From May to November there is a rainless period at this locality. There are pastures of various sizes situated among the plantations of *Pinus brutia* Ten., *Quercus* spp., *Castanea sativa* Mill. and the orchards of *Prunus avium* L., *Pyrus malus* L., *Cydonia vulgaris* Pers. on this locality. On the pastures, *Polypodium* sp., *Cistus creticus* L., *Trifolium bocconei* Savi, *Medicago* × *varia* (Martyn) Arcang., *Rubus canescens* L. occur except of grasses. On the pasture where the samples were collected, a total of 30-40 cows and several horses feed all day long on the pasture and they are brought back to their shelters at night.

The location at 900 m a.s.l. is situated ca. 5 km southeast of the pasture at 600 m, out of the agricultural land and is therefore less impacted by human activities. The samples were collected on a large pasture surrounded by the forest of *Pinus nigra* (Arnold). Except of grasses, *Polypodium* sp., *Verbascum* sp., *Juniperus oxycedrus* L., *Pyrus amygdaliformis* Vill., *Rosa canina* L., *Cistus laurifolius* L. were common on the pasture. In the study area, a total of 80-100 cows, and no other mammalians, on this pasture feed all day long without going back to their shelters at night from April up to November. According to our observation, the locality is more humid, with scarce rain even through summer period. Avarage temperature and average rainfall amount of Manisa province provided in Figure 2.

Figure 1. Map of the study area (western Turkey).



	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Average Temperature (° C)	15,2	20,6	25,8	28,3	27,8	23,4	18	11,8
Average Rainfall Amount (kg /m²)	57,6	32,9	12,1	5,2	4,4	16,6	41,3	98,6

Figure 2. Avarage temperature and average rainfall amount in Manisa province, Western Anatolia (http://www.dmi.gov.tr/veridegerlendirme/il-ve-ilceler-istatistik. aspx?m =Manisa).

For this study, both localities were visited in ca. 14-day intervals from mid April to the mid November. During the winter, cows were not present on the pastures and the beetles were therefore not sampled in this period. Samples were collected randomly by a handle shovel, placed into a plastic jars and transported to the laboratory, where the insects were separated from the dung. Fifteen samples of ca. 50 g of dung were collected during each visit on the

locality. The material referred to in this study is deposited in the Lodos Entomological Museum (LEMT), Department of Plant Protection, Aegean University (Izmir, Turkey) and first author's private collections. Taxonomy and higher classification follows Lodos et al. (1999) and Löbl & Smetana (2006).

Rössner et al. (2010) revised the status of *Onthophagus medius* in the *O. vacca* complex: in our sense, there is no doubt on the validity of their conclusions and we also consider *O. medius* (Kugelann, 1792) and *O. vacca* (Linnaeus, 1767), as specifically different, thus giving more clues on the distribution and ecology of both taxa.

Results

Species composition

In total, 3.164 specimens of 33 species from 13 genera of the Scarabaeoidea were collected at both locations during 2004 and 2006 (Table 1). Those species belonged to Aphodiidae (8 species, 1.180 specimens), Geotrupidae (2 species, 10 specimens) and Scarabaeidae (23 species, 1.974 specimens). The main four species were with the following numbers as percentage of the total catch: *Aphodius* (s. str.) *fimetarius* (Linnaeus, 1758), 19.2 %; *Onthophagus* (*Palaeonthophagus*) *ruficapillus* Brullé, 1832, 18.8 %; *Onthophagus* (s. str.) *taurus* (Schreber, 1759), 12 %; and *Onthophagus* (*Palaeonthophagus*) *medius* (Kugelann, 1792), 8.7 %. In addition, 12 species were present between 1.6-5.7 % and 17 species were accidental (< 1 %) as percentage of the total catch.

In the area located at 600 m, *O. ruficapillus* was predominant, which makes, with 271 specimens, 21.6 % of total catch at 600 m and at 900 m, *A. fimetarius* which makes, with 342 specimens, 17.9 % of total catch. Concerning the relative abundance (at 600 m / at 900 m), this species was followed in the other dominant species by *O. taurus* (7.3 % / 15 %), *O. medius* (7.8 % / 9.3 %) and *A. luridus* (4.8 % / 6.2 %). The remaining species were collected less numerous or only occasionally. In 2004, *O. ruficapillus* was the predominant species with 325 specimens and 19.7 % of total catch and in 2006, *A. fimetarius* which represented, with 310 specimens, 20.5 % of total catch.

