DIVERSITY OF *SITONA* SPECIES (COLEOPTERA, CURCULIONIDAE) IN CULTIVATED PLANTS BELONGING TO THE FABACEAE FAMILY

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Abstract. *Sitona* species are significant because they cause damage by feeding on shoots and leaves of Fabaceae plants. In this study, dominant species and intensity of *Sitona* in alfalfa, sainfoin, vetch, fodder pea, red lentil, and fenugreek plants cultivated in the Eastern and Southeastern Anatolia regions between April-July 2020-2021 were investigated. Samples were collected with a sweep net from 209 fields in 10 provinces of both regions. As a result of surveys, a total of 5168 individuals belonging to *Coleositona* and *Sitona* genus (Coleoptera: Curculionidae) were collected from six species of crops grown in two regions. Among them, 11 species were recorded from alfalfa, seven from red lentil, six from vetch, six from sainfoin, four from fenugreek, and four from fodder pea. *S. macularius* was the most dominant and abundance species in red lentil, vetch, fodder pea, sainfoin and fenugreek were 92.6%, 67.2%, 73.3%, 97.3% and 44.4%, respectively. In alfalfa too, the most dominant and abundant species was *S. humeralis* with 51.3%. The values of the Margalef diversity index showed minor differences between plant varieties. The Shannon-Weaver diversity index varied between 0.12 and 1.41. The maximum species diversity was recorded in alfalfa, whereas the minimum was observed in fodder pea and fenugreek plants.
Keywords: *Sitona, communities, richness, abundance, Fabaceae plants*

Introduction

Sitona, which has more than 100 species is a genus within the broad-nosed weevils of Curculionidae family (Entiminae), widely distributed in the Palaearctic and Nearctic regions and in parts of the Palaeotropic region (Velázquez de Castro et al., 2010). All *Sitona* species are associated with leguminous plants (Fabacae) both in adult and immature stages and produce a generation a year and spend the winter in different biological periods (Papadopoulou, 2013; Rim et al., 2019; Gözüaçık et al., 2021a). The damage in legumes plants is caused both by adults and larvae. Adults are harmful at the time of germination of plants, injuring young shoots and causing their degradation and death. When the plant matures, they feed on the leaves and in the case of high infestation cause total defoliation of plants (Wiech and Clements, 1992). Larvae devour roots, causing open injury, also, preparing a suitable environment for various bacteria and fungi to damage the plant (Manglitz et al., 1963; Pesho, 1975; Dintenfass and Brown, 1986; Mowat and Shakell, 1989). Also, consuming of nitrogen root nodules formed by soil bacteria (Rhizobium), causing strong reduction of the content of the nitrogen in roots, which leads to significant decrease in yield (Aeschlimann, 1980; Syrett, 1992; Skot et al., 1994; Murray, 1996; Cantot, 2001). In the years when the population is dense, the larvae can destroy more than 90% of the nodules (Cardona, 1983; Tahhan and Hariri, 1982), which is why nitrogen deficiency emerges in the vegetative growth stage of the plants. Therefore, many species are considered severe agricultural pests of cultivated pulses and are considerably known in Europe and North America. 27 *Sitona* species have been identified in agriculture and non-agricultural fields in different regions of Türkiye (Lodos et al., 1978, 2003; Avgın and Colonnelli,

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2011; Alonso-Zarazaga et al., 2017; Çekiç, 2017). Most of these species have been identified from non-agricultural areas. In agricultural areas, *Sitona* species were investigated mostly on alfalfa and lentil plants. In alfalfa fields in Türkiye; *Sitona bicolor* Fåhraeus, *S. callosus* Gyllenhal, *S. concavirotris* Hochhuth, *S. cylindricollis* Fåhraeus, *S. hispidulus* (Fabricius), *S. humeralis* Stephens, *S. lineatus* (Linnaeus), *S. longulus* Gyllenhal, *S. macularius* (Marsham), *S. obsoletus* (Gmelin) and *Sitona puncticollis* Stephens species were identified (Kıvan, 1995; Tamer et al., 1997; Coşkuncu and Gencer, 2010; Gözüaçık et al., 2021b). On the other hand, only *S. macularius* was found to be harmful in red lentil plant. According to the data of TURKSTAT (2021), leguminous crops are grown in a total of 2 136 631 ha in Türkiye, of which 881.239 ha (41.221%) are for edible food and 1 255 392 ha of which are for animal feed. In the provinces (Adıyaman, Ağrı, Bingöl, Diyarbakır, Elazığ, Mardin, Muş, Siirt, Şanlıurfa and Van) where the studies are carried out, the share of legume production areas consists of 26.4% (233 031 ha) of the total cultivation area for edible food and 22% (275 928 ha) for animal feed.

