ONLINE ISSN 2651-3579

Journal of the Entomological Research Society

Volume: 23 Part: 2 2021

JOURNAL OF THE ENTOMOLOGICAL RESEARCH SOCIETY

Published by the Gazi Entomological Research Society

Subscription information

Published by GERS in single volumes three times (March, July, November) per year. The Journal is distributed to members only. Non-members are able to obtain the journal upon giving a donation to GERS.

Papers in *J. Entomol. Res. Soc.* are indexed and abstracted in Biological Abstract, Zoological Record, Entomology Abstracts, CAB Abstracts, Field Crop Abstracts, Organic Research Database, Wheat, Barley and Triticale Abstracts, Review of Medical and Veterinary Entomology, Veterinary Bulletin, Review of Agricultural Entomology, Forestry Abstracts, Agroforestry Abstracts, EBSCO Databases, Scopus and in the Science Citation Index Expanded.

Publication date: August 01, 2021

J. Entomol. Res. Soc., 23(2): 105-119, 2021 *Research Article*
Doi: 10.51963/jers.v23i2.1861 *Online ISSN:2651-3579*

Susceptibility response of varieties and local lupine *Lupinus albus* L. population to *Bruchus rufimanus* Boheman, 1833 (Coleoptera: Chrysomeloidae)

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ABSTRACT

This study aimed to evaluate the susceptibility response of varieties and local populations of lupine *Lupinus albus* to broadbean seed beetle *Bruchus rufimanus* in multi-environment field tests. Seed damage rate and susceptibility index were assessed in each environment and subjected to a heritability-adjusted genotype and genotype x environment biplot analysis. It was found that the susceptibility index of damaged seeds was positively correlated to precipitation amount and humidity, and inversely to minimal and maximal temperature values. The seed damage rate was positively correlated to temperatures but negatively to rain and humidity. The local Polish population *WAT* and cultivars *Pink Mutant*, *Solnechnii*, and *Bezimenii* 1 had the lowest seed damage rate and stable position across environments. Meanwhile, these cultivars showed a low susceptibility index and low variability. The discrepancy between the early phenological development of *Pink Mutant*, *Solnechnii*, and *Bezimenii* 1 and the life cycle of *B. rufimanus* was one of the reasons for the species' tolerance to *B. rufimanus* Correlations between damaged seed and susceptibility index as well as the mass of 1000 seeds and sensitivity index were strongly positive and negative, respectively. WAT, Pink Mutant, *Solnechnii*, and *Bezimenii* 1 had a clear advantage by defending itself from *B. rufimanus* attack, which makes them particularly interesting for breeding purposes.

Key words: *Bruchus rufimanus*, beetle, lupine, seed damage rate, susceptibility index

Nikolova, I.M. (2021). Susceptibility response of varieties and local lupine *Lupinus albus* L. population to *Bruchus rufimanus* Boheman, 1833 (Coleoptera: Chrysomeloidae). *Journal of the Entomological Research Society*, 23(2), 105-119.

INTRODUCTION

Broad bean beetle, *Bruchus rufimanus* Boheman, 1833 (Coleoptera: *Chrysomelidae)* is a common pest on faba bean (*Vicia faba* L.) all over Europe and worldwide (Roubinet, 2016). Bean beetle hosts, in addition to *V. faba*, are various genera *Vicia*, *Pisum* and *Lathyrus* (Delobel & Delobel, 2006; Ward, 2018).

Ramos & Fernández-Carrillo (2011) firstly reported that lupine plants were a new host of different species of the genus *Bruchidius,* subfamily Bruchinae (*Bruchidius rubiginosus* Desbrochers). Harris (1980) established that *B. chinensis* L was an important lupine seed pest, but in a later study, the author found that broadbean seed beetle it is one of the most destroyed seed pests in lupine (Hurej, Twardowski, & Kozak, 2013).

Bruchus rufimanus is univoltine insect. Adults emerge from overwintering sites and enter host crops to feed on pollen for several weeks, which females must do to terminate reproductive diapause. After that, females lay eggs on the pod surface. The larvae develop in the seeds and the adults emerge at harvest. Bruchids make a round output hole in seeds and go through it. Broad bean beetle moving to sheltered winter sites, or they remain in the seed until the following year doing no further damage during storage (Bogatsevska et al, 2006; Carrillo-Perdomo et al, 2019).

The development duration, reproduction, damage degree and generation viability were determined largely by temperature in many insect species (Zhou Guo, Chen, & Wan, 2010; Kutcherov, 2015; Hasan & Ansari, 2016). For example, changes in development and damage rate by temperature were reported regarding *Acanthoscelides obtectus* Say (Stewart et al, 2015). However, climatic conditions have a considerable impact on the attack and pest damage (Dermody, O'Neill, Zangerl, Berenbaum, & DeLucia, 2008; Hullé, d'Acier, Bankhead-Dromet, & Harrington, 2010).

Control of *Bruchus rufimanus* is primarily conducted by use of insecticides against adults before oviposition, at the stage of the mid-flowering and early pod-formation. Pyrethroids are ones of the most use insecticides but managing adult pest attacks is difficult due to their mobility, and the lack of persistence of pyrethroids at high temperatures (Mansoor et al, 2015).

European restrictions and environmental concerns have increased the need for alternative measures. Site selection, crop rotation, cultivar and seed selection, sowing date and plant density are potential means to pest control. Ones of the effective alternative measures to beetle management are the identification of tolerant genotypes, integrate these genotypes in breeding programs, and to identify the genes involved in the tolerance mechanisms. In this regard, Szafirowska (2012) found that cultivars and their phenological development affect the activity of *B. rufimanus* and the quantity of damage. Southgate (1979) suggested that the seed size and portion remaining following Bruchinae larval feeding among different cultivars were important traits of germination capacity and damage extent. Roubinet (2016) observed differences in susceptibility between several cultivars of *B. rufimanus* and the timing of flowering or pod formation, turned out to be important factors influencing on the bruchid attack.

The application of alternative cropping strategies, specifically the use of different cultivars, is an efficacious and ecologically friendly approach to plant protection against main insect pests.

This study aimed to evaluate the susceptibility response of varieties and local populations of lupine *Lupinus albus* L. to *Bruchus rufimanus* in multi-environment field tests.

MATERIAL AND METHODS

Field trial was conducted with 23 white lupine cultivars: Astra, Nahrquell, Ascar, BGR 6305, Shienfield Gard, WAT, Kijewskij Mutant, Hetman, Start, Amiga (originated from Poland), Garant (originated from Ukraine), Tel Keram, *Bezimenii* 1, *Bezimenii* 2, Pflugs Ultra, *Termis Mestnii*, Horizont, *Solnechnii*, Pink Mutant, *Manovitskii*, Barde, Dega, *Desnyanskii* (originated from Russia) during the period 2014-2016 at the Institute of Forage Crops (Pleven, Bulgaria). Sowing was made by hand, in optimum sowing time, according to the technology of cultivation. The experiment was laid out using a randomized block design. The studied genotypes were grown in a density of 50 plants/m^2. Each plot unit (5,50 m broad × 2 m length) included twelve rows spaced 50 cm apart.

The soil type is leached chernozem with $pH_{(KCl)}$ - 5.49 and content of total nitrogen N - 34.30 mg/1000 g soil, P_2O_5 – 3.72 mg/100 g soil and K_2O - 37.50 mg/100 g soil.

We used the coefficient of early-ripeness (Kuzmova, 2002) for quantitative assessment in the period from germination to early flowering:

Cr=1 + [{Nc-Nmin}/{Nmax-Nmin}],

where: Nc is the duration of the sowing period - beginning of flowering for the particular cultivar; Nmax and Nmin are the maximum and minimum duration (in days) of the sowing-beginning of flowering period for all tested cultivars.

The values of the coefficient were as followed: for ultra-early ripening cultivars - from 1.00 to 1.17; for early-ripening cultivars - 1.17 to 1.33; for medium-early ripening cultivars - 1.34 to 1.66, and for late-ripening ones > 1.66.

During the growing season, insect pest control was not applied. The degree of *Bruchus rufimanus* seed damage was determined after lupine harvesting. Bulk samples, containing 1500 seeds, were taken for each accession. Susceptibility index (SI, %) was calculated by the following formula:

SI = (a-b) / a x 100, where:

a - weight of 1000 healthy seeds;

b - weight of 1000 seeds damaged by the broad bean beetle

In order to eliminate interactions between variables and to include genotype and genotype x environment (GGE) interactions as well, HA-GGE biplot analysis was carried out (Yan & Holland, 2010). Biplot graphs are suitable for simultaneous visualization of interacting factors and based mathematically on SVD (singular-value decomposition) models. Biplots are used frequently, in a comparison of multiple genotypes in different environments (Rubiales et al, 2014; Sánchez-Martín et al, 2014). In this way, the "best" genotype will have the lowest values for the evaluated trait and stability through all environments, and low G × E interactions.

To evaluate the influence of environmental factors on DR and SI, different climatic variables were subjected to Non-Metric Multidimensional Scaling (NMDS) ordination (Anderson, 2001). Data on the meteorological variables: rainfall, average air temperature, as well as average relative humidity were obtained from Pleven meteorological station for each environment (National Institute of Meteorology and Hydrology, Pleven Branch). In order to focus on the occurrence of bruchids in the field, the climatic parameters used in the analysis ranged from March to June of 2014, 2015 and 2016 years. To determine a relative impact of the selected climatic variables on the performance of DR and SI, canonical correspondence analysis (CCA) (Ter Braak, 1986) was carried out. The analysis was performed using the Paleontological Statistics Software Package (PAST) (Hammer, Harper, & Ryanh, 2001). Pearson correlation was calculated to study the possible relationship between the parameters evaluated (DR and SI with genotype) at 5% probability ($p \leq 0.05$). Analyses were performed using CCA. Relationships between damaged seeds and certain plant traits were tested using multiple regression analysis of Statgraphics (1995) for Windows Ver. 2.1 Software program. The data were subjected to one-way ANOVA, and the averages were compared by Tukey's test at 5% probability ($p \leq 0.05$).

RESULTS AND DISCUSSION

During the studied period the meteorological conditions varied (Fig. 1), and had an impact on *Bruchus rufimanus* development, reproduction and damage rate. April, May and June months in 2015 were characterized by a higher average daily temperature (up to 1.0 and 0.7^{0}C in 2014 and 2016, respectively) as well as a lower rainfall and air humidity (up to 107.1 and 25.5 mm, and 9.7 and 6.7% in 2014 and 2016, respectively). Such conditions led to an earlier appearance of *B. rufimanus* and their stronger attack compared to 2014 and 2016 years. The plants were in the sensitive stage of flowering and pod formation to bruchid infestation in May and the first ten days of June 2015. At the same time, the plants suffered from a lack of moisture. During 2016, after sowing, the subsequent dry weather delayed seed germination. In April-June the higher temperatures accelerated the plant development and favored the *B. rufimanus* attack. During 2014 the meteorological conditions were characterized by the highest rainfall amount, and relative humidity combined with low temperatures during the growing season suppressing infestation and damage rate of *B rufimanus*.

A wide range of the values obtained for DR and SI were noted for the 23 lupine cultivars studied in the three environments. ANOVA (Table 1) revealed a significant effect of genotype (G), environment (E) and G × E in both variables, being the highest average of a square for E, followed by G and the lowest for G × E.

A canonical correspondence analysis (CCA) helped to visualize the distinct relations of DR and SI components to climatic variables (Fig. 2). Whereas SI was positively correlated with bulk precipitation and humidity, and inversely to T_{min} and T_{max}, the seed damage rate was positively correlated with T_{min} and T_{max} but negatively to rain and humidity. Moreover, T_{min} and T_{max} were associated with the environmental 2 droughts (2015), and opposed to rain and humidity during the environmental 1 wet period (2014). Because of a negative effect of rainfall on DR, the seed damage decreasing at rainy seasons as could be seen in the driest environments. This might be due to the fact that rainfall could disturb bruchid oviposition and reduce egg viability (Roubinet, 2016). In the opposite, rainfall and humidity had a positive effect, with SI increasing at higher values.