From the species evaluated in present study, 25 were recorded from area located at 600 m and all species except for *Onitis humerosus* (Pallas, 1771) were recorded from area located at 900 m above sea level. In 2004, the number of species was 29, and in 2006, it was 30. There was just a single species found only at the elevation of 600 m whereas there were seven species only found at 900 m; the number found in both two areas was 24.

Table 1. Number of specimens collected at both altitudes during 2004 and 2006 for this study

Species	2004		2006		Sum	Ratios (%)
	600 m	900 m	600 m	900 m		
Aphodiidae						
Aphodius distinctus (Müller, 1776)	27	24	13	28	92	2.9
Aphodius erraticus (Linnaeus, 1758)	27	30	45	42	144	4.6
Aphodius fimetarius (Linnaeus, 1758)	143	155	123	187	608	19.2
Aphodius lugens (Creutzer, 1799)	4	33	0	12	49	1.6
Aphodius luridus (Fabricius, 1775)	26	52	34	67	179	5.7
Aphodius granarius (Linnaeus, 1767)	29	12	23	3	67	2.1
Aphodius scrutator (Herbst, 1789)	2	7	1	4	14	< 1
Aphodius quadrimaculatus (Linnaeus, 1761)	8	13	2	4	27	< 1
Geotrupidae						
Geotrupes spiniger (Marsham, 1802)	0	7	0	2	9	< 1
Thorectes brullei (Jekel, 1866)	0	0	0	1	1	< 1
Scarabaeidae						
Caccobius histeroides (Ménétriès, 1832)	2	2	1	5	10	< 1
Caccobius schreberi (Linnaeus, 1767)	20	48	12	27	107	3.4
Cheironitis ungaricus (Herbst, 1789)	0	3	1	2	6	< 1
Cheironitis furcifer (Rossi, 1792)	0	6	0	0	6	< 1
Cheironitis pamphilus (Ménétriès, 1849)	4	0	2	1	7	< 1
Copris lunaris (Linnaeus, 1758)	3	4	7	13	27	< 1
Euoniticellus fulvus (Goeze, 1777)	6	32	0	24	62	2
Gymnopleurus geoffroyi (Fuessly, 1775)	3	4	4	10	21	< 1
Gymnopleurus mopsus (Pallas, 1781)	0	2	0	2	4	< 1
Onitis damoetas Steven, 1806	0	2	0	1	3	< 1
Onitis humerosus (Pallas, 1771)	3	0	0	0	3	< 1
Euonthophagus amyntas (Olivier, 1789)	11	9	2	7	29	< 1
Euonthophagus atramentarius (Ménétriès, 1832)	0	0	1	4	5	< 1
Onthophagus fracticornis (Preyssler, 1790)	14	18	12	10	54	1.7
Onthophagus furcatus (Fabricius, 1781)	19	32	7	44	102	3.2
Onthophagus illyricus (Scopoli, 1763)	0	5	0	4	9	< 1
Onthophagus medius (Kugelann, 1792)	51	82	47	95	275	8.7
Onthophagus opacicollis Reitter, 1892	42	34	23	17	116	3.7
Onthophagus ruficapillus Brullé, 1832	147	178	124	145	594	18.8
Onthophagus taurus (Schreber, 1759)	68	127	23	160	378	12
Onthophagus vacca (Linnaeus, 1767)	28	12	20	8	68	2.2
Scarabaeus armeniacus Ménétriès, 1832	0	0	0	2	2	< 1
Sisyphus schaefferi (Linnaeus, 1758)	6	26	34	20	86	2.7
Total	693	959	561	951	3.164	100
Ratios %	21.9	30.3	17.7	30.1		

The number of species found only in 2004 was two; in 2006, there were three and the number of species found both in 2004 and 2006 was 27.

The total number of specimens collected in the area located at 600 m was 1.254 and 39.6 % as percentage of the total catch; 1.910 in the area located at 900 m and 60.4 % as percentage of the total catch. In 2004, the number of specimens was 1.652 (52.2 %) and in 2006 it was 1.512 (47.8 %).

Seasonal dynamics

Of the 33 species recorded during this study, the four predominant species, i.e. *Aphodius fimetarius*, *Onthophagus ruficapillus*, *O. taurus* and *O. medius* were collected in higher numbers of specimens which allows us to evaluate their seasonal dynamics on the localities (Figure 3 and 4).

A. fimetarius occurred during the whole period of sampling, but it was absent or showing low abundance in the period ca. from July to October (especially absent between the dates of 10.VIII and 10.X.2004) with peaks in May, and in October in both years and on both localities. At 600 m, the species is more abundant, and with a peak only in May, than at 900 m in 2004, but at 600 m, it is generally less abundant in the other months and in all period of 2006 than 900 m.

O. ruficapillus generally occurred during the whole period of sampling, both in 2004 and 2006. The peaks were recorded at the end of April, during May and during the second half of October and seem to coincide with peaks of *A. fimetarius* at least partly.

O. taurus occurred in the whole period of sampling at 900 m, both in 2004 and 2006, with peaks in the second half of April, first half of May and during October. But at 600 m, the species was absent or showing low abundance in all the period of 2006. At 900 m, the species was more abundant than at 600 m in 2004 and 2006.

O. medius occurred during the whole period of sampling both in 2004 and 2006, with peaks in the second half of May, second half of September and second half of October.

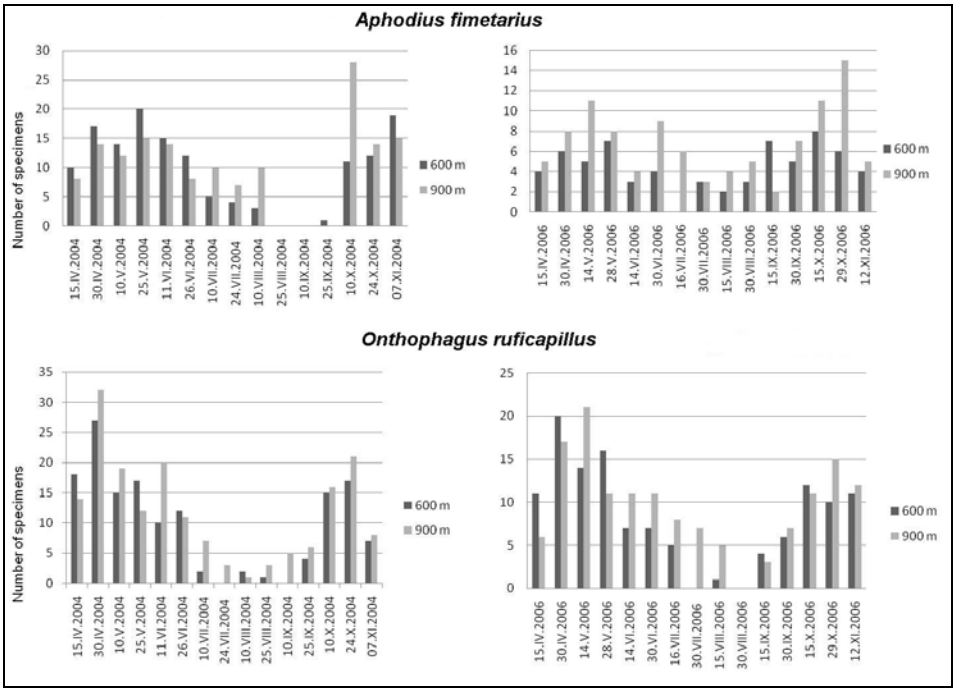


Figure 3. Seasonal dynamics of *Aphodius fimetarius* (Linnaeus, 1758) and *Onthophagus ruficapillus* Brullé, 1832 on the studied localities in Manisa, western Turkey during 2004 and 2006.