The aim of this study is to investigate the *Sitona* species and to contribute to the management of agricultural production by identifying the dominant pest species and their intensities in red lentil (*Lens culinaris* Medik.), chickpea (*Cicer arietinum* L.), alfalfa (*Medicago sativa* L.), sainfoin (*Onobrychis viciifolia* Scop.), vetch (*Vicia sativa* L.), fodder pea (*Pisum sativum* L.), and fenugreek (*Trigonella esculenta* Willd.) plants in Eastern and Southeastern Anatolian regions, where legumes are edible and forage are mostly planted in Türkiye. In addition, this study will contribute to the planning of future studies that will guide the control of these species by determining the distribution and density of *Sitona* species in each crop.

Materials and methods

Study areas

The studies were carried out in the Eastern Anatolia Region (Ağrı, Bingöl, Elazığ, Muş, and Van provinces) with 82 alfalfa (*Medicago sativa* L.), 53 sainfoins (*Onobrychis viciifolia* Scop.), 4 vetches (*Vicia sativa* L.) and in the Southeastern Anatolia Region (in the provinces of Adıyaman, Diyarbakır, Mardin, Siirt, and Şanlıurfa) of Türkiye, 53 red lentils (*L. culinaris*), 11 chickpeas (*C. arietinum*), 4 vetches (*V. sativa*), 17 alfalfa (*M. sativa*), 2 fodder pea (*P. sativum*), and 2 fenugreek (*T. esculenta*), in a total of 209 fields (*Fig. 1*), in April-July of the years 2020-2021. In addition, the geographical and climatic characteristics of both regions are given in *Table 1*.

Insect collection and identification

Sample collections were carried out once in two weeks in the vegetative growth periods of the plants in non-pesticide fields in both years. *Sitona* species were collected a total of 50 sweep net randomly from 5-10 different points in each field. Adult individuals collected were killed with ethyl acetate and were labeled and brought to the laboratory for identification. These samples were identified at the species level based on keys (Velázquez de Castro et al., 2010; Delbol and Lempereur, 2014) using a stereomicroscope. The samples were placed in the Entomological Collection of Iğdır University, Plant Protection Department, Türkiye.

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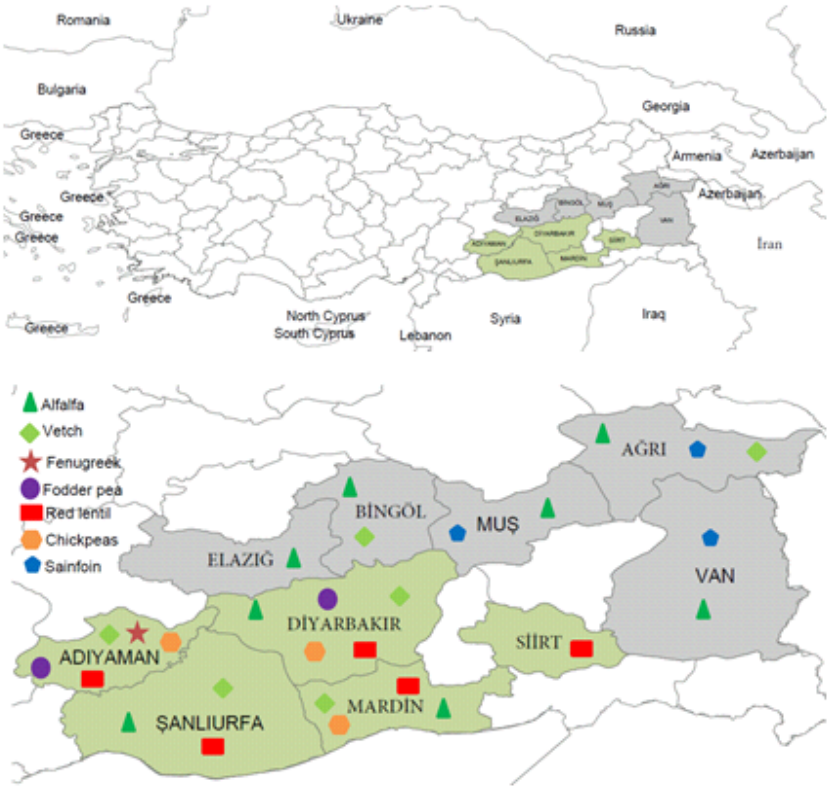