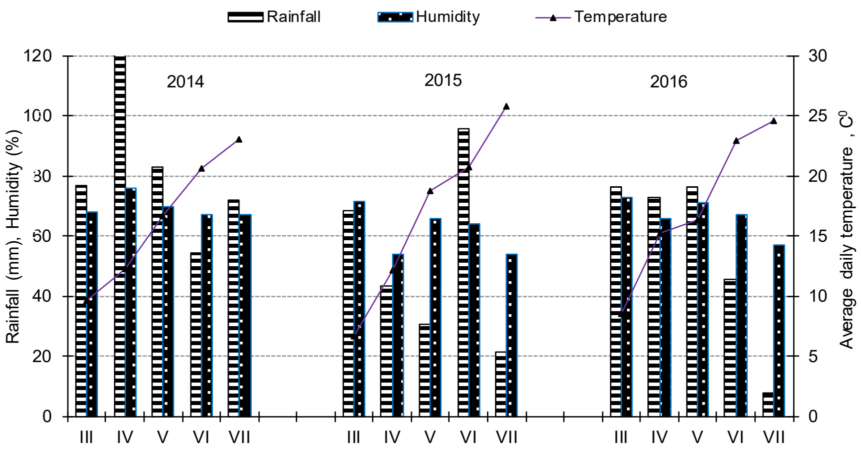

Fig. 1. Meteorological conditions of the period 2014-2016.

According to the results of GGE biplot analysis (Fig. 3), the difference in vector length among environments showed phenotypic variances within different environments. Based on the discrimination power (vector length) E1, followed by E2 were most discriminating, GGE biplot manifested clearly long vectors for E1 and E2, and shorter vector for E3, respectively.

A HA-GGE biplot is the preferred GGE biplot for test environment and genotype evaluation (Yan & Holland, 2010). AGGE biplot presents the average characteristic and stability, which gives us an essential visualization of the data (Yan, 2001; Yan & Rajcan, 2002). A GGE biplot is a biplot based on environment-centered data (Gabriel, 1971), which removes the environment's main effect and integrates the genotypic main effect with the genotype-by-environment interaction effect of a genotype-by-environment dataset (Yan, Hunt, Sheng, & Szlavnics, 2000).

Although there are no exact relations, the goodness of approximation for the correlation coefficients by the angles is related to the goodness of fit of the biplot. Depending on the angle between two environments vector correlation is different. In that aspect, the environments were more or less positively correlated (acute angles). An exception was found between E1 and E2 environments which were not correlated (right angle). Additionally, within the environmental group, E1 was apparently less associated with E3, while strongly positively correlated were E2 and E3.

Table 1. Analysis of variance for *Bruchus rufimanus* seed damage rate (DR) and susceptibility index (SI) of the 23 lupim genotypes.

Source	Df	Sum Sq	Mean Sq	F value	Pr(>F)
DR					
ENV	2	17878.48	8939.239*	3213.711	8.11E-10
REP(ENV)	6	16.690	2.782	58.494	8.03E-35
GEN	22	14129.08	642.231*	11.232	1.2E-11
ENV * GEN	44	2515.781	57.177 *	1202.361	9.9E-153
PC1	23	2511.448	109.193	2296.210	
PC2	21	4.333	0.206	4.340	
Residuals	132	6.277	0.048		
SI					
ENV	2	2755.412	1377.706*	381.713	4.74E-07
REP(ENV)	6	21.656	3.609	33.620	2.21E-24
GEN	22	4587.940	208.543*	11.733	5.64E-12
ENV * GEN	44	782.079	17.775*	165.566	1.74E-96
PC1	23	678.050	29.480	274.600	-
PC2	21	104.029	4.954	46.140	-
Residuals	132	14.171	0.107	-	-

Legend: DF- degrees of freedom; G * E- term of genotype * environment interaction);
* Significant at 0,0001 level probability

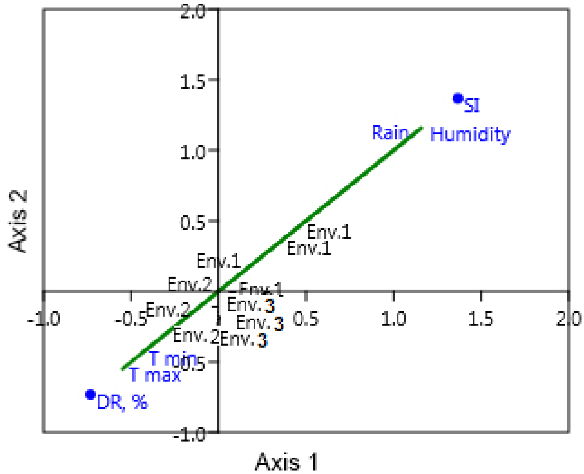

Fig. 2. CCA graph based on the correlation of DR and I of *Bruchus rufimanus* for 23 lupine cultivars according to several climatic parameters. The period analyzed was from April to June, T_{max} = maximum temperature; T_{min} = minimum temperature; DR = seed damage rate (%); SI, %= susceptibility index.

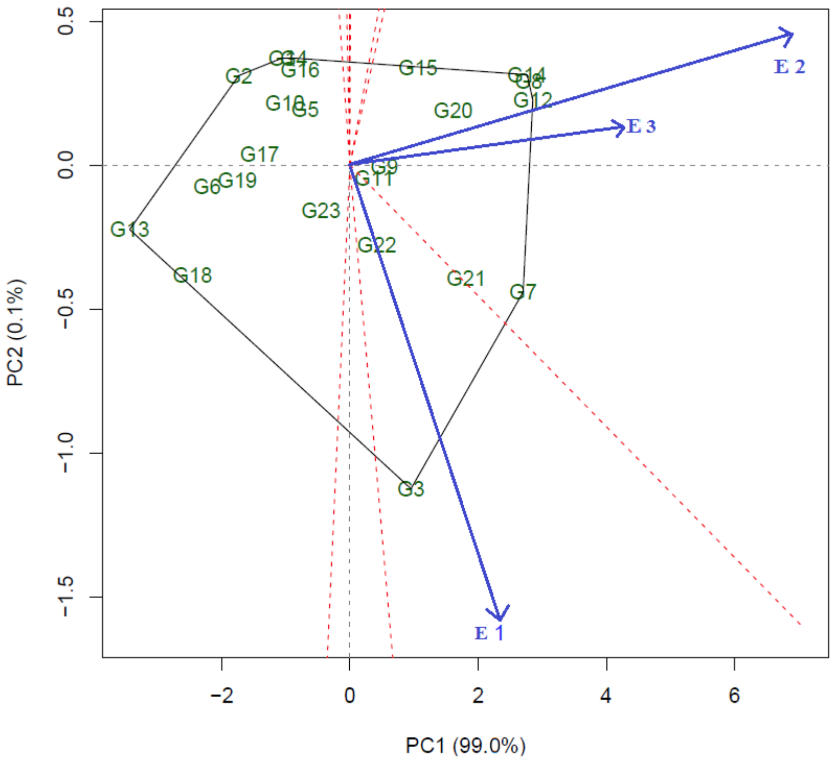

Fig. 3. The GGE biplot based on seed damage rate (2014-2016 period). The genotypes are designated with the symbol "G", and the respective number from 1 to 23, as followed: G1-Astra, G2-Nahrquell, G3-Ascar, G4-BGR 6305, G5-Shienfield Gard, G6-WAT, G7-Kijewskij Mutant, G8-Hetman, G9-Start, G10-Amiga, G11-Garant, G12-Tel Keram, G13-Bezimenii 1, G14-Bezimenii 2, G15-Pflugs Ultra, G16-Termis Mestnii, G17-Horizont, G18-Solnechnii, G19-Pink Mutant, G20-Manovitskii, G21-Barde, G22-Dega, G23-Desnyanskii. The years are designated with the letter E and number 1; 2; and 3 for 2014, 2015 and 2016, respectively, Note: G14 and G8 are strongly overlapped, as well as G1 and G4; G5 and G10 genotypes.

In order to determine which of the 23 lupine genotypes studied were the least affected by *B. rufimanus* attack based on their representation in the biplots, the ranking of the genotypes (considering stability across the environments studied) for both variables assessed, is shown in Table 2.

Thus, in the case of damaged seeds, the genotype with the lowest DR was G13 (6.3%) despite exposed environmental interactions, followed by the genotypes G18 (10.9%), G6 (11.8%), G19 (14.0%) and G17 (15.5%), whose responses were more stable, as indicated by their position close to the axis 1. The results showed that genotypes G19, G17 and G6 were considered as the most stable being the ones closest to the midpoint of the boxplot, and less preferred by *B. rufimanus*. Relatively stable and damage tolerant with somewhat difference among each other, exhibited G1, G4 and G16. Genotype G2 had lower values for that trait, but it was more affected by the environment. The most susceptible genotypes (high DR, represented on the opposite side of the biplot) were G12 (35.8%), G8 (34.7%) and G14 (34.6%). According to the GGE biplot analysis, the values of G12, G8, and G14 to PC2 are equally distantly situated at zero pointing to higher variability (poorer stability). The same level of poor stability and damage sensitivity also showed G7 and G21 genotypes. The variables of the five genotypes above mentioned were highly expressed in E3 and E2 environments.

Table 2. Ranking of the twenty-three lupin genotypes with the lowest levels of Bruchus rufimanus seed damaged rate (DR) and susceptibility index (SI) (ascending order).

DR							SI					
1	G13	11	G5	21	G14		**1**	G6	11	G23	21	G7
2	G18	12	G23	22	G8		**2**	G19	12	G3	22	G12
3	G6	13	G11	23	G12		**3**	G18	13	G22	23	G14
4	G2	14	G22				**4**	G13	14	G11		
5	G19	15	G9				**5**	G2	15	G9		
6	G17	16	G3				**6**	G1	16	G5		
7	G1	17	G15				**7**	G17	17	G20		
8	G10	18	G20				**8**	G10	18	G21		
9	G4	19	G21				**9**	G4	19	G8		
10	G16	20	G7				**10**	G16	20	G15		

Stability throughout the environments has been taken into account by considering each genotype position in the biplots

The first two principal components (PC1 and PC2) determined 99.1% of the dispersion.

The GGE biplot based on SI analysis (Fig. 4) represented 96.2% of the total trait variation between the first two principal components (PC1 and PC2). The environment with the shortest vector was E1, and the longest E2, respectively. The most discriminative environment was E2 in which less rainfall was registered. The genotype 6 (G6) was the most responsive to that trait (the lowest value of SI - 5.6%) followed by G19, G18, G13 (7.4; 7.9 and 9.0%, respectively) (see Table 2). A similar level of sensitivity showed G2 and G1, too. According to the ordinate, G6 was highly stable, followed by G19 within the group of the low susceptibility index. Lower variability had G18 and G13 genotypes. The sensitivity index at genotype 4 (G4) was close to the average for the biplot.

The genotype presented the highest value of SI and identified as highly sensitive was G14, followed by G12 and G7, respectively. Furthermore, the genotype 14 (G14) was considerably variable (poor stability) together with G22. Also, G14 had the highest value in E2, which was the most favourable for its susceptibility.