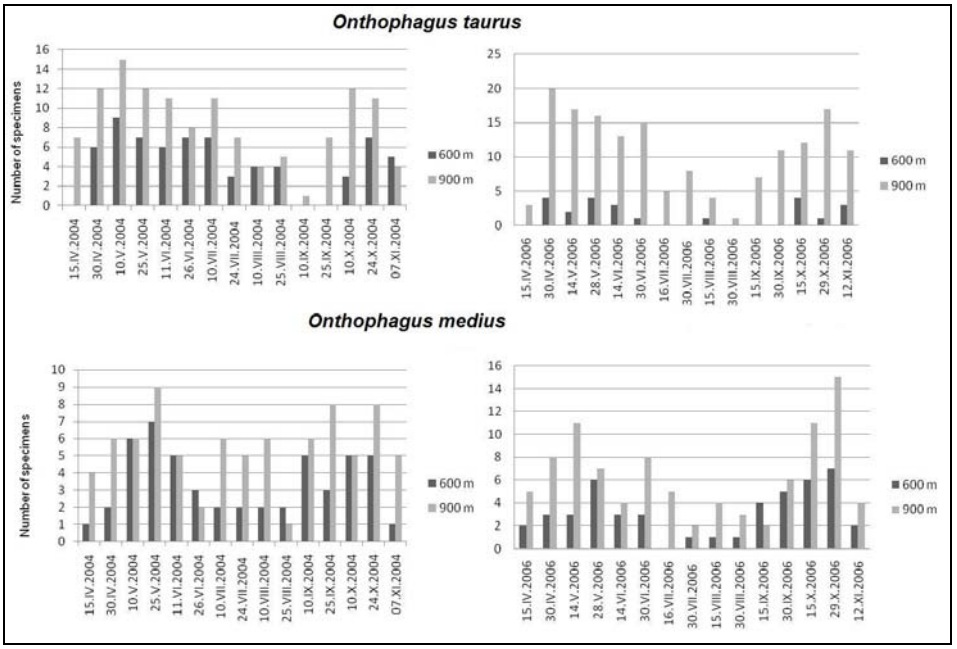


Figure 4. Seasonal dynamics of *Onthophagus taurus* (Schreber, 1759) and *Onthophafus medius* (Kugelann, 1792) on the studied localities in Manisa, western Turkey during 2004 and 2006.

Comparison with seasonal dynamics on European localities

The data on seasonal dynamics obtained by us for western Turkey can be compared with those from some European localities studied by other authors. Data from winter and early spring are absent from our study and the occurrence could not be evaluated for this period. In spite of this, our findings agree with data from Southern Europe.

Lobo (1993), analysed the relationship between species' local abundance and distribution over a range of spatial scales for a community of Iberian dung beetles. In his study, many species are identical with those of our study (*Aphodius fimetarius*, *Onthophagus vacca*, *O. taurus*, *Euoniticellus fulvus* etc.). Those species seem to be species which are well represented in dung pats. Although their average abundances in captures are small, in generally, the seasonal dynamics in this study agree with our data.

Palestrini et al. (1995) studied a dung-inhabiting beetle community at a low altitude area of an Italian Alpine valley (Pesio valley) by considering the pattern of beetle succession in droppings and their seasonality. According to the study, dung beetles showed the lowest values of species richness and diversity during August. *Onthophagus*-species mainly occurred during May and June, whereas *Aphodius* species were more diversified, with some mainly occurring during May and June, some during September, and others during July.

Errouissi et al. (2004) monitored dung beetle assemblages by monthly dung-baited pitfall trapping from July to October at five sites in the Southern Alps (Verdon Valley) at 1.000-2.000 m. According to this study, mostly *Onthophagus* spp. were predominant in most Mediterranean sites in Southern Alps during July and August, while *Aphodius* spp. predominated August-assemblages. During the September- and October-periods, Scarabaeidae decreased and, in turn, Aphodiinae became predominant in most assemblages.

Jay-Robert et al. (2008) sampled annual dung beetle assemblages in two sub-Mediterranean sites in southern Europe, which differed by 600 m in elevation. According to this study, the Scarabeid species occurred in the whole period of sampling, with peaks in April, in September and October in both low and medium elevation sites with showing low abundance in the period ca. from June to August.

In our study, in generally, most of the collected species were not predominant if compared with each other. Many species of our study were absent or showing low abundance in the period ca. from July to August with peaks in spring and in autumn in both years and on both localities. The climate imposes a marked seasonality on the southern temperate dung-beetle communities of Europe, with a decrease in activity during the summer droughts,

especially at low altitudes (Lumaret & Kirk, 1991). This was also observed in our study where very low values of species diversity, species richness, and species abundance were in fact recorded during July and August, in keeping with local climate data.

According to Rössner et al. (2010), the ranges of *O. vacca* and *O. medius* overlap. *O. medius* have a generally shorter period of activity that peaks during May. They have a much wider distribution in the humid and temperate climate and occurs much further north than *O. vacca.* According our results, *O. medius* occurred during the whole period of sampling with peaks in the second half of May, second half of September and second half of October. In addition, they were showing low abundance at 600 m than 900 m.

Discussion

The characteristic feature of coprophilous insect communities in temperate regions is the dominance of dung beetles (Scarabaeoidea), especially small species belonging to the genus *Aphodius* (Bajerlein, 2009). Almost all Palearctic Laparosticti are coprophagous however some species turned out to be saprophagous e.g. among the family Aphodiidae (Hanski & Cambefort, 1991). According to our study, *Aphodius fimetarius* was the predominant species and this species is considered to be bivoltine and euryoic (Paulian & Baraud, 1982), where it can be found in large populations (Merritt & Anderson, 1977). According to Hanski (1980), species richness of *Aphodius* is greatest in early summer, while the outbreaks of the species usually occur in spring, late summer, and autumn. The phenological differences within Aphodiidae were always significantly higher than the seasonal differences between dung-dwellers and soil-diggers. *Onthophagus* species must arrive at the dung when it is still fresh and scarcely used by other beetles. In most of the *Aphodius*-species, conversely, the entire egg, larval, and pupal development typically takes place in the dung and, therefore, also considering their high fecundity, it is not essential that these beetles should quickly colonize the dung pads (Palestrini et al., 1995).

According to Errouissi et al. (2004), in the Southern Alps species diversity diminished when elevation increased, because the fauna at altitude was roughly a rarefied sample from the valley fauna, as was shown in most southern mountains in the Iberian Peninsula (Jay-Robert et al., 1997). On the contrary, in temperate sites, diversity and abundance generally increased with increasing elevation and many Aphodiidae species exploited a large range of niches. Our findings agree with this data: at 900 m, species diversity and the total number of specimens collected were higher than at 600 m. The altitude of the sites is the main factor that influences the diversity of these dung beetle assemblages. The

peak in species richness at middle elevations, the higher number of geographically restricted species at lower altitudinal levels, and the compositional differences along with these mountain gradients seem to result from the mixing at these altitudes of dung beetle assemblages that have different environmental adaptations and, probably, different origins (Escobar et al., 2005). The temperature and moisture seem to affect considerably the seasonal dynamics, limiting the abundance of the beetles especially during the dry and hot summer period in lower latitudes.

According to Roslin (2001), ecological variation among community members is a crucial factor in the analysis of local community composition, and that local species richness should always be conditioned by regional richness. The dung pat species richness in our study and the study of Lobo et al. (2007), was dominated by Scarabaeinae in spite of the fact that the number of Aphodiinae that occur at each locality is higher. According to Lobo et al. (2007), this is probably because the more abundant species of Scarabaeinae species are able to colonize a larger number of dung pats in each locality than the generally rare Aphodiinae.

Such differences suggest that seasonal dynamics is labile and they could be modified by species-species interactions (including competition) as well as by weather or other abiotic factors.

To sum up, even though the coprophilous Scarabaeoidea exhibit some interspecific variation in their seasonal dynamics, they seem to have a rather fixed breading pattern.

Özet

Manisa yöresindeki bazı koprofag Scarabaeoidea (Coleoptera) türlerinin mevsimsel aktiviteleri üzerine notlar

Bu çalışmada, 2004 ve 2006 yıllarında Batı Anadolu'da Manisa İli'ndeki, Dagmarmara yakınlarında bulunan iki lokalitenin, farklı yüksekliklerinde (600 m ve 900 m) ergin Scarabaeid (Laparosticti) türlerinin mevsimsel aktiviteleri araştırılmıştır. Bu iki lokaliteden elde edilen inek gübresinde bulunan Aphodiidae, Geotrupidae ve Scarabaeidae familyalarından 33 koprofag Scarabaeoidea türü kaydedilmiştir. Toplam örnek sayısı ve oransal durumu esas alındığında ilk dört tür sırasıyla şunlardır: *Aphodius* (s. str.) *fimetarius* (Linnaeus, 1758), % 19.2; *Onthophagus* (*Palaeonthophagus*) *ruficapillus* Brullé, 1832, % 18.8; *Onthophagus* (s. str.) *taurus* (Schreber, 1759), % 12 ve *Onthophagus* (*Palaeonthophagus*) *medius* (Kugelann, 1792), % 8.7. Kaydedilen türlerin mevsimsel aktiviteleri değerlendirilmiş ve temel olarak Avrupa'dan yayınlanan sonuçlarla karşılaştırılmıştır.

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