

Orijinal araştırma (Original article)

Comparison of Alticini (Coleoptera: Chrysomelidae: Galerucinae) species diversity in different habitats selected from Bafa Lake Natural Park (Aydın) basin with a new record for Turkish fauna¹

Türkiye faunası için yeni bir kayıtlarla birlikte Bafa Gölü Tabiat Parkı (Aydın)'ndan seçilmiş farklı habitatların Alticini (Coleoptera: Chrysomelidae: Galerucinae) tür çeşitliliğinin kıyaslanması

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Summary

Alticini species composition, richness and abundance were studied comparatively in four different habitats with different floristic characteristics chosen from Bafa Lake Natural Park. The study was conducted regularly at 15-day intervals during 2012 and 2013. A total of 480 individuals belonging to 10 genera and 55 species of Alticini were collected. Among them *Longitarsus aeruginosus* (Foudras, 1860) (Coleoptera: Chrysomelidae) was determined as new record for the Alticini fauna of Turkey and is presented with related figures. According to Shannon-Wiener, Simpson and Berger-Parker indices of diversity, Meadow area 1 (MA1) was detected as the most diverse habitat. Jaccard and Bray-Curtis similarity indices showed that Alticini communities in Olive grove area 1 (OGA1) and Meadow area 1 (MA1) were more closely related. Data gathered from regular samplings were also displayed by graphics obtained from analyses of Rarefaction and Abundance plot k-dominance. The reasons affecting species diversity of areas were discussed.

Keywords: Alticini, diversity, Bafa Lake Natural Park, new record, Turkey

Özet

Bafa Gölü Tabiat Parkı'ndan seçilen farklı floristik özelliklere sahip dört alanın Alticini tür kompozisyonu, çeşitliliği ve benzerliği karşılaştırmalı olarak çalışılmıştır. Araştırma 2012 ve 2013 yılları boyunca 15 günlük periyotlarla gerçekleştirilmiştir. Çalışmada 10 cinse bağlı 55 türe ait toplam 480 Alticini bireyi toplanmıştır. Bu türlerden *Longitarsus aeruginosus* (Foudras, 1860) (Coleoptera: Chrysomelidae) Türkiye Alticini faunası için yeni kayıt olarak belirlenmiştir ve ilgili şekillerle birlikte sunulmuştur. Shannon-Wiener, Simpson ve Berger-Parker çeşitlilik indekslerine göre Çayırılık Alan 1 tür çeşitliliği en yüksek alan olarak tespit edilmiştir. Jaccard ve Bray-Curtis benzerlik indeksleri, Çayırılık Alan 1 ve Zeytinlik Alan 1'in daha yakın ilişkili olduğunu göstermiştir. Sonuçlar Rarefaction ve Abundance plot k-dominance analizlerinden elde edilen grafiklerle de desteklenmiştir. Alanların tür çeşitliliğini etkileyen muhtemel sebepler tartışılmıştır.

Anahtar sözcükler: Alticini, çeşitlilik, Bafa Gölü Tabiat Parkı, yeni kayıt, Türkiye

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Introduction

The flea beetles, tribe Alticini, make a highly diverse group of leaf beetles comprising of around 600 genera and 11,000 described species. The total number of Palearctic flea beetle fauna has reached to 2400 species, classified in 64 genera (Biondi & D'Alessandro, 2012; Kang et al., 2013; Konstantinov et al., 2013; Nadein, 2013). Turkish Alticini fauna contains 22 genera and about 340 species (Ekiz et al., 2013; Özdikmen et al., 2014). Despite some efforts to identify the actual number of species, studies focusing on Alticini species diversity and composition patterns are still very limited in Turkey.

Members of Alticini are highly specialized phytophagous insects, most of them being mono- or oligophagous (Biondi et al., 2013). Adult flea beetles feed on various parts of the plants, including leaves and non-woody stems (Konstantinov & Tishechkin, 2004). Some of them are serious agricultural pests causing direct damage or transmitting viruses, however several species are beneficial due to their importance as biological control agents of weeds (Booth et al., 1990; Jolivet & Verma, 2002). The remarkable diversity of the group is correlated with their specific feeding habits. Huge population densities on their host plants have made alticines considerable ecologically and economically important. Detailed knowledge of species diversity patterns is therefore important for conservation biology, biodiversity monitoring and community ecology (Aslan, 2010).

Natural parks are landscape protected by means of long-term planning, use and agriculture. These valuable landscapes are preserved in their present state and promoted for tourism purposes. Currently, a total of 189 natural parks are located in Turkey (MFWA, 2013) and Bafa Lake is one of them. The natural parks are of great importance for the diversity of phytophagous insects because of their rich floristic composition. However, detailed faunistical studies on Alticini group are absent or very limited in especially western parts of Turkey. Bafa Lake is also important being a protected wetland area with high plant diversity. So, the aims of this study are to: (i) survey the Alticini fauna of Bafa Lake Natural Park located in western Turkey, (ii) compare the species diversity and faunal similarity among different habitats with several characteristics chosen from the lake basin, and (iii) add one more species to the Alticini fauna of Turkey.

Material and methods

Study site

The survey was carried out in Bafa Lake Natural Park situated in the Aegean Region of Turkey around the borders of Söke District (Aydın) and Muğla Province (Fig.1). Bafa Lake is located between 37° 28' N and 37° 32' N longitudes – 27° 22' E and 27°32' E latitudes, covering an area of 65–70 km², and at an altitude of 2.5–3 m. Its maximum depth changes seasonally between 20-23 m (Öztürk et al., 2002).

The lake was formerly a bay of the Aegean Sea, later isolated from the sea as a result of alluvium blockage of the opening of Latmos Bay caused by alluvial deposits of the Greater Menderes River. Bafa Lake (including its surroundings) was declared as Natural Park by the Turkish government in 1994. It is also included in the list of international RAMSAR agreement which was organized for protecting the important wetlands (MFWA, 2013).

Four sites bordering the lake and representing different floristic compositions were selected for the inventory. The main characteristics of these habitats are as follows:

Meadow area 1 (MA1) is located in the east coast of Bafa Lake. It has a flat bottom area and is entirely covered with grassy vegetation. The site is mostly dominated by members of plant families viz., Lamiaceae, Poaceae, and Fabaceae. Open areas like that without woods and larger groups of trees tend to have great proportions of herbs. Likewise it has a quite rich floristic composition as compared to other sites.

Meadow area 2 (MA2) is located in the north coast of the lake. Plants belonging to Malvaceae and Poaceae families are mainly dominant in this area. It has a virtually uniform herbaceous cover as compared to MA1.

Olive grove area 1 (OGA1) is located in the south-east coast of Bafa Lake. Olive trees, one of the representatives of the typical Mediterranean climate, are especially common in the southern parts of the lake. Beside olive trees, members from the families Poaceae, Boraginaceae, Lamiaceae and Brassicaceae form the widespread plant species of the area.

Olive grove area 2 (OGA2) is located in the southwest coast of the lake and situated on the side of the Greater Menderes Basin. Shrubby plants, such as juniper and carob, constitute the majority of the vegetation. The area is much exposed to human impact compared to others.



Figure 1. Location of the Bafa Lake showing the study sites around the natural park.

Sampling method and collection

Field surveys were performed at 15-day intervals from March to September in 2012 and February to November in 2013. Adult flea beetles were collected from various plants using an entomological sweep-net and mouth aspirator. Sampling was performed in each study site respectively each consisted of 750 sweeps of the net. Collected beetles were taken to the laboratory to be mounted and labeled. Specimens were identified to species level under a LEICA EZ4 stereo-microscope using the taxonomic keys and figures given by Čížek & Doguet (2008), Warchałowski (2010) and Konstantinov et al. (2011). The insect samples are deposited at the Biology Department of Süleyman Demirel University, Isparta, Turkey.

Data analysis

Species composition, diversity and similarity of Alticini communities in the four study sites of Bafa Lake Natural Park were examined by using the program BioDiversity Pro (McAleece et al., 1997). The Shannon-Wiener (H'), Simpson ($1/D$) (for measuring diversity), and Berger-Parker ($1/d$) (considering the dominance) were used as the alpha-diversity indices (Equations 1-3). The Jaccard (C_j) and Bray-Curtis (C_N) indices were used to determine the degree of similarity in species composition between the Alticini communities of different sites (Equations 4 and 5). The similarity dendrograms obtained from the results of cluster analysis were plotted (Magurran, 2004). Sample-based rarefaction curves and k-dominance plots were created to describe Alticini communities in more detail.

Shannon-Wiener diversity index is defined as

$$H' = -\sum p_i \ln(p_i) \quad (1)$$

Simpson index is defined as

$$D = \sum p_i^2 \quad (2)$$

Berger-Parker index is defined as

$$d = \frac{N_{max}}{N} \quad (3)$$

The quantity p_i is the proportion of individuals found in the i th species, S is the number of species, N is the total number of individuals, N_{max} is the number of individuals in the most abundant species (Magurran, 2004). For Simpson's index and Berger-Parker index of dominance, the reciprocal forms ($1/D$ and $1/d$) were used so that an increase in the value of index accompanies an increase in diversity and a reduction in dominance.

Cluster analyses were performed by using Jaccard and Bray-Curtis indices in order to determine the similarity among the sites.

Jaccard index is defined as

$$C_j = \frac{a}{a+b+c} \quad (4)$$

Bray-Curtis index is defined as

$$1 - C_N \quad (C_N = \frac{2jN}{N_a + N_b}) \quad (5)$$

where N_a is the total number of individuals in area A, N_b is the total number of individuals in area B, and $2jN$ is the sum of the lower of the two abundances for species found in both areas (Magurran, 2004).

Results

Species diversity and composition

A total of 480 flea beetles belonging to 10 genera and 55 species were recorded as a result of field studies carried out during two years in four different sites selected from surroundings of Bafa Lake Natural Park (Table 1).

Table 1. List of Alticini species collected from the four sites in Bafa Lake Natural Park

Species	MA1	MA2	OGA1	OGA2	Total number	Relative Abundance (%)
<i>Phyllotreta</i> Chevrolat						
<i>P. punctulata</i> (Marshall)	4				4	0.83
<i>P. atra</i> (Fabricius)	7				7	1.46
<i>P. fallaciosa</i> Heikertinger		4			4	0.83
<i>P. bulgarica</i> Gruev		5			5	1.04
<i>P. erysimi</i> Weise				6	6	1.25
<i>P. lativittata</i> Kutschera				2	2	0.42

Table 1. List of Alticini species collected from the four sites in Bafa Lake Natural Park (continued)

Species	MA1	MA2	OGA1	OGA2	Total number	Relative Abundance (%)
<i>P. nigripes</i> (Fabricius)			5		5	1.04
<i>P. vittula</i> (Redtenbacher)		4			4	0.83
<i>P. corrugate</i> Reiche				11	11	2.29
<i>Aphthona</i> Chevrolat						
<i>A. warchalowskii</i> Fritzlar			3		3	0.63
<i>A. kuntzei</i> Roubal				2	2	0.42
<i>A. pygmaea</i> (Kutschera)		5			5	1.04
<i>Longitarsus</i> Berthold						
<i>L. albineus</i> (Foudras)			24	27	51	10.63
<i>L. baeticus</i> Leonardi	9	7	8	16	40	8.33
<i>L. anchusae</i> (Paykull)			7		7	1.46
<i>L. aeruginosus</i> (Foudras)	13				13	2.71
<i>L. pellucidus</i> (Foudras)			4		4	0.83
<i>L. tabidus</i> (Fabricius)	3		8		11	2.29
<i>L. cerinthes</i> (Schränk)				2	2	0.42
<i>L. ochroleucus</i> (Marsham)				5	5	1.04
<i>L. nigrofasciatus</i> (Goeze)				3	3	0.63
<i>L. luridus</i> (Scopoli)	5	3		8	16	3.33
<i>L. angelikae</i> Fritzlar				4	4	0.83
<i>L. foudrasi</i> Weise		2			2	0.42
<i>L. fallax</i> Weise		2			2	0.42
<i>L. aeneicollis</i> (Faldermann)	5				5	1.04
<i>L. atricillus</i> (Linnaeus)	2				2	0.42
<i>L. succineus</i> (Foudras)	2				2	0.42
<i>L. ballotae</i> (Marsham)	8		6		14	2.92
<i>L. bertii</i> Leonardi	2				2	0.42
<i>L. lycopi</i> (Foudras)	7				7	1.46
<i>L. karlheini</i> Warchalowski		6			6	1.25
<i>Altica</i> Muller						
<i>A. oleracea</i> (Linnaeus)		3			3	0.63
<i>Podagrica</i> Chevrolat						
<i>P. fuscicornis</i> (Linnaeus)	7		5		12	2.50
<i>Dibolia</i> Latreille						
<i>D. occultans</i> (Koch)	2				2	0.42

Table 1. List of Alticini species collected from the four sites in Bafa Lake Natural Park (continued)

Species	MA1	MA2	OGA1	OGA2	Total number	Relative Abundance (%)
<i>D. carpathica</i> Weise	2				2	0.42
<i>D. depressiuscula</i> Letzner		4			4	0.83
<i>D. cynoglossi</i> (Koch)		2			2	0.42
<i>Psylliodes</i> Berthold						
<i>P. aerea</i> Foudras	3				3	0.63
<i>P. toelgi</i> Heikertinger	3		3		6	1.25
<i>P. cuprea</i> (Koch)	7	4	9		20	4.17
<i>P. isatidis</i> Heikertinger	24	19	20	4	67	13.96
<i>P. circumdata</i> (Redtenbacher)	4			9	13	2.71
<i>P. wrasei</i> Leonardi & Arnold	20		6		26	5.42
<i>P. napi</i> (Fabricius)	3				3	0.63
<i>P. gibbosa</i> Allard	2				2	0.42
<i>P. anatolicus</i> Gök & Cilbiroglu		1			1	0.21
<i>P. chrysocephalus</i> (Linnaeus)		5			5	1.04
<i>P. ozisiki</i> Leonardi & Arnold		8			8	1.67
<i>Crepidodera</i> Chevrolat						
<i>C. aurea</i> (Geoffroy)	6				6	1.25
<i>C. aurata</i> (Marsham)			2		2	0.42
<i>Hermaeophaga</i> Foudras						
<i>H. ruficollis</i> (Lucas)		3			3	0.63
<i>Chaetocnema</i> Stephens						
<i>C. tibialis</i> (Illiger)	15		9		24	5.00
<i>C. coyei</i> (Allard)	4				4	0.83
<i>C. obesa</i> (Boieldieu)		6			6	1.25
Number of individuals	169	93	119	99	480	
Number of species	26	19	15	13	55	

Species composition and abundance varied within the sites of natural park where MA1 contained 26 species, MA2 contained 19 species, OGA1 contained 15 species and OGA2 contained 13 species in total. *Longitarsus* Berthold, *Psylliodes* Latreille and *Phyllotreta* Chevrolat were the most common Alticini genera in the study area, respectively. *Longitarsus* was the most species-rich and abundant genus during the whole study period with a percentage of 41% among all others (Fig. 2). *Longitarsus albineus* (Foudras), *L. baeticus* Leonardi, *Psylliodes isatidis* Heikertinger, *P. cuprea* (Koch), *P. wrasei* Leonardi & Arnold and *Chaetocnema tibialis* (Illiger) were determined as the most abundant species, comprising about 48% of the total specimens collected during study.

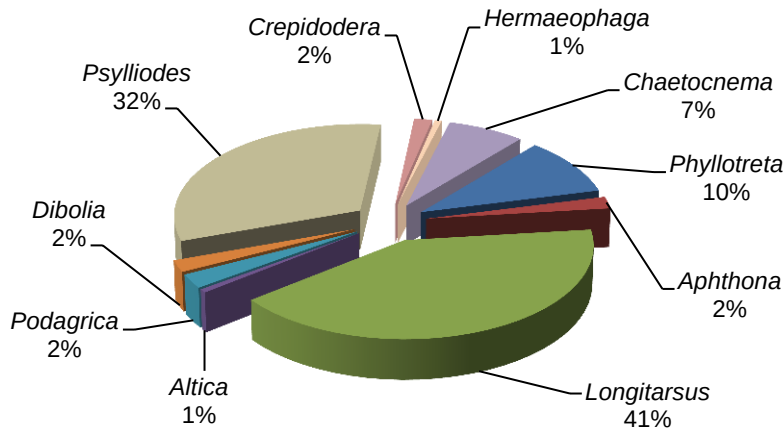


Figure 2. Percentages of collected genera based on species number.

Of the total number of specimens, 35% were collected in site MA1, 25% in OGA1, 21% in OGA2, and 19% in MA2. According to Shannon-Wiener, Simpson and Berger-Parker indices of diversity, MA1 was the most diverse area having the highest number of species and individuals (Table 2). The lowest diversity was recorded from OGA2 in parallel with species numbers. MA2 had the highest value of evenness which means that this site has individuals more equally distributed among species. Although MA2 has the lowest number of individuals, high evenness value accompanied with high species number ranked it above the sites OGA1 and OGA2.

Table 2. Results of the alpha-diversity indices of Alticini communities in the four sites

Indices	MA1	MA2	OGA1	OGA2
S	26	19	15	13
N	169	93	119	99
Shannon-Wiener (H')	1.287	1.184	1.076	0.971
Simpson (1/D)	16.355	13.538	10.355	7.664
Berger-Parker (1/d)	7.042	4.895	4.958	3.667

Analyses of rarefaction and abundance plot k-dominance also showed similar results indicating MA1 as the most diverse. In the analysis of rarefaction, the most diverse site is located at the top of the graph (Fig. 3a). However, sites with higher diversities are ranged at undermost in the analysis of abundance plot k-dominance in which species are ranked with cumulative abundances (Fig. 3b).

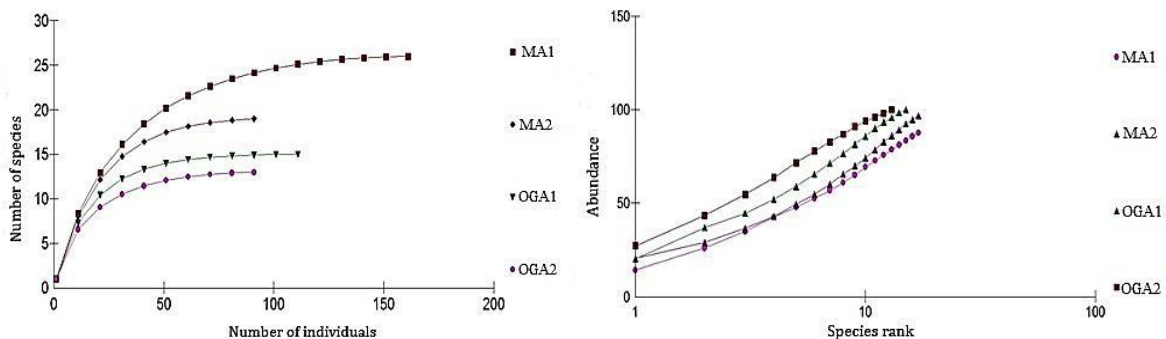


Figure 3. (a) Sample-based rarefaction curves for the flea beetles of the studied sites (b) Diagram of k-dominance of flea beetles in the studied sites.

Faunal similarity

Both Jaccard and Bray-Curtis similarity indices indicated that Alticini communities in OGA1 and MA1 were more closely related (Fig. 4).

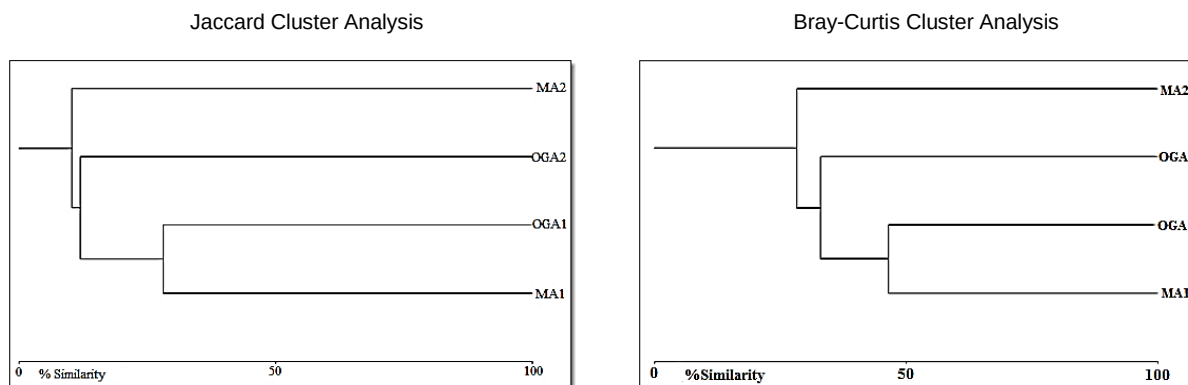


Figure 4. Similarity between Alticini communities inhabiting the four sites, based on species composition (Jaccard) and quantitative data (Bray-Curtis).

Cluster analysis based on species composition (Jaccard's index) revealed a similarity of 28% between the Alticini communities of the two sites. However, according to Bray-Curtis index which takes into account both species composition and number of individuals, the similarity rate was 46% (Table 3).

Table 3. The similarity indices (Jaccard and Bray-Curtis) of Alticini species compositions between the sites

Jaccard					Bray-Curtis				
	MA1	MA2	OGA1	OGA2		MA1	MA2	OGA1	OGA2
MA1	*	9.76	28.13	11.43	MA1	*	25.19	46.53	16.42
MA2	*	*	9.68	10.34	MA2	*	*	28.30	14.58
OGA1	*	*	*	12	OGA1	*	*	*	33.03
OGA2	*	*	*	*	OGA2	*	*	*	*

Among the species collected from Bafa Lake Natural Park, some samples belonging to the genus *Longitarsus* were noticed by the authors of which evaluation revealed that these were specimens of *L. aeruginosus*, unknown from Turkey till now. The new record is briefly reviewed below.

Longitarsus aeruginosus (Foudras, 1860) (Coleoptera: Chrysomelidae: Galerucinae)

Material examined: Aydın, Bafa Lake Natural Park, 30 m, 16.VIII.2013, 9♂♂, 4♀♀.

Known distribution: Albania, Andorra, Austria, Belgium, Belarus, France, Great Britain, Germany, Greece, Italy, Luxembourg, Malta, The Netherlands, Portugal, Spain, Cyprus (Löbl & Smetana, 2010).

Diagnostic notes: It is completely yellowish-brown; about 2.4-2.8 mm in length, upper side finely and shallowly punctuate. Aedeagus very similar to that of *Longitarsus succineus* (Foudras 1860) but clearly differs from it in lateral view; spermatheca quite typical, especially in the structure and morphology of the ductus (Fig. 5). Specimens are larger and darker than *L. succineus*, also there are various setae on apex of each elytron.

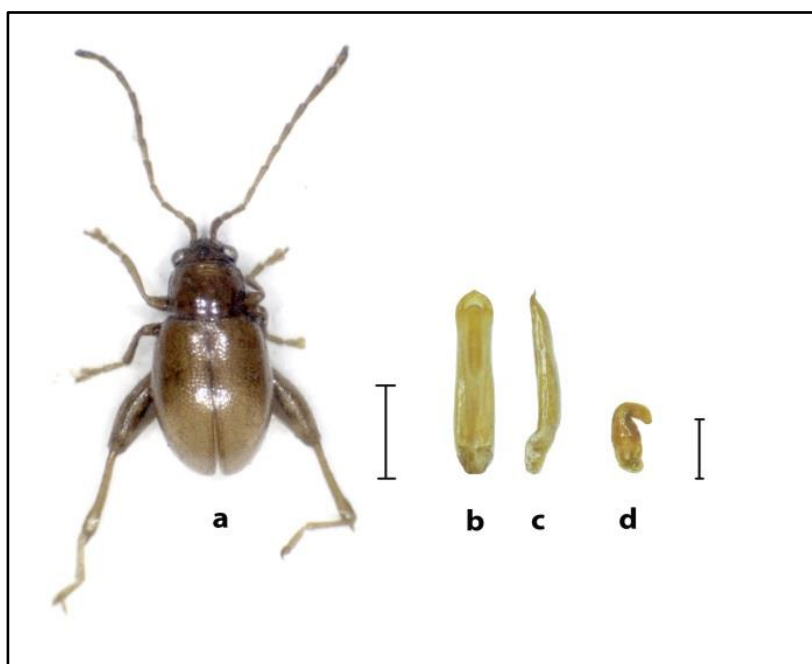


Figure 5. *Longitarsus aeruginosus* habitus and genitalia. (a) habitus (Scale bar: 1 mm) (b) aedeagus ventral view (c) aedeagus lateral view (d) spermatheca (Scale bar: 0.4 mm).

Host plant record: It was not possible to determine the exact host plant association of *L. aeruginosus* in the study area, because samples were collected from several plants by sweeping. However, previous host plant record for this species was given as *Eupatorium cannabinum* L. belonging to the family Asteraceae (Döberl, 1994; Warchalowski, 1996).

Discussion

Totally, 55 flea beetle species were recorded from Bafa Lake Natural Park one of which, *L. aeruginosus*, is new record for Alticini fauna of Turkey. The flea beetles reported from the study area in the present study represent about 16% of the whole Turkish Alticini.

The species composition of phytophagous beetles may vary considerably between sites because of the differences in some determinants for insect species diversity such as host plant abundance, distribution and species richness. Flea beetles are highly specialized phytophagous insects; therefore the Alticini diversity is closely associated with the herbaceous vegetation diversity and abundance (Aslan, 2010). In this study, Meadow area 1 (MA1) was identified as the most diverse site. The main reason of this is the high plant diversity in the area and less anthropogenic impacts compared to others. The composition of Alticini communities in the sites also changed based on the richness and availability of host plant species, or their alternatives existing at each site. The differences in the species composition of the two meadow communities can be explained by differences in the floristic composition and plant density at the sites which probably resulted from different humidity and soil conditions. Olive grove area 2 (OGA2) has the lowest species diversity. This is because; the area has mostly uniform herbaceous cover and is much disturbed by grazing and human activities such as mowing, fertilizing, and draining.

Cluster analyses using Bray-Curtis and Jaccard similarity indices showed that, among the four areas studied, the highest similarities of species compositions were found between MA1 and OGA1. These two areas present similar vegetation structure thus, are more similar in species composition. According to results from Jaccard cluster analysis, MA2 and OGA1 were clearly separated from other sites. However, Bray-Curtis cluster analysis with respect to species abundance revealed a low degree of

similarity between the communities MA2 and OGA2. This difference arise from the point that Bray-Curtis index takes into account both species composition and number of individuals while Jaccard index works only on shared species. OGA2 is located close to the Greater Menderes Basin and therefore is exposed to more olive cultivation and fishing activities. These factors are probably responsible for the low species richness and distant faunistic composition of the Olive grove area 2.

Longitarsus albineus, *L. baeticus*, *P. isatidis*, *P. cuprea*, *P. wrasei* and *C. tibialis* were the most frequent and abundant species collected from Bafa Lake Natural Park throughout the field studies lasted two years. *Longitarsus* was remarkably dominant within the whole genera in all collections. This may be due to the broader trophic spectrum and ecological tolerance of the genus members in addition to their ability of using various habitats.

Phyllotreta lativittata Kutschera, *Aphthona kuntzei* Roubal, *Longitarsus cerinthes* (Schrank), *L. nigrofasciatus* (Goeze), *L. foudrasi* Weise, *L. fallax* Weise, *L. atricillus* (Linnaeus), *L. succineus*, *L. bertii* Leonardi, *Dibolia occultans* (Koch), *D. carpathica* Weise, *D. cynoglossi* (Koch), *Psylliodes anatolicus* Gök & Cilbiroglu, *P. gibbosa* Allard and *Hermaphysa ruficollis* (Lucas) occurred more rarely in the study sites during field surveys represented by single or double specimens. These rare species are either accidental species, coming from the vegetation nearby the study sites, or generalist species, that are not specialized on feeding on distinct plant species.

In this study, Alticini species composition and diversity among four different sites of Bafa Lake Natural Park which is one of the important protected areas of Turkey were comparatively investigated. Species richness and number of individuals in grasslands including the two meadow areas were higher than olive grove areas. So, we can say that grasslands have higher species diversity in terms of chrysomelids agreed in many other studies (Řehounek, 2002; Wąsowska, 2004; Aslan & Ayvaz, 2009; Aslan, 2010). One more aim of the present study was to search for any Alticini species specialized to feed on olive trees. But, during the field surveys conducted between 2012 and 2013 in the chosen olive grove areas, we didn't ever observe such an association. Consequently, of the factors that have impact on the diversity of Alticini communities, the influence of the vegetation richness and structure is the greatest. As the presented results show, the vegetation diversity and occurrence of actual host plants decides the flea beetle diversity or similarity of particular areas.

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