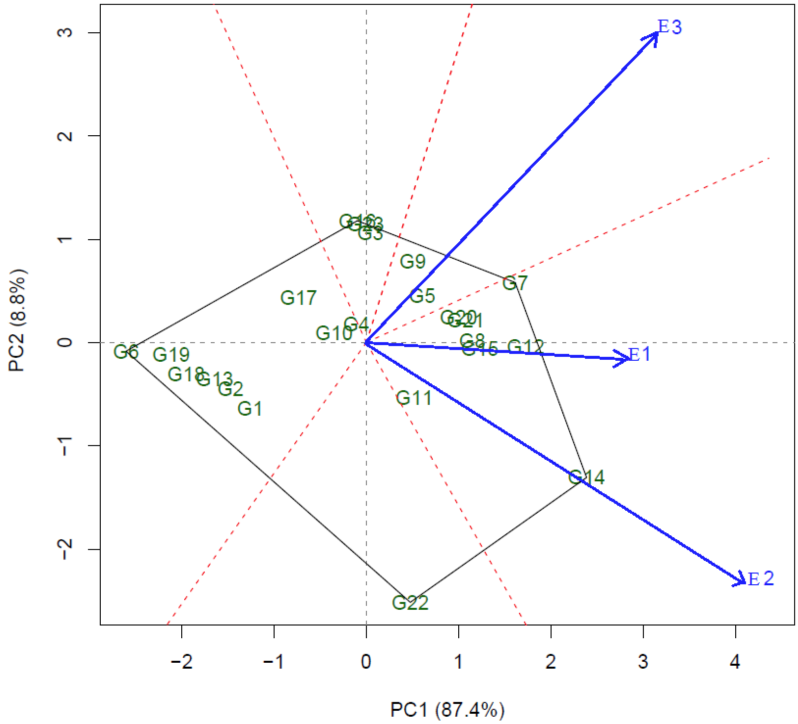

Fig. 4. The GGE biplot based on susceptibility index (2014-2016 period). The genotypes are designated with the symbol "G" and the respective number from 1 to 23, as follow G1-Astra, G2-Nahrquell, G3-Ascar, G4-BGR 6305, G5-Shienfield Gard, G6-WAT, G7-Kijewskij Mutant, G8-Hetman, G9-Start, G10-Amiga, G11-Garant, G12-Tel Keram, G13-Bezimenii 1, G14-Bezimenii 2, G15-Pflugs Ultra, G16-Termis Mestnii, G17-Horizont, G18-Solnechnii, G19-Pink Mutant, G20-Manovitskii, G21-Barde, G22-Dega, G23-Desnyanskii. The years are designated with the letter E and number 1; 2; and 3 for 2014, 2015 and 2016, respectively, Note: G23, G16 and G3 are strongly overlapped, as well as G21 and G20 genotypes.

Pearson correlations between DR and SI with genotype as a weighting variable ($r = +0.812$, $p= 0.0001$) revealed a significantly high coefficient value, which suggests a strong association between both parameters.

The decreased DR and SI values for G6, G19, G18 and G13 might be the result of the combination of different resistance mechanisms. The antixenosis mechanisms might be involved in the resistance of these genotypes by reducing the oviposition over their pods as the result of morphological, phenological or/and chemical plant factors that adversely affect the insect behaviour. Such morphological traits hindering the penetration of the larvae could be related to a pod or seed coat thickness, seed weight, chemical compounds that hamper the penetration of pods or seeds (alkaloids in lupines) (Keneni et al, 2011). The discrepancy between the phenological development of the host plant and the life cycle of *B. rufimanus* could be a marker for tolerance, too. In our case, several differences among the phenological development of the genotypes, affecting *B. rufimanus* damage, were observed (Fig. 5). After passing of the budding stage were found differences in the growing period length. *Astra*, *Termis Mestnii* and *Barde* were characterized by the lowest duration of the germination-beginning of flowering period (37 days). *Pink Mutan*t (G19), *Solnechnii* (G18), and *Bezimenii* 1 (G13) had a lower duration of that period (38 days). The early cultivars (with early flowering) reached technical maturity on average after 129-134 days, and the late ones - for 140-148 days. Cultivars *Ascar* (G3), *Termis Mestnii* (G16), *Barde* (G21), as well as *Pink Mutant* (G19), *Solnechnii* (G18), and *Bezimenii* 1 (G13), could be included in the group of ultra-early ripening cultivars (the coefficient of early-ripeness 1.00-1.14, N_{min} and N_{max}: 37-38 days). Medium-early ripening cultivars were *Astra* (G1), *Kijewskij Mutant* (G7), *Start* (G9), *BGR* 6305 (G4), *WAT* (G6), *Garant* (G11), *Tel Keram* (G12), *Bezimenii* 2 (G14), *Pflugs Ultra* (G15) (coefficient of early-ripeness >1.34, N_{min} and N_{max}: 39-40 days), and the late-ripening ones - *Hetman* (G8), *Shienfield Gard* (G5) and *Nahrquell* (G2) (coefficient of early-ripeness > 1.66, N_{min} and N_{max}: 41 days).

Several cultivars of the ultra-early ripening group stood out with considerably lower values of damage traits (DR and SI). For example, *Pink Mutant*, *Solnechnii*, and *Bezimenii* 1 had early flowering and slightly preference by *B. rufimanus*, while late-ripening *Hetman* and *Shienfield Gard* was considerably preferred by bruchids. The discrepancy between the early phenological development of those cultivars, and the life cycle of *B. rufimanus* was one of the reasons for the species' tolerance to *B. rufimanus*.

In the previous studies, the influence of cultivar on damage caused to *Vicia faba* L. grain by *B. rufimanus* was evidented (Ebedah, Mahmoud, & Moawad, 2006; Szafirowska, 2012). In these studies was suggested that plant architecture, flowering period and abundance, and the timing of pod formation were the key factors affect the activity of *B. rufimanus*. According to Bruce, Martin, Smart, & Pickett (2011), Ceballos, Fernbndez, Zyciga, & Zapata (2015), several plant characteristics could adversely affect insect behaviour: the authors found that some susceptible genotypes flowered later than the average, which could have contributed in some way to the escape of these pea plants from bruchid infestation. More recent research identified phenological tolerance in cultivars with early flowering stage becoming unavailable to the weevils during the period when the attack is likely to be most severe (Bell & Crane, 2016).

On the other hand, the data obtained from the present study showed the mass of 1000 seeds strongly negatively correlated with the sensitivity index, r= -0.842. It was noticed that genotypes exceeding 300 g per 1000 seeds, such as G6 (322.2g), G19 (317.1g), G13 (308.2g), and G18 (304.3g) were distinguished by low susceptibility index values (from 5.6 to 7.9%). As contrary, genotypes with much smaller seeds like G14, G21, and G20 (173.2, 222.2, and 232.9, respectively) were characterized by higher SI values (from 19 to 23%). Larger seeds are considerably richer in nutrients than small seeds, where larvae destroyed a large amount of them. For example, Mateus, Mexia, Duarte, Pereira & Tavares de Sousa (2011) reported that the attack by bruchids caused a significant reduction in seed weight, between 0.03 (large seeds) and 0.08 g (smaller seeds), depending on the genotypes/cultivars, corresponding to a decrease in nutrients available to the embryonic development. In that aspect, the genotype G14, G21 and G20 were one of the cultivars with the highest susceptibility indexes as the larva destroyed most of the grain content for its feeding.

Also, antixenosis mechanisms might be involved in the tolerance of these genotypes by reducing the preference of *B. rufimanus* adults for feeding as the result of chemical plant factors that adversely affect insect behaviour. Probably, studied lupine cultivars may differ chemically to a great extent (in alkaloid content), and in that context, some species of them may even be toxic to some animals. The negative role of different alkaloids in cultivated lupines was indicated by Ströcker, Wendt, Kirchner & Struck (2013). The presence of such antinutrient substances in the genotype-host probably repelled *B. rufimanus* and explain the weak preferences of bruchids.

Regarding effect of some botanical oils, including lupine seeds on the granary weevil, *Sitophilus granarius* L. (Curculionidae) reported Makarem, Kholy, Abdel-Latif & Seif (2017). According to the authors, lupine oil protected the grain against weevils up to the 6th-week post-treatment achieving mortalities between 60.0 and 100%. Meanwhile, the highest degree of inhibited oviposition and adult emergence was detected with a lupine oil treatment compared to other oils.

On the other hand, proteinase inhibitors are potential candidates for biocontrol of insect pests since insect digestive proteinases are promising targets towards control of various insects (Sharma, Nath, Kumari, & Bhardwaj, 2012). Proteases have been found to be effective against many Coleopteran (Elden, 2000). Scarafoni et al (2008) reported for the inhibitory properties of a trypsin inhibitor from *Lupinus albus* L., a leguminous plant believed to be devoid of any protease inhibitor. Several protease inhibitors have been reported to exhibit inhibitory activity against insect proteases. Although the proteases were not investigated in the present study, seed genotypes slightly affected by *B. rufimanus* had presumably protease inhibitors strongly suppressing its activity.

It is necessary to examine not only the individual effect of plant traits but also their mutual impact on the beetle damage. The applied regression analysis in Table 3 showed that the interaction of plant traits had a significant effect on the damaged seed rate. The susceptibility index (SI) had the highest regression coefficient (r=1.915) (Table 3, below). It had a significant positive effect. The coefficient of early-ripeness had a significantly strong effect on the *B. rufimanus* selection (r= −1.687), but negatively correlated. The mass of 1000 seeds had a low positive effect (r=0.048) on the damaged seeds in the complex interaction between plant traits and seed damage rate.

According to the results obtained , G6, G19, G18 and G13 genotypes seems to have a clear advantage in defending itself from *B. rufimanus* attack. The low DR and SI values make genotypes particularly interesting for breeding purposes due to it probably presents a combination of different mechanisms like seed weight and phenological development adversely affect *B. rufimanus* behaviour. The possibility of combining these two types of resistance mechanisms is of great importance due to the durability of the tolerance to *B. rufimanus*, and successfully overcome an attack if one of these levels is broken.

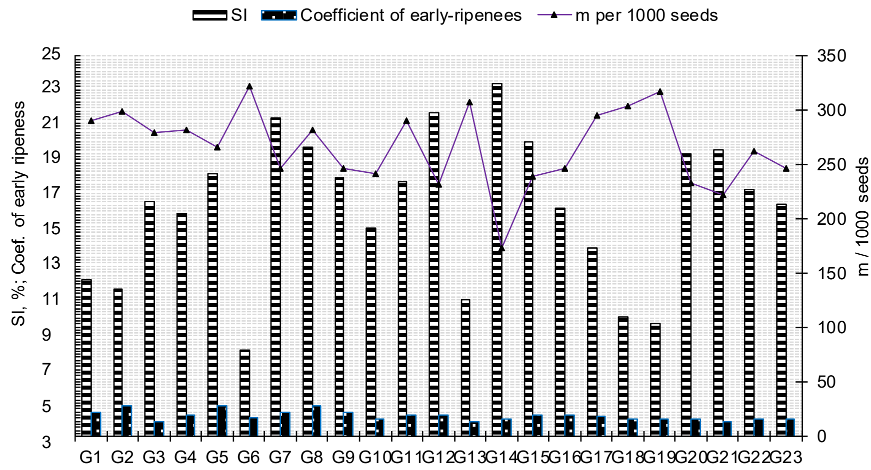

Fig. 5. Characteristics of lupine genotypes. Legend: SI- susceptibility index; G1-Astra, G2-Nahrquell, G3-Ascar, G4-BGR 6305, G5-Shienfield Gard, G6-WAT, G7-Kijewskij Mutant, G8-Hetman, G9-Start, G10-Amiga, G11-Garant, G12-Tel Keram, G13-Bezimenii 1, G14-Bezimenii 2, G15-Pflugs Ultra, G16-Termis Mestnii, G17-Horizont, G18-Solnechnii, G19-Pink Mutant, G20-Manovitskii, G21-Barde, G22-Dega, G23-Desnyanskii.

Table 3. Regression coefficient of the damaged seed rate depending on some plant parameters for lupine genotypes.