Figure 1. *Provinces where the research was conducted in the Eastern and Southeastern Anatolia regions*

Table 1. *Geographical and climatic conditions of the regions*

Regions	Geographical position (GPS)	Climatic characteristics	Average altitude (m)
Eastern Anatolia region (Ağrı, Bingöl, Elazığ, Muş, Van)	39°25′35″ N, 41°14′4″E	The summer season is short and cool. The winter season is cold and long	**1782** (Min. 1030 - Max. 2401)
Southeast Anatolia region (Adıyaman, Diyarbakır, Mardin, Siirt, Şanlıurfa)	38°6′32″N, 41°19′43″E	The summer season is very hot. Winter season is rarely cold	**670** (Min. 377 - Max. 990)

Data analysis

Species composition, diversity, and similarity of *Sitona* communities in the two regions on six plants were examined by using the program BioDiversity Pro (McAleece et al., 1997). The Shannon-Wiener *(H')* (for measuring diversity), Simpson (I) and Berger-Parker *(d)* (considering the dominance), and Margalef's richness were used. The following tests were carried out to find results at different levels. Biodiversity indices were calculated following the standard formulas.

The species diversity (H′) for each Fabaceae plant variety was calculated using the Shannon–Wiener index (Shannon and Weaver, 1949) (*Eq. 1*):

$$\text{Diversity index} = H' = -\sum pi \ln (pi) \qquad \text{(Eq.1)}$$

where *pi* is the proportion of individuals belonging to the *i*th species.

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Simpson's index for dominance was used so that an increase in the value of the index accompanies an increase in diversity and a reduction in dominance. Simpson's index was defined (Magurran, 2004) (*Eq. 2*):

$$I = \Sigma pi^2 \quad \text{(Eq.2)}$$

Species richness (D) was calculated using the formula given by Margalef (1958) (*Eq. 3*):

$$D = (S - 1) / InN \quad \text{(Eq.3)}$$

where S = total number of species N = total number of individuals in the sample In = natural logarithm.

Measurement of evenness or calculating the evenness of species was used (Pielou, 1966) (*Eq. 4*):

$$e = H / InS \quad \text{(Eq.4)}$$

The obtained findings were subjected to square root transformation in the JMP Pro 13 statistical package program and variance analysis was performed. A Student's test (LSD 0.05) was used to group the significant data.

Results and discussion

This study was carried out to reveal the species diversity, abundance, richness, and dominant pest species of *Sitona* species in red lentil (*Lens culinaris* Medik.), alfalfa (*Medicago sativa* L.), sainfoin (*Onobrychis viciifolia* Scop.), vetch (*Vicia sativa* L.), fodder pea (*Pisum sativum* L.), and fenugreek (*Trigonella esculenta* L.) plants. On these plants, *Coleositona limosus* Rossi, *Sitona callosus* Gyllenhal, *S. concavirostris* Hochhuth, *S. cylindricollis* Fåhraeus, *S. hispidulus* (Fabricius), *S. humeralis* Stephens, *S. lateralis* Gyllenhal, *S. lineatus* (Linnaeus), *S. lividipes* Fåhraeus, *S. longulus* Gyllenhal, *S. macularius* (Marsham), *S. obsoletus* (Gmelin), and *S. puncticollis* Stephens species (Coleoptera: Curculionidae) were determined. In our field investigation, the relationships between the plant varieties, the average of the *Sitona* species, and the number of individuals collected ($P > 0.01$) were found to be significant (*Table 2*).

The *Sitona* species and individual numbers of the species collected from both regions differed in each plant. In the studies, a total of 5168 individuals were collected, with 1702 from red lentil, 76 from vetch, 15 from fodder pea, 1513 from sainfoin, 9 from fenugreek and 1853 from alfalfa. Among the species collected in both regions, *S. macularius* was the highest with 63.4%, and *S. puncticollis* was the least with 0.1% (*Table 2*). The distribution of cultivated legume plants in regions shows differently, due to the climatic conditions of the regions. While alfalfa and vetch plants are cultivated in both regions, in the Southern Anatolia region it has been observed that red lentil, fodder pea, chickpea, and fenugreeks are cultivated, but as for the Eastern Anatolia region, sainfoin cultivation is more common. The average number of individuals in a sweep net was 0.64 in red lentil, 0.19 in vetch, 0.15 in fodder pea, 0.89 in Sainfoin, 0.09 in fenugreek, and 0.37 in alfalfa determined. However, *Sitona* species were not found in

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chickpea plants. 1702 individuals from 7 species were collected from 53 red lentil cultivated fields in Adıyaman, Diyarbakır, Mardin, Siirt, and Şanlıurfa provinces. With a rate of 92.65% (n = 1577), it was determined in all red lentil fields that *S. macularius* was a widespread and dominant species. *S. concavirostris* was obtained with a rate of 6.6% (n = 112) after *S. macularius*. These species were followed *S. humeralis* 0.35% (n = 6), *C. limosus* 0.16% (n = 3), *S. callosus* 0.12% (n = 2), *S. hispidulus* 0.06% (n = 1) and *S. puncticollis* 0.06% (n = 1), respectively. *S. macularius* has been reported to be the main pest of red lentil plants in Western Asia and Northern Africa (Kılıç et al., 1968; Hariri, 1981; Solh et al., 1986). Also, in the *Sitona* species found in red lentils in northern Syria, *S. macularius* (95%) was recorded as the most abundant species (Tahhan and Hariri, 1982). *S. macularius* adults feed on the leaves of young seedlings in red lentil, while their larvae feed on nodules of the roots, reducing the fixation of nitrogen in the atmosphere (Hariri, 1981; Weigand et al., 1991), it has been determined that it causes losses between 14.1-17.7% in stalk and grain yields (Cardona, 1983). 76 individuals from 6 species were collected from 8 vetch fields in Adıyaman, Ağrı, Bingöl, Diyarbakır, Mardin, and Şanlıurfa provinces. These species were found *S. macularius* 67.1%, *S. longulus* 23.8%, *S. lateralis* 3.9%, *S. lineatus* 2%, *S. hispidulus* 1.3%, and *S. obsoletus* 1.3%, respectively. Velázquez de Castro et al. (2007) stated that *C. limosus*, *S. ambiguus*, *S. costipennis*, *S. lateralis*, *S. lepidus*, *S. lineatus*, *S. lineellus*, *S. longulus*, *S. macularius*, *S. puncticollis*, and *S. suturalis* species fed on vetch. 15 individuals from 4 species were collected in two fodder pea fields in Adıyaman and Diyarbakır provinces. It was determined that *S. macularius* was the dominant species with 73.3% of the collected species. Other species were found *S. concavirostris* 13.3%, *S. lateralis* 6.7%, and *S. lineatus* 6.7%, respectively. 1513 individuals from 6 species were collected in 34 sainfoin (*O. viciifolia*) fields in Ağrı, Muş, and Van provinces. It was determined that *S. macularius* was the most common and dominant species with a rate of 97.3% in sainfoin. *S. macularius* were followed *S. callosus* 1.5%, *S. cylindricollis* 0.4% (n = 6), *S. humeralis* 0.3%, *S. longulus* 0.3%, and *S. obsoletus* 0.2%, respectively. In previous studies, it was reported that *S. lineatus* and *S. macularius*, *S. callosus*, and *S. tenuis* are fed on the sainfoin (Lodos et al., 1978; Velázquez de Castro et al., 2007). 1853 individuals from 11 species were collected from 99 alfalfa fields in Adıyaman, Ağrı, Bingöl, Diyarbakır, Elazığ, Mardin, Muş, Şanlıurfa, and Van provinces. Alfalfa is determined to be having the richest diversity in terms of *Sitona* species because it is a perennial plant and contains many leguminous weeds. Studies carried out in alfalfa fields, 11 in Türkiye (Kıvan, 1995; Tamer et al., 1997; Coşkuncu and Gencer, 2010; Gözüaçık et al., 2021b), 13 in Bulgaria (Angelov, 1978), with 4 in Iran (Arbab and McNeill, 2014) were found to be abundant in the number of *Sitona* species diversity. In our studies, it was determined that *S. humeralis* was the most prevalent and dominant species with a rate of 51.3% in 11 species detected in all alfalfa fields. *S. humeralis* was followed *S. longulus* 17.9%, *S. lividipes* 15.9%, *S. macularius* 8.8%, *S. lineatus* 3.6%, *S. concavirostris* 0.9%, *S. callosus* 0.8%, *S. hispidulus* 0.5%, *S. puncticollis* 0.16%, and *S. obsoletus* 0.1%, respectively (*Table 2*). *S. humeralis* was determined as the most dominant species in alfalfa areas with an of rate 80% in Iran (Arbab and McNeill, 2014), 51% in Bulgaria (Atanasova, 2012), and 81.4% in Türkiye (Gözüaçık et al., 2021b). However, *S. longulus* was found to be the more dominant species in the alfalfa fields of Van province with a rate of 58.6%, and *S. lividipes* with a rate of 51.1% in the alfalfa fields of Bingöl located in eastern Anatolia region.

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Table 2. *The relationships between the number of Sitona weevils and plant varieties*

Species (Plants/*Sitona*)	Rl*	V*	*Fp	*S	*F	C	A	Mean	Total	RA** (%)
S. callosus	2 t	0 v	0 v	23 j	1 u	0 v	15 m	5.67 g	41	0.8
S. concavirostris	112 g	0 v	2 t	0 v	0 v	0 v	17 l	18.7 e	131	2.5
S. cylindricollis	0 v	0 v	0 w	6:00 PM	0 v	0 v	0 v	0.86 i	6	0.1
S. hispidulus	1 u	1 u	0 v	0 v	0 v	0 v	9 o	1.57 h	11	0.2
S. humeralis	6:00 PM	0 v	0 v	5 q	0 v	0 v	951 c	137.4 b	962	18.6
S. lateralis	0 v	3 s	1 u	0 v	1 u	0 v	1 u	0.857 i	6	0.1
S. lineatus	0 v	2 t	1 u	0 v	0 v	0 v	66 h	9.857 f	69	1.3
S. lividipes	0 v	0 v	0 v	0 v	0 v	0 v	294 e	42 d	294	5.7
S. longulus	0 v	18 k	0 v	4 r	0 v	0 v	332 d	50.57 c	354	6.8
S. macularius	1577 a	51 i	11 n	1472 b	4 r	0 v	163 f	468.3 a	3278	63.4
S. obsoletus	0 v	1 u	0 v	3 s	0 v	0 v	2 t	0.86 i	6	0.1
S. puncticollis	1 u	0 v	0 v	0 v	0 v	0 v	3 s	0.57 j	4	0.1
Cs. limosus	3 s	0 v	0 v	0 v	3 s	0 v	0 v	0.86 i	6	0.1
Mean	130.8 b	5.8 d	1.15 e	116.4 c	0.69 f	0 g	142.5 a	56.78		
Total	1702	76	15	1513	9	0	1853		**5168**	

CV: 2.1, $LSD_{0,05}$: *Sitona* species 0.073**, Plant varieties 0.054**, *Sitona* species × Plant varieties 0.19**, ** = P < 0.01
*Rl: Red lentil, *V: Vetch, * Fp: Fodder pea, *S: Sainfoin, *F: Fenugreek, *C: Chickpea *A: Alfalfa, **RA: Relative abundance

As seen in *Figure 2*, the diversity index was calculated between 0.12 (red lentil) and 1.41 (alfalfa). Simpson diversity index was 4.0 (fenugreek), 3.03 (alfalfa), 2.0 (vetch), 1.9 (fodder pea), 1.2 (red lentil), and 1.1 (sainfoin), respectively. It was observed that there was great variability between species diversity and individual numbers in each region. The number of species was highest in alfalfa (11 species), followed by red lentil (7 species), vetch-sainfoin (6 species), and fodder pea-fenugreek (4 species) (*Table 2*) as followed. Simpson's dominant index ranged from 0.25 to 0.95. Accordingly, *S. macularius* in sainfoin (0.95), red lentil (0.86), fodder pea (0.53), vetch (0.50), and fenugreek (0.25), *S. humeralis* in alfalfa (0.33) was the dominant species. In this case, there was a similarity between the Berger-Parker dominance index and Simpson's dominance index: *S. macularius* with 0.97 in sainfoin, 0.93 in red lentil, 0.73 in fodder pea, 0.67 in vetch and 0.44 in fenugreek, and *S. humeralis* with 0.51 in alfalfa were the most dominant species in both regions. According to these results, *Sitona* species *S. humeralis* in alfalfa (Bogatzevska, et al., 2006; Atanasova, 2012; Arbab and McNeill, 2014; Gözüaçık et al., 2021b), *S. macularius* species in red lentil (Kılıç et al., 1968; Hariri, 1981; Solh et al., 1986; Tahhan and Hariri, 1982) were identified as key pests. Margalef richest index: The lowest number of individuals collected was determined on the fenugreek (1.37) and the lowest Sainfoin with the highest number of individuals (0.68).

In both regions, the average number of *Sitona* weevils was determined the highest in alfalfa (142.5 individuals). This was followed by red lentil (130.8), sainfoin (116.4), vetch (5.8), fodder pea (1.15) and fenugreek (0.69), respectively (*Table 2*). *S. macularius* was the most common species with an average number of 468.3 individuals. This was followed by *S. humeralis* (137.4 individuals), *S. longulus* (50.57 individuals), *S. lividipes* (42 individuals), *S. concavirostris* (18.7 individuals), *S. lineatus* (9.86 individuals), *S. hispidulus* (1.57 individuals), *S. obsoletus*, *S. lateralis*, *S. cylindricollis*, *Coleositona limosus* (0.86 individuals), and *S. puncticollis* (0.57 individuals). *S. macularius* was the most dominant species in all habitats in both regions, except for

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alfalfa. Hoffman (1950) stated the distribution of *S. macularius* in Europe, North Africa, Egypt, Türkiye, Syria, Turkestan, and the Caucasus and also reported that this species feeds on plants such as pea, alfalfa, wild pea, and lupine.

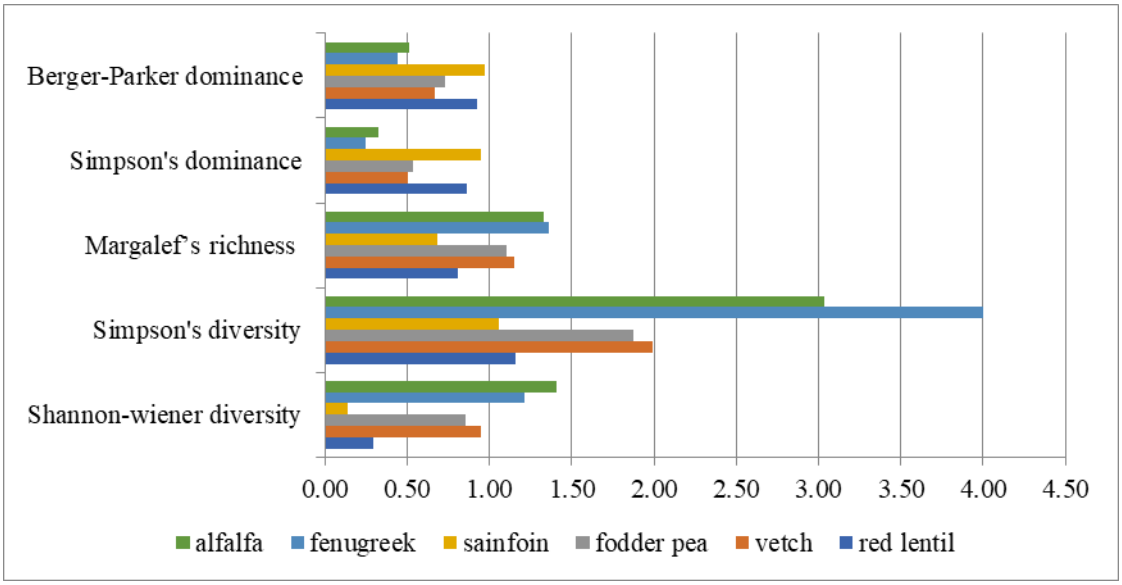

Figure 2. *The diversity index of Sitona sampled from alfalfa, sainfoin, vetch, fodder pea, red lentil, and fenugreek plants cultivated in the Eastern and Southeastern Anatolia regions*

Conclusion

Thirteen *Sitona* weevils were identified in alfalfa, sainfoin, vetch, fodder pea, red lentil, and fenugreek (Fabaceae) plants grown in two different ecological regions. It was determined that *S. macularius* was the dominant pest of red lentil, vetch, sainfoin, fodder pea, and fenugreek, while *S. humeralis* was the dominant pest of alfalfa. In general, adults of these weevils do not attract attention because of their rather small body length (3-6 mm) and their larvae feed on the root part of the plant. Accordingly, this study will be beneficial to producers and those researchers in this field. In addition, it would be more appropriate to focus on control of the main pest of each plant while creating a pest control strategy according to IPM.

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Conflict of interests. There is no conflict of interests.

Data availability. All data generated or analyzed during this study are included in this published article.

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