Source	*df*	*SS*	*MS*	*F*	*Significance F*
Regression	3	1319.330	439.780	33.140	0.051
Residual	19	252.143	12.270		
Total	22	1571.470			

Parameter	*Coefficients*	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-17.145	15.206	-1.127	0.000	-48.970	14.681
SI	1.915	0.339	5.653	0.000	1.206	2.623
M of seeds	0.048	0.045	1.059	0.087	-0.047	0.142
CER	-1.687	2.843	-0.593	0.100	-7.639	4.264

Legend: SI- Susceptibility index, M of seeds- m per 1000 seeds, CER- Coefficient of early-ripeness

CONCLUSIONS

Bruchus rufimanus damage was affected by climatic parameters. The susceptibility index (SI) of damaged seeds was positively correlated with precipitation amount and humidity, and inversely to minimal and maximal temperature values. The seed damage rate was positively correlated with temperature, but negatively to rain and humidity.

The local Polish population *WAT* and cultivars *Pink Mutant*, *Solnechnii*, and *Bezimenii* 1 (G6, G19, G18 and G13 genotypes, respectively) had the lowest seed damage rate and stable position across all environments. Meanwhile, these cultivars showed a low susceptibility index (SI) and low variability.

The discrepancy between the early phenological development of Pink Mutant, *Solnechnii*, and *Bezimenii* 1, and the life cycle of *B. rufimanus* was one of the reasons for tolerance to bruchids. Correlations between seed damage rate (DR) and susceptibility index (SI) as well as the mass of 1000 seeds and sensitivity index were strongly positive and negative, respectively.

Cultivars *Pink Mutant*, *Solnechnii*, *Bezimenii* 1 and local Polish population *WAT* had a clear advantage in defending itself from *B. rufimanus* attack, which makes them particularly interesting for breeding purposes.

The matching of early flowering with higher seed weight in cultivars could be used as a marker of tolerance to *B. rufimanus* broad bread weevil, and apparently an effective mechanism of plant defense.

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Received: February 20, 2020 *Accepted: June 06, 2021*

J. Entomol. Res. Soc., 23(2): 121-132, 2021 *Research Article*
Doi: 10.51963/jers.v23i2.1906 *Online ISSN:2651-3579*

Notes on the Seasonal Dynamics of Some Paederinae (Coleoptera: Staphylinidae) Species in the Vineyards of Manisa, Western Anatolia

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ABSTRACT

Paederinae (Coleoptera: Staphylinidae) specimens were collected via two light traps which were established in a vineyard in Sarıgöl district of Manisa between April 15th and November 15th in 2018-2019 in this study. Thus, the densities and seasonal activities of the species obtained were evaluated. At the end of the study, a total of 7.274 specimens were identified based on seven species, which are *Astenus melanurus* (Küster, 1853), *A. procerus* (Gravenhorst, 1806), *Luzea graeca* (Kraatz, 1857), *Medon dilutus pythonissa* (Saulcy, 1865), *Paederus fuscipes* Curtis, 1826, *Scopaeus bicolor* Baudi Di Selve, 1848 and *S. debilis* Hochhuth, 1851. It seems all recorded species are predators. The most abundant species are *S. debilis* with 7.006 specimens and *P. fuscipes* with 204 specimens. The identified species were found to be intense and active especially from mid-May to the end of July in general. According to the observations during field studies, it was found that *P. fuscipes* species was a predator of *Aphis illinoisensis* Shimer, 1866 and *A. gossypii* Glover, 1877 (Homoptera, Aphididae) species. This species is most active at the beginning and the end of dry summer.

Key words: Light trap, Paederinae, *Paederus fuscipes*, *S. debilis*, predator, Turkey, *Vitis vinifera*.

Anlaş, S., Yener, H., & Yağmur, E.A. (2021). Notes on the seasonal dynamics of some Paederinae (Coleoptera: Staphylinidae) species in the vineyards of Manisa, Western Anatolia. *Journal of the Entomological Research Society*, 23(2), 121-132.

INTRODUCTION

Turkey provides opportunity for the production of agricultural products due to its climatic and geographical characteristics. One of these products is grape. Although grape (*Vitis vinifera* Linnaeus, 1753) is a plant grown in many places worldwide, its homeland is Anatolia and its neighboring regions. Therefore, it is grown in many different geographical regions of Turkey. Turkey is ranked sixth in the world in grape production and about 30% of the vineyard area is located in Manisa province in Turkey (Semerci, Kızılıtuğ, Çelik, & Kiracı, 2015). There are many insects which damage the grape plant. Therefore, many studies have been carried out on insects which damage the grape plant because of its economic importance. For that reason, mostly insecticides have been used in the control against grape plant pests. However, studies on the determination of natural enemies of grape plant pests and their potential for use in pest control are extremely limited.

Staphylinidae is represented by about 65.000 species in 33 subfamilies in the worldwide, is the largest family of the Coleoptera order (Newton, 2017; Irmler, Klimaszewski, & Bethz, 2018). Paederinae, one of the largest subfamilies of this family, is represented by more than 6,000 species, belonging to 225 genera (Herman, 2001). The species belonging to the Paederinae subfamily are found in almost all habitats, but mostly in moist areas. However, they are generally abundantly found in stream, lake and riversides, moist grassy areas, humic parts of the soil and agricultural areas. As many of the Paederinae species are predators, they are agriculturally beneficial.

Since some of the Paederinae species exhibit light-directed behavior, it is possible to collect and examine them by light traps. However, studies on the collection and evaluation of Paedarinae species with light traps are very few. These studies are generally faunistic studies and ecological studies are very limited. Few ecological studies on Paederinae species have been conducted by Bohac & Bezdek (2004), Abdullah & Sina (2009), Nasir, Akram, & Ahmed (2012), Tezcan & Anlaş (2009), Özgen, Anlaş, & Eren (2010) and Anlaş, Özgen, Yağmur, & Örgel (2017).

Although it is known that some of the Paederinae species are predators, it is not known which Paederinae species are the predators of which pest species. In addition, no specific study has been conducted with light traps on these species up to date. It is known that among Paederinae subfamily *Paederus* species, which is also of medical importance, and especially *Paederus fuscipes* Curtis, 1826 species, are abundant in agricultural areas (cotton, cereal, rice, corn and various vegetable fields) and that they are predators of many pests of such genera as *Corcyra* spp. (Lepidoptera, Pyralidae), *Heliothis* spp. (Lepidoptera, Noctuidae) and *Aphis* spp. (Homoptera, Aphididae) and therefore they are known to be useful for agriculture (Berglind, Ehnstram, & Ljungberg, 1997; Krakerb, Van Huis, Van Lenterenb, Heonge, & Rabbingea, 2000; Komala-Devi, Yadav, & Anand, 2003; Nasir et al, 2012). Apart from this, no study has been found regarding which invertebrate species are preys of Paederinae species. However, some species have been stated to be general pradators, as mentioned. For example, it has been observed that *Achenium depressum* (Gravenhorst, 1802) and *Scopaeus* *mitratus* Binaghi, 1935 are known as predators in cotton fields (Garcia-Ruiz et al, 2018), *Paederus limnophilus* Erichson, 1840, *Paederidus rubrothoracicus* (Goeze, 1777) and *P. ruficollis* (Fabricius, 1775) are known as general predators in agricultural areas (Kolasa, Kubisz, Mazur, Scibior, & Kajtoch, 2018).

No specific studies on Paederinae species found in vineyards have been conducted up to now. In this study, Paederinae species in vineyard areas were collected for the first time with the aid of light traps in Sarıgöl district, Manisa, western Anatolia. It was attempted to reveal the seasonal activities of the identified species, by determining the density of the collected specimens according to the species. It is also aimed to determine the presence of predatory Paederinae species.

MATERIAL AND METHODS

In this study, light traps were used to determine which Paederinae species occur in a selected vineyard area in Sarıgöl District, Manisa province. This area is located in Western Anatolia, includes in the Mediterranean climate, which is characterized by dry, hot summers and mild, moist winters. Average temperature and average rainfall amount of studied localities are provided in Fig. 1. Two light traps were set between April 15th and November 15th in 2018-2019 with a two-year study.

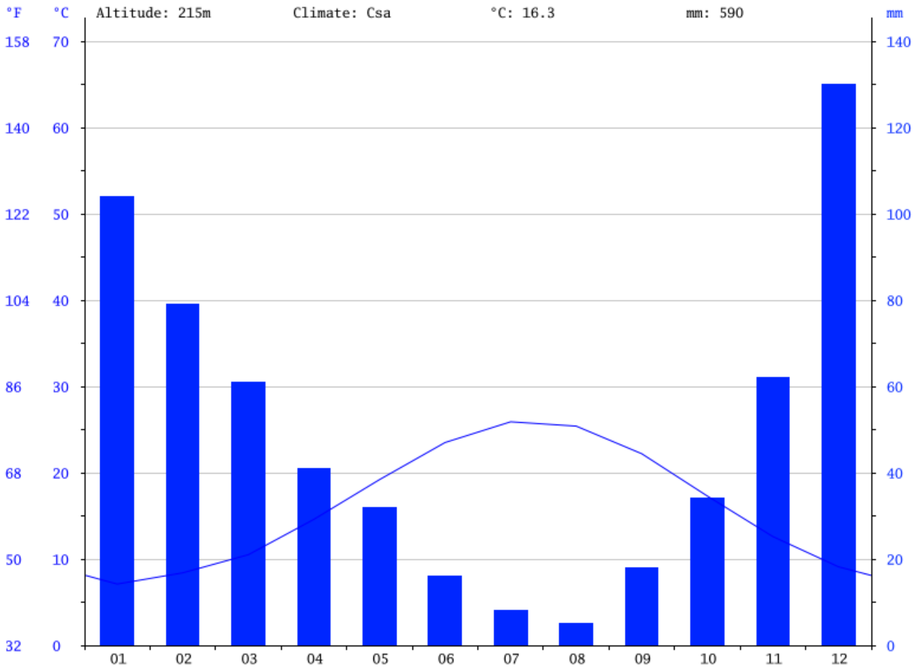

Fig. 1. Avarage temperature and average rainfall amount in Sarıgöl District, Manisa, Turkey (Source: tr.climate-data.org).

The vineyard area is 9 da in total and has a coarse textured soil. The vineyard has 3-year-old „Thompson seedless“ grape variety. The planting space is 3.00 X 1.8 meters and it was set with semi pergola training system. All cultural practices in the vineyard were done under farmer conditions. Light traps were set at 38°14‘18.93“N, 28°42‘25.35“E and 38°14‘19.57“N 28°42‘29.38“E (Fig. 2). A 60 watt Philips energy saver white day light bulb was used at each trap and traps were cleared at two weeks' intervals.

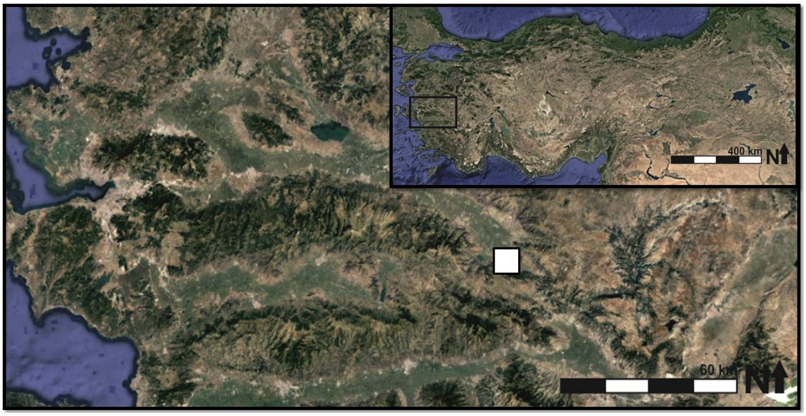

Fig. 2. The locality of light trapping study area in Sarıgöl, Manisa, Turkey.

In the vineyard area where the study was carried out, insecticide was applied against *Anaphothrips vitis* Priener in April and May, against *Lobesia botrana* Denis & Schiffermüller in May, June and July and against *Planococcus citri* Risso in May and June by spraying. Unlike 2018, a broad spectrum insecticide with Deltamethrin effective substance was used in the first application (on 12.05.2019) for *L. botrana* in 2019.

The morphological studies were conducted using a Stemi 508 microscope (Zeiss, Germany). The photographs of the habitus, forebody and aedeagus of the studied species were taken with a digital camera (Zeiss Axiocam ERC5s). All photographs were edited with the Helicon Focus v. 6, and Coreldraw X5 software. The map was made using the software Google Earth Pro (2019). The materials were identified by the first author and were deposited in the Alaşehir Zoological Museum, Manisa, Turkey (AZMM).

RESULTS

Species composition

In this study, Paederinae samples were collected through two light traps set in a vineyard area in Sarıgöl district, Manisa, western Anatolia between April 15 and November 15, in 2018-2019. At the end of the study, a total of 7.274 specimens were collected to seven species. These species are *Astenus melanurus* (Küster, 1853), *A. procerus* (Gravenhorst, 1806), *Luzea graeca* (Kraatz, 1857), *Medon dilutus pythonissa* (Saulcy, 1865), *Paederus fuscipes* Curtis, 1826, *Scopaeus bicolor* Baudi Di Selve, 1848 and *S. debilis* Hochhuth, 1851 (Table 1).

Table 1. Number of specimens of the recorded species in the studied locality in Sarıgöl, Manisa between April 15th and November 15th in 2018-2019.

Species	Year	30.04	15.05	30.05	15.06	30.06	15.07	30.07	15.08	30.08	15.09	30.09	15.10	30.10	15.11	TOTAL
***Scopaeus debilis* Hochhuth**	**2018**	68	131	952	432	945	658	577	339	403	295	21	33	1	-	**4855**
	2019	52	65	77	234	713	403	235	123	129	88	8	22	-	2	**2151**
***Scopaeus bicolor* Selve**	**2018**	3	1	-	-	-	-	-	-	-	-	-	-	-	-	**4**
	2019	4	2	5	-	-	-	-	-	-	-	-	-	3	3	**17**
***Paederus fuscipes* Curtis**	**2018**	24	35	19	2	12	7	4	-	-	-	-	8	3	2	**116**
	2019	15	23	18	7	2	2	1	1	-	2	6	11	-	1	**89**
***Astenus procerus* (Gravenhorst)**	**2018**	-	2	1	1	-	-	-	-	-	-	-	1	-	-	**5**
	2019	-	-	-	-	-	-	-	-	-	-	1	1	-	-	**2**
***Astenus melanurus* (Küster)**	**2018**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**
	2019	2	-	1	-	-	-	-	-	-	1	-	-	-	-	**4**
***Luzea graeca* (Kraatz)**	**2018**	1	-	2	1	-	1	-	-	-	1	-	2	1	-	**9**
	2019	3	2	-	1	1	2	1	-	-	2	1	4	-	-	**17**
***Medon dilutus pythonissa* (Saulcy)**	**2018**	-	-	1	-	-	-	-	-	-	-	-	-	-	-	**1**
	2019	-	-	-	-	-	-	-	1	2	-	-	1	-	-	**4**
TOTAL (for years)	**2018** **2019**	**96** **76**	**169** **92**	**975** **101**	**436** **242**	**957** **716**	**666** **407**	**581** **237**	**339** **125**	**403** **131**	**296** **93**	**21** **16**	**44** **39**	**5** **3**	**2** **6**	**4990** **2284**
TOTAL		**172**	**261**	**1076**	**678**	**1673**	**1073**	**818**	**464**	**534**	**389**	**37**	**83**	**8**	**8**	**7274**

When the specimen numbers of the identified species were examined, it was observed that most specimens belong to *S. debilis* (Fig. 3; for more illustrations of this species see Frisch, 1999) with 7.006 specimens. Belonging to this species, 4.855 specimens were collected in 2018 and 2.151 in 2019. Following this species, the most abundant species is *P. fuscipes* (Fig. 4) with a number of 204 specimens. Others than these two species were examined, it was observed that very few specimens belonging to these species could be collected. For this reason, it is thought that these species are found incidentally in Sarıgöl vineyards or are represented by very few specimens. When these species and the number of the collected specimens were examined; 26 specimens of *L. graeca* species, 21 specimens of *S. bicolor* species, seven specimens of *A. procerus* species, five specimens of *M. dilutus pythonissa* and lastly four specimens of *A. melanurus* species were determined.

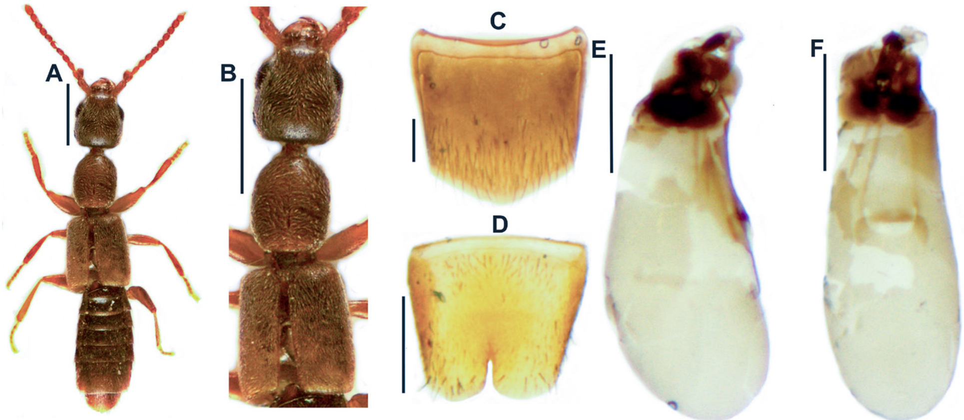

Fig. 3. *Scopaeus debilis* Hochhuth, 1851. A-habitus; B-forebody; C-male sternite VII; D-male sternite VIII; E-aedeagus, lateral view; F-aedeagus, ventral view. Scale bars: 0.5 mm (A-B); 0.2 mm (C-F).

Seasonal dynamics

It was seen that most specimens belong to the species *S. debilis*. Considering the distribution of the specimens by months, it was observed that the most samples for the year 2018 fell into the traps at the end of May with a number of 952 samples. At the end of June, this number was 945 specimens. Only one specimen was collected at the end of October and none in mid-November. Evaluating the year 2018 in general, it was seen that 68 samples were captured on April 30, then the number of samples increased until May 30, then decreased to 432 and then increased again and reached 945 on June 30. After that, it was observed that the number of specimen decreased and reached 658 on July 15, and then continued to decrease 577 on July 30, and decreased to 339 on August 15. It was seen that 403 specimens were collected with very little growth in the following period, and then the samples collected decreased gradually and no samples were collected on November 15. When the year 2019 was evaluated, it was observed that the period in which most specimens were collected was the end of June. In this period, 713 samples were collected. No sample could be collected on October 30. When the seasonal activity of the species was examined, 2018 and 2019 were found to be almost the same (Fig. 5).

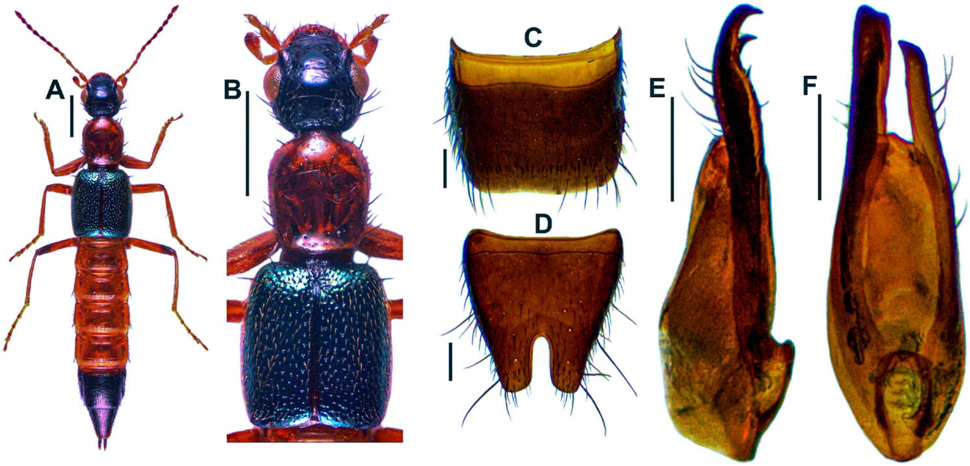

Fig. 4. *Paederus fuscipes* Curtis, 1826. A-habitus; B-forebody; C-male sternite VII; D-male sternite VIII; E-aedeagus, lateral view; F-aedeagus, ventral view. Scale bars: 1 mm (A-B); 0.2 mm (C-F).

P. fuscipes species is the most caught species after *S. debilis*. 116 specimens belonging to this species were recorded in 2018 and 88 in 2019. When the seasonal activity of the species was analysed, it was observed that most number specimens fell into the traps in April and May, few or no specimens fell into the traps during summer months and that the number of specimens in autumn months was still higher than the summer though it was not as much as spring months (Fig. 5). The seasonal activity of the *P. fuscipes* species was previously investigated by Anlaş et al (2017) for the Aegean Region, and due to few samples obtained in this study, it could not be fully compared with the previous results. According to this study, it was observed that the numbers of *P. fuscipes* species began to increase as of May, reached a high level at the beginning and in the middle of June, decreased in the dry period, that is July and August, and reached the highest numbers at the beginning and in the middle of September (Anlaş et al, 2017).

Accordingly, as a result of this study, it was detected that the density of *P. fuscipes* specimens collected with the help of light traps are almost similar to Anlaş et al (2017). The most important difference is that few samples were collected in the Sarigöl vineyard areas during autumn months. When other recorded species were examined after *S. debilis* and *P. fuscipes* species, it was observed that very few specimens of these species were collected. For this reason, it is thought that these species are found incidentally in Sarıgöl vineyard areas or are represented by very few specimens. Seasonal activities could not be evaluated appropriately due to few specimens of these species.

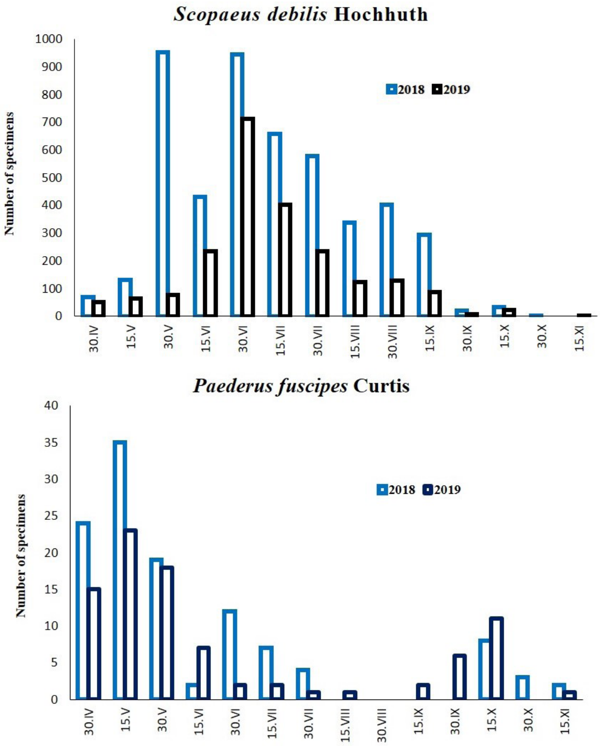

Fig. 5. Seasonal dynamics of *Scopaeus debilis* and *Paederus fuscipes* in the vineyard in Sarıgöl, Manisa between April 15th and November 15th in 2018-2019.

When the seasonal activities of the species in Sarıgöl vineyards were evaluated in both 2018 and 2019 together by considering all the samples of the seven species determined at the end of this study, it was seen that a total of 172 specimens were caught at the end of April, which was the first collection. After that, it was found that in the middle of May, the number increased to 261, after that, at the end of May, the number of the samples collected increased significantly to 1.076. After this date, the number of samples decreased to 678 in the collection in mid-June. By the end of June, it was observed that the most specimens were collected in this period by 1673. Then, the number of specimens fell to 1073 and then to 818. After that, the number of specimens continued to decrease in the middle of August and fell to 464 and at the end of the month, it reached 534 specimens with a small increase. In the collection made in the middle of September, the number of collected specimens decreased again to 389 specimens, then the number of the specimens decreased further, first to double digit numbers and then to eight specimens in late October and mid November. To sum up, it was understood that they reached the highest numbers at the end of May and June, they were also present in the summer months and their numbers were gradually decreasing in the autumn months.

Observations on recorded species

Apart from the light traps set within the scope of the study, various survey studies were carried out in the vineyard area in an attempt to observe the obtained species. As a result of the field studies, it was seen that the Paederinae species in the vineyard area were not active during the daytime and their full activities started in the evening and night hours. Accordingly, the bottom parts of the stones in the vineyard and its surrounding areas, the underneath of the barks and the leaves, the surroundings of the weeds and the areas where they can hide were investigated during the daytime. As a result of the investigation, some species belonging to Staphylinidae family were found in these areas and it was observed that these species were generally different from the species caught by light traps. The species identified in these areas were generally species of *Ocypus* spp., *Philonthus* spp. and *Quedius* spp. (Staphylinidae, Staphylininae) The species belonging to these genera are generally those which live on the soil and feed on small invertebrates, but no related species have been collected by light traps. Some of the identified Paederinae species were observed, though in small numbers, on and around the grape plant.

Accordingly, it has been observed that *P. fuscipes* species is active at night but it can be found in moist or wet areas around the vineyard during the day. It has been also observed that this species attack especially nymphs, sometimes adult plant lice, that is *Aphis* species. Two of these aphid species have been determined and identified as *Aphis illinoisensis* Shimer, 1866 and *A. gossypii* Glover, 1877 (Homoptera, Aphididae).

Some observations have been made regarding *S. debilis* species, which are the most abundant within the study. It was observed that this species attacked the nymphs of the A. illinoisensis species, similarly *P. fuscipes*. However, according to observations, *P. fuscipes* was found to be more predatory than *S. debilis*. The reason for this may be the fact that *P. fuscipes* has a larger body than *S. debilis* and carries a strong toxic substance in its hemolymph. However, existence of this species in small numbers in the vineyards restricts its effectiveness. Apart from this, no other observations could be made with the other species, which are *A. melanurus, A. procerus*, *L. graeca*, *M. dilutus pythonissa* and *S. bicolor*. The reason for this may be that these species exist in small numbers in the vineyard. However, as it is very difficult to distinguish between *S. bicolor* species and *S. debilis* species in the field with the naked eye, it is thought that *S. bicolor* species may also attack these pests in addition to the *S. debilis* species, which are thought to be predators of the above mentioned species. In addition, in a few observations, some Reduviidae (Heteroptera) species have been observed to attack *S. debilis* species.

DISCUSSION

This study, which was carried out between 2018-2019 in order to determine predator Paederinae species in Sarıgöl vineyards and to monitor their seasonal activities, is the first study of its kind in Turkey. As a result of the study, a total of seven species have been determined. These species are *Astenus melanurus* (Küster), *Astenus procerus*

(Gravenhorst), *Luzea graeca* (Kraatz), *Medon dilutus pythonissa* (Saulcy), *Paederus fuscipes* Curtis, *Scopaeus bicolor* Baudi Di Selve and *Scopaeus debilis* Hochhuth. A few studies related to the collection of samples by using only light traps have been conducted in Turkey so far on this subject.

When the species identified in these studies were compared to other studies on rove beetles , it was observed that *M. dilutus pythonissa*, *P. fuscipes* and *S. bicolor* species were collected through light traps from organic cherry orchards in Kemalpaşa (İzmir) in the study previously conducted by Tezcan & Anlaş (2009). While *S. debilis* Hochhuth species was determined to be the dominant species in this study, it was seen that the dominant species was *S bicolor* in the study conducted by Tezcan & Anlaş (2009).

In another study, Özgen et al (2010) determined eight species belonging to the Paederinae subfamily with light traps in pistachio and cotton fields in Diyarbakır, Batman, Siirt and Mardin provinces in the Southeastern Anatolia Region. The species of *A. melanurus* and *P. fuscipes* collected in that study were also found in our study. Apart from this, while *Luzea graeca* species was found in our study, *Luzea nigritula* (Erichson, 1840) species of the same genus, was found in the study conducted by Özgen et al (2010). Likewise, in our study, *M. dilutus pythonissa* species was found, while in this study *Medon semiobscurus* (Fauvel, 1875) species of the same genus was found. It has been seen that in the study published by Özgen et al (2010), the most abundantly found species was *Scopaeus ebneri* Scheerpeltz, 1929.

Anlaş et al (2017), studied on the seasonal activity of *P. fuscipes* Curtis, which is an important species regarding medical and public health terms, in the Aegean Region, found this species in abundance from many light trap localities. This species, which is also useful in agriculture, was identified in this study. However, in our study, it was seen that this species could not be collected in large numbers. According to Nasir et al (2012), this species is affected by intensive agricultural spraying. Considering the intensive insecticide applications of Sarıgöl vineyard areas, where the project was carried out, this result could be considered normal. Nasir et al (2012) collected *P. fuscipes* with different methods in his study in many agricultural fields in Pakistan. A large number of specimens of this species were recorded with the help of one of these methods, that is light trap. In the light of the samples collected, the seasonal activity of the species in Pakistan was discussed. They also stated that *P. fuscipes* fed on aphids and other soft-bodied insects and carmine spider mites and larvae of fruit flies. In this study, it was found that this species attacked some types of aphids, too. In their study in the Czech Republic, Bohac & Bezdek (2004) determined 26 species belonging to Staphylinidae using light trap. It is understood that only the *P. fuscipes* species belongs to the Paederinae subfamily. However, it is seen in that study that this species is not abundant and not dominant. Apart from that, it is stated that the light trap can be used as an effective method to capture Staphylinidae species.

Except for Paederinae species, a large number of species of Aleocharinae (*Aleochara* sp., *Atheta* sp., *Drusilla* sp., *Oxypoda* sp.), Pselaphinae, Tachyporinae (*Mycetoporus* sp. *Tachinus*, *Tachyporus* sp.), Oxytelinae (*Anotylus* sp., *Bledius* sp., *Carpelimus* sp., *Platysetethus* sp.), Steninae (*Stenus* sp.) and Staphylininae (*Gabrius* sp., *Philonthus* sp., *Platydracus* sp., *Quedius* sp., *Xantholinus* sp.) subfamilies were also collected in this study. However, as most of them could not be identified in terms of species level, they could not be evaluated in this study.

At the end of the study, while 4.990 specimens were collected in 2018, 2.284 specimens were found in 2019. Hereby, it was observed that the number of specimens collected in 2018 constituted 68.6% of the total material, while this rate remained at 31.4% in 2019. It is believed that the number of specimens collected in 2019 was less than the previous year, due to climatic causes and especially insecticide applications made before some collection periods. It is thought that the reason for the low number of samples collected on May 30, 2019 in the study compared to 2018 is due to the use of non-selective deltamethrin active ingredient-containing insecticide. The seasonal activities of the detected species in general show us that the predator Paederinae species are especially intense and active from mid-May to the end of July. The number of specimens collected in this period was remarkably higher than other periods. When the species and abundances obtained as a result of the study are evaluated in general, Paederinae species diversity in the Sarıgöl vineyards is considered to be weak. It has been determined that there are few other species other than *S. debilis* species, which is predominantly present and constitutes 96.3% of all samples. The most intense among these is *P. fuscipes* with 204 specimens. Although there is little Paederinae species diversity in the Sarigöl vineyard areas, there are many dominant predator species of Staphylinidae (e. g. *Aleochara* sp., *Ocypus* sp., *Philonthus* sp., *Quedius* sp., *Xantholinus* sp., *Tachyporus* sp.). This is considered important as it shows that this area has not yet lost its biodiversity.

ACKNOWLEDGMENTS

We would like to thank Dr. S. Örgel (Alaşehir), S. Yaman (Akhisar) and Doruk Köksal (Aydın) for their contributions and Fatma Musluoğlu (Alaşehir) for proof-reading the English manuscript. This study was supported by the Manisa Celal Bayar University Scientific Research Projects Coordination Unit (BAP, project no. 2018- 095).

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Received: May 15, 2020 *Accepted: April 28, 2021*

J. Entomol. Res. Soc., 23(2): 133-140, 2021 *Research Article*
Doi: 10.51963/jers.v23i2.1915 *Online ISSN:2651-3579*

New Record and DNA Barcoding of *Dolichogenidea laevigata* (Ratzeburg, 1848) as a Parasitoid of *Archips rosana* (Linnaeus, 1758) from Iran

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ABSTRACT

This is the first report for Iran of *Dolichogenidea laevigata* (Ratzeburg, 1848) (Hymenoptera: Braconidae: Microgastrinae) parasitizing larvae of the European leaf roller *Archips rosana* (Linnaeus, 1758) (Lepidoptera: Tortricidae). The parasitized larvae of *A. rosana* were obtained from different host plants. The occurrence of *D. laevigata* and its diagnosis are presented. In addition, a full DNA barcode (the mitochondrial cytochrome oxidase subunit I, (COI) barcoding region) of the species was obtained for the first time.

Key words: Microgastrinae, parasitized larvae, Lepidoptera defoliator, DNA barcoding.

Farahani, S., & Abdoli, P. (2021). New record and DNA barcoding of *Dolichogenidea laevigata* (Ratzeburg, 1848) as a parasitoid of *Archips rosana* (Linnaeus, 1758) from Iran. *Journal of the Entomological Research Society,* 23(2), 133-140.

INTRODUCTION

The European leaf roller, *Archips rosana* (Linnaeus, 1758), is a defoliator of hardwood trees and shrubs that is distributed throughout Europe, North Africa, North America, Middle East, Iran, Iraq, Turkey, Azerbaijan and Kazakhstan (Ferriere, 1941; Kapidani & Duraj, 1991; Ulusoy, Vatansever, & Uygun, 1999; Güncan, Yoldaș, & Koçlu, 2013; Amano & Higo, 2015). The larvae of *A. rosana* roll and tie leaves together for shelter and feeding. This species is univoltine, and the adult moths fly from the end of May to the early of August with a peak flying period in the 2nd half of June. The larvae are polyphagous which attack fruit trees, forest trees and other trees of the family Rosaceae (Polat & Tozlu, 2010).

Biological control is one of the most effective and important components of integrated pest management programs used to suppress pests. Mayer & Beirne (1974) recorded 28 different parasitoid species attacking *A. rosana* larvae on apple trees. Polat & Tozlu (2010) collected 11 hymenopteran parasitoids of *A. rosana* belonging to Ichneumonidae, Pteromalidae, Chalcididae, Torymidae, Eulophidae and Eupelmidae. Aydoğdu (2014) was reported 22 hymenopteran parasitoids of *A. rosana* from cherry trees in Turkey, of which most of them were attributed to family Braconidae (13 species). Yu, van Achterberg, & Horstmann (2016) compiled all published information and listed 165 parasitoid species attacking *A. rosana* from different families of Hymenoptera, including 60 species of Braconidae.

Microgastrinae is one of the largest subfamilies of Braconidae, consisting of 81 genera and 2999 extant species worldwide (Fernandez-Triana, Shaw, Boudreault, Beaudin, & Broad, 2020). Until now, about 111 species of Microgastrinae have been documented for the fauna of Iran (Farahani, Talebi, van Achterberg, & Rakhshani, 2014; Ghafouri Moghaddam, Rakhshani, van Achterberg, & Mokhtari, 2018; Abdoli & Pourhaji, 2019; Abdoli, Talebi, & Farahani, 2019a; Abdoli, Talebi, Farahani, & Fernandez-Triana, 2019b; Abdoli, Talebi, Farahani, & Fernandez-Triana, 2019c; Zargar, Gupta, Talebi, & Farahani, 2019a, 2019b, 2020; Fernandez-Triana et al, 2020; Abdoli, Talebi, Fernandez-Triana, & Farahani, 2021).

The genus *Dolichogenidea* Viereck, 1911 is a large group with more than 360 described species in the worldwide, and more than 120 species have been found in the west Palaearctic region (Fernandez-Triana, Sakagami, & Shimizu, 2018; Liu, He, & Chen, 2018; Abdoli et al, 2019c; Fernandez-Triana et al, 2020). Recently, Abdoli et al (2019c) listed 13 species of *Dolichogenidea* and described *D. fernandeztrianai* Abdoli &Talebi, 2019 a as a new species from Iran. *Dolichogenidea laevigata* (Ratzeburg, 1848) is a solitary endoparasitoid wasp which is known to attack the caterpillars of Lepidoptera, especially the family Tortricidae (Yu et al, 2016). *Dolichogenidea laevigata* is distributed in the Palaearctic and Oriental regions (Yu et al, 2016).

The objective of this study is to improve our knowledge about biological control agents of *A. rosana* for its better management and we here introduce a new record of parasitoids from Iran as a part of the ongoing research on the systematic of Microgastrinae.

MATERIAL AND METHODS

The specimens of the present study were collected in the National Botanical Garden of Iran in May 2019. The sampled site was located at 35 44′ N, 51 10′ E, elevation 1320m in Tehran, Iran. Larvae of *A. rosana* were collected from different host trees including *Acer* spp., *Quercus* spp., *Morus* sp., *Celtis* sp., *Parrotia persica*, where their leaves had been rolled by larvae (Figs. 1 A-B). Then, larvae were kept under laboratory conditions in plastic cages (Diameter: 17 and High: 25 cm) at 25±2°C, 16:8h (L: D) and reared on host-plant leaves to obtain adults for verification as *A. rosana*.

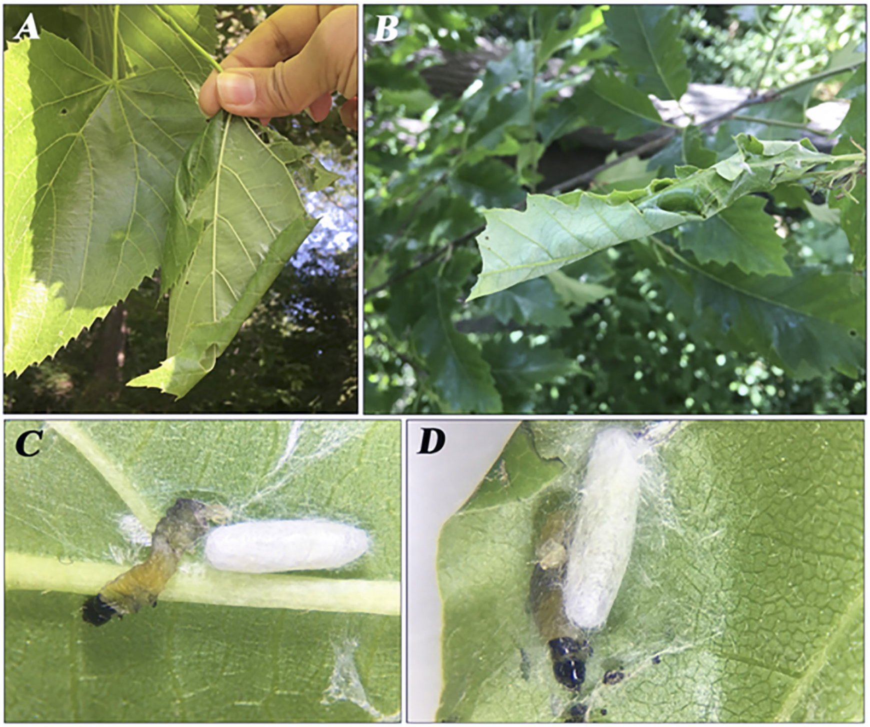

Fig. 1A-D. A-B, Damage of *Archips rosana* (rolled and tied leaves); C-D, Pupa of *Dolichogenidea laevigata* beside dead larva of *A. rosana*.

The parasitoid specimens were identified with the keys of Nixon (1972), Papp (1978), Tobias (1986), Chen & Song (2004) and Liu et al (2018). Morphological terminology follows Wharton, Marsh, & Sharkey (1997) for wing venation and Karlsson & Ronquist (2012) for the other body parts used in description of the new record. The abbreviations T1, T2, and T3 refer to the metasomal mediotergites 1, 2, and 3, respectively.

The specimens were photographed with a Keyence VHX-1000 Digital microscope, using a lens with a range of 13-130×. Multiple images through the focal plane later were combined to produce a single in-focus image. The software associated with the Keyence system produced the focused images taken with that camera. The measurements were done using an Olympus™ SZX9 stereomicroscope equipped with a graticule. DNA barcoding of new record focused on the sequencing of a short standardized portion of the mitochondrial cytochrome c oxidase I gene (COI). The sample in this study has had legs removed for DNA extraction. DNA extraction method follows Brewster and Paoli (2013). The COI gene was amplified using primers (LCO1490-HC02198) following standard protocols (Folmer, Black, Hoeh, Lutz, & Vrijenhoek, 1994). The barcode sequence was deposited in the National Center for Biotechnology Information (NCBI) and also, the sequence of the species was assigned in BOLD (Barcode of Life Datasystems).

The specimens of *D. laevigata* are deposited in the Collection of Research Institute of Forests and Rangelands, Agricultural Research Education and Extension Organization (AREEO), Tehran, Iran.

RESULTS

Pupae of wasps appeared by mid-late May beside dead larvae (Fig. 1 C-D). Only one species of Braconidae (e.g., *Dolichogenidea laevigata* (Ratzeburg, 1848)) is reported for the first time from Iran. In addition, mitochondrial cytochrome oxidase subunit I (COI) barcoding region has been sequenced for the first time.

Taxonomy

***Dolichogenidea laevigata* (Ratzeburg, 1848) (Figs. 2A-G)**

Microgaster laevigatus Ratzeburg, 1848, p. 50.

Apanteles calcaratus Ivaniv, 1899

Microgaster hoplites Ratzeburg, 1848

Distribution in Iran

Tehran (This is a new record for Iran).

General distribution

Oriental (China), Palaearctic (Armenia, Azerbaijan, Bulgaria, China, Former Czeshoslovakia, Finland, France, Georgia, Germany, Hungary, Israel, Italy, Kazakhstan, Korea, Latvia, Lithuania, Moldova, Netherlands, Poland, Romania, Russia, Slovakia, Spain, Sweden, Switzerland, Turkey, Ukraine, United kingdom, Uzbekistan, Former Yugoslavia) (Yu et al, 2016).

Material examined: Iran, Tehran province, National Botanical Garden of Iran, 15.05.2019, 6♂♂, 3♀♀. Host. *Archips rosana.* leg.: S. Farahani.

Diagnosis (female)

Propodeum with areola weakly defined by an impression (Fig. 2E); in fore wing, vein R1 slightly longer than pterostigma; vein R1 4.30-4.50× as long as distance of vein R1 to vein 3RSb (Fig. 2F); T1 subparallel-sided (i.e., slightly narrower medially), weakly punctuate in posterior half and otherwise smooth, with a distinct protuberance on central area, length 1.50× posterior width; T2 smooth; T3 longer than T2 (Fig. 2G); hypopygium pointed apically and slightly protruding beyond apical tergites; ovipositor sheath with uniform width from base to apex and 1.50-1.60× metatibia (Fig. 2D); body black or dark brown; tegula, mouthparts and legs (except for coxae) yellow; pterostigma brown with a basal yellow spot; mesosoma in ventral view, with a pair of yellow bands.

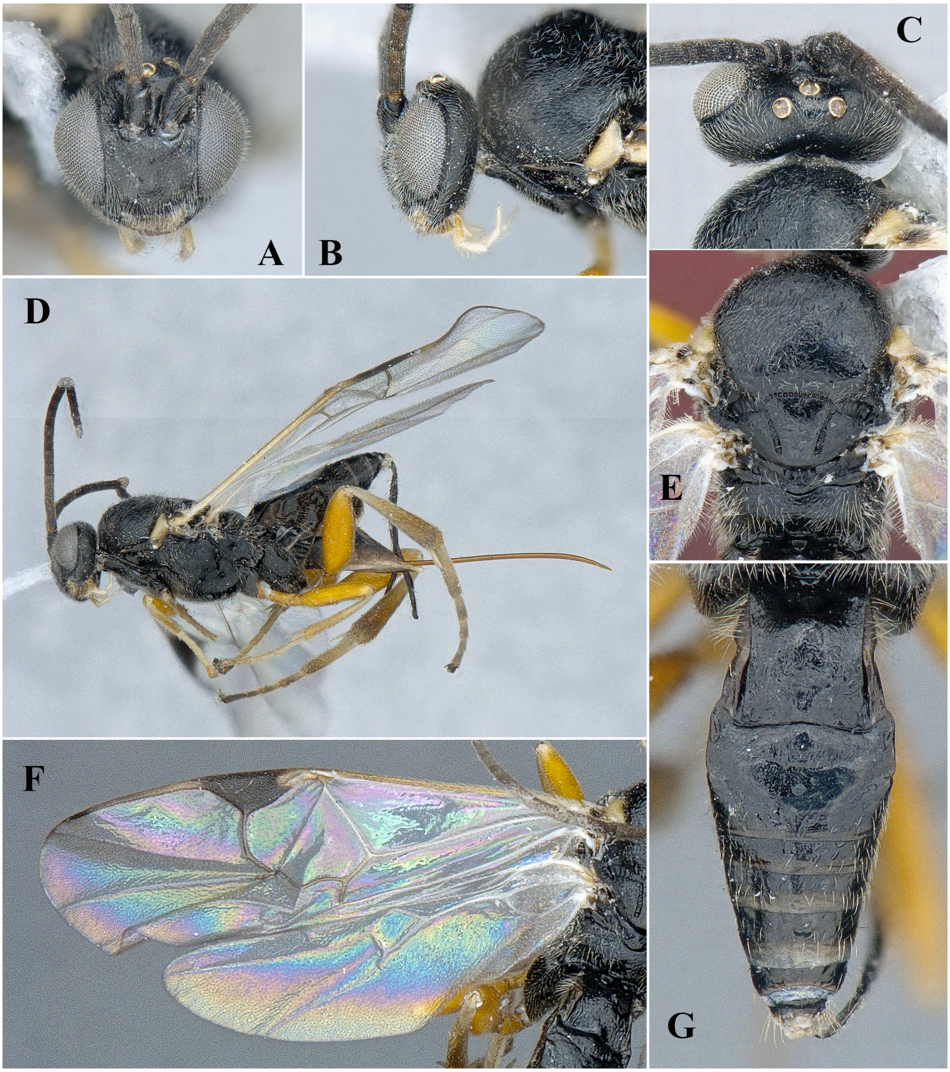

Fig. 2A-G. *Dolichogenidea laevigata*. A, Head, frontal view; B, Head, lateral view; C, Head, dorsal view; D, Habitus, lateral view; E, Mesosoma, dorsal view; F, Wings; G, Metasoma, dorsal view.

Male

All characters similar to female, with the exception of T1 smooth, T1 length 2.00× its posterior width, T1 posterior half parallel-sided; antenna clearly longer than body (where as in female antenna as long as to slightly shorter than body); mesosoma clearly shorter than metasoma (where as in female mesosoma as long as metasoma).

DNA barcode

The DNA barcode sequence for *D. laevigata* is available at the NCBI database (National Center for Biotechnology Information: https://www.ncbi.nlm.nih.gov/), with accession number MT180835.

The sequence of the species was assigned in BOLD (Barcode of Life Datasystems: http://www.boldsystems.org/index.php). The Barcode Index Number BOLD:AED8893, with the closest species found to be *Dolichogenidea phaloniae* (Wilkinson, 1940).

The COI sequence of *D. laevigata* is as below:

ATATTTGGTTTATGATCTGGAATATTAGGATTTTCAATAAGATTAATTATTCGTT-
TAGAATTGGGAATACCTGGGAGGTTAATTGGTAATGATCAAATTTATAATAG-
TATAGTTACTTCTCATGCATTTATTATAATTTTTTTTATAGTTATACCTGTAATAATTG-
GAGGATTTGGTAATTGATTAATTCCTTTGATATTAGGATCACCTGATATATCATTTC-
CTCGAATAAATAATATAAGTTTTTGATTATTAATTCCTTCTTTATTTATATTAATTTTAA-
GAGGATTTATTAATACTGGTGTTGGAACGGGTTGGACTGTTTATCCACCATTGT-
CATTAATTTTAGGTCATGGTGGAATATCAGTTGATTTAGGAATTTTTTCTTTACATT-
TAGCTGGTGCTTCATCAATTATAGGTGCTGTTAATTTTATTACAACAATTTTAAAT-
ATACGAACAAATTTATTTATAATAGATAAAATATCTTTATTTTCTTGATCAGTTTTTAT-
TACTGCAATTTTATTATTATTATCTTTACCTGTTTTAGCTGGAGCAATTACTATATTAT-
TAACTGATCGTAATTTAAATACAAGATTTTTTGATCCTTCTGGTGGTGGAGATC-
CAATTTTATATCAACATTTATTTTGATTTTTTGGTCACCCAA.

Hosts

Yu et al (2016) listed all host records from the historical literature, but in many cases those records are incorrect (Fernandez-Triana et al, 2020).

DISCUSSION

The genus *Dolichogenidea* is newly recorded from Tehran province. *Dolichogenidea laevigata* as a biological control agent is known to attack the forest Lepidopteran pest especially the family Tortricidae (Yu et al, 2016). In view of this finding, the potential of this parasitoid for biological control of *A. rosana* in Iran should be investigated and the information presented in this paper can be helpful in the development of biological control programs to manage of this pest.

This study has added one new record of *Dolichogenidea* from Iran, thus increase the total number of species to 15 in Iran (Abdoli et al, 2019a). *Dolichogenidea laevigata* is similar to *D. lineipes* from which it can be distinguished by the pale spot at the base of the stigma and the apical segments of the antenna are different (Nixon, 1972).

The mitochondrial cytochrome oxidase subunit I (COI) of *D. laevigata* barcoding region was sequenced for the first time. There are almost 4,100 DNA-barcode compliant sequences of *Dolichogenidea* in BOLD representing 456 different BINs (Barcode Index Numbers), of these records, 239 species is presented.

ACKNOWLEDGMENTS

This work is supported by Research Institute of Forests and Rangelands, Agricultural Research Education and Extension Organization (AREEO), Tehran, Iran. We cordially thank section editor, Dr Jose Fernandez-Triana (Canadian National Collection of Insects, Ottawa, Canada), and an anonymous reviewer for their valuable comments and recommendations on the earlier version of this paper. Thanks to Department of Entomology, Tarbiat Modares University for providing facilities.

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Received: June 05, 2020 *Accepted: July 08, 2021*

J. Entomol. Res. Soc., 23(2): 141-152, 2021 *Research Article*
Doi: 10.51963/jers.v23i2.1929 *Online ISSN:2651-3579*

New Records of the Craneflies (Diptera: Limoniidae, Tipulidae) from the Western Balkans

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ABSTRACT

We collected adult cranefly specimens during 2016 and 2017 with entomological nets from some localities in Kosovo, North Macedonia and Serbia. A number of 7 species belonging to 5 genera and 2 families were collected. Four species found during this investigation are first records for Republic of Kosovo: *Geranomyia fuscior* Stary, 2012, *Limonia macrostigma* (Schummel, 1829), *Rhypholophus bifurcatus* Goetghebuer, 1920, *Tipula* (*Savtshenkia*) *benesignata* Mannheims, 1954 and three other species are first records for Republic of North Macedonia: *Erioptera* (*Erioptera*) *fusculenta* Edwards, 1938, *Tipula* (*Savtshenkia*) *gimmerthali gimmerthali* Lackschewitz, 1925 and *Tipula* (*Schummelia*) *variicornis variicornis* Schummel, 1833. The most interesting finding are *Geranomyia fuscior*, which was previously known only from Albania, Portugal and Libya, and *Tipula* (*Savtshenkia*) *gimmerthali gimmerthali* which is reported for the first time from the Western Balkans, due to the fact that less is known about their distribution in the area. This study represents an important contribution to the knowledge of species composition and distribution of crane flies in Western Balkans.

Key words: Diptera, new records, rare species, Kosovo, North Macedonia.

Bilalli, A., Ibrahimi, H., Musliu, M., Grapci-Kotori, L., Geci, D., Slavevska-Stamenkovič, V., Hinič, J., Mitić-Kopanja, D., Keresztes, L.(2021). New Records of the Craneflies (Diptera: Limoniidae, Tipulidae) from the Western Balkans, *Journal of the Entomological Research Society*, 23(2), 141-152.

INTRODUCTION

Craneflies are one of the largest groups of the Diptera, containing over 15609 valid species and subspecies (Oosterbroek, 2021). The immature stages of the majority of the species live in aquatic or semiaquatic habitats. Some aquatic species live entirely submerged and lack functional spiracles, while others come to the surface to take oxygen. Semiaquatic species occur in a wide range of habitats. The semiterrestrial and terrestrial larvae live in environments that are considerably moisturised. All adult craneflies are terrestrial (de Jong, Oosterbroek, Gelhaus, Reusch, & Young, 2008). Some species occupy wetlands such as salt marshes (Autio, Salmela, Suhonen, & Suhonen, 2013; Rogers, 1932).

Craneflies are crucially important in the trophic webs, exhibiting mostly a detritivorous diet during their larval phase. Adults of most of the species do not feed, but in some species they will take nectar, pollen, and water. Their position in food webs makes them an important trophic link between aquatic and terrestrial environments (e.g., Baxter Fausch, & Sauders, 2005).

The survey of the species from the Western Balkans began in the second half of the 19th century and at the beginning of the 20th century and was undertaken by Egger (1863), Loew (1873), Bergroth (1888), and Strobl (1893, 1902), who had described and/or documented most of the presently known taxa. The numbers of taxa in some of the Balkan countries are as follows: Slovenia 211, Croatia 185, Bosnia and Herzegovina 154, Serbia 200, Montenegro 147, and Republic of North Macedonia 191 (Oosterbroek, 2021). For Kosovo there are no comprehensive data on the number of species.

The goal of this paper is to contribute to the distribution of crane flies in the Balkan Peninsula, which remains relatively under-investigated in terms of the cranefly fauna.

MATERIALS AND METHODS

Sampling and study area

Adult crane fly specimens were collected with entomological nets during 2016 and 2017 in Kosovo, North Macedonia and Serbia. Four of the sampling sites are located in Kosovo: S1 is in Bollosicë village in Kopaonik Mountain, spring area of Llap River, S2 and S3 are in the Karadak Mountain (Dërmjak and Stanqiq), while S4 is located in Sharr National Park (Gajre). Three localities (S5, S6 and S7) are in the Republic of North Macedonia (Tanushë, Tabanovc and Dolno Sonje) and one locality (S8) is in Serbia (Jastrebac) (Table 1 and Fig. 1).

The collected samples were preserved in 96% ethanol.

Male terminalia were left overnight in 10% KOH and for one hour in undiluted glacial acetic acid to neutralize and wash out the soap created from the soft tissues. Then they were transferred to a larger amount of glycerol to wash out the acid, and then to a drop of glycerol on a slide with rounded excavation. The slide was carefully transferred to the compound microscope to take the photos. Photos of the wing were taken with an Olympus stereomicroscope (SZ51) with Cannon Camera (650D) attached. Photos of the genital structures were taken with a compound Olympus microscope (CX23) equipped with standard planchromatic objectives. The camera was Cannon 750D, and as stacking software we used Zerene Stacker. Stacking results consists of 10-15 single exposures with the stereomicroscope and 20-50 exposures with the compound microscope.

Table 1. Locality data for the 8 sampling stations of crane fly in Kosovo, Republic of North Macedonia and Serbia.

Code	Sampling Stations	Latitude ˚N	Longitude ˚E	Altitude
S1	Bollosicë	43.118169	20.99330	1330
S2	Dërmjak	42.17264	21.31582	625
S3	Stanqiq	42.25506	21.55029	836
S4	Gajre	42.21016	21.24076	653
S5	Tanushë	42.23356	21.42733	1358
S6	Tabanovc	42.219713	21.697831	380
S7	Dolno Sonje	41.942766	21.377597	635
S8	Jastrebac	43.398180	21.395490	997

The material, representing adult specimens, was preserved in ethanol 98% and deposited in the Diptera Collections of the Faculty of Biology and Geology, affiliated to the Zoological Museum of the University of Babes-Bolyai, Cluj Napoca, Romania.

The systematic, distribution and nomenclature follow the Catalogue of the Craneflies of the World (CCW: Oosterbroek, 2021).

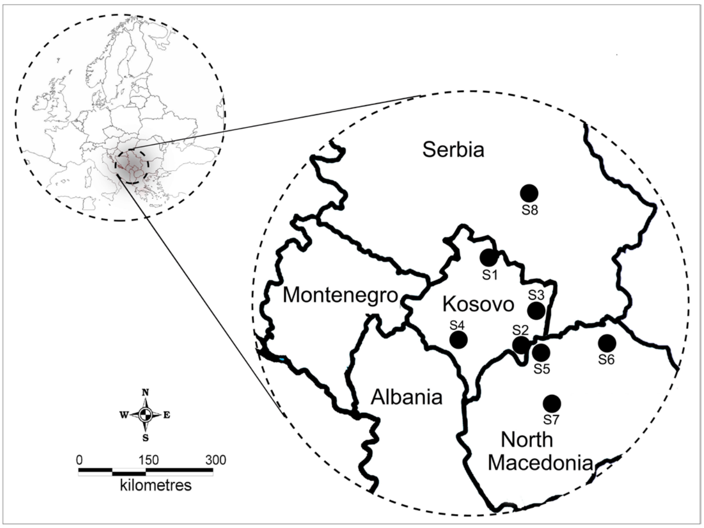

Fig. 1. Eight sampling stations in Kosovo, Republic of North Macedonia and Serbia. Details of sampling stations are in Table 1.

RESULTS AND DISCUSSION

During this investigation we collected 17 cranefly specimens (14 males and 3 females), belonging to 7 species, 5 genera and 2 families. Four species belong to the family Limoniidae and three species belong to the family Tipulidae.

Two species were registered with higher numbers of specimens: *Rhypholophus bifurcatus* (11 specimens) and *Tipula* (*Savtshenkia*) *benesignata* (2 specimens), while other species were found with only one specimen each.

Four species that were found during this investigation were recorded for the first time from Kosovo: *Geranomyia fuscior* Stary, 2012, *Limonia macrostigma* (Schummel, 1829), *Rhypholophus bifurcatus* Goetghebuer, 1920 and *Tipula* (*Savtshenkia*) *benesignata* Mannheims, 1954**.** Three other species are the first records for the Republic of North Macedonia: *Erioptera* (*Erioptera*) *fusculenta* Edwards, 1938, *Tipula* (*Savtshenkia*) *gimmerthali gimmerthali* Lackschewitz, 1925 and *Tipula* (*Schummelia*) *variicornis variicornis* Schummel, 1833.

The most interesting finding during this investigation is the species *Geranomyia fuscior,* which was described only a few years ago based on specimens that were collected in Portugal and Libya, as well as preserved mater ial from Albania. The finding of this species in Kosovo indicates that its areal extent in the Balkans may be bigger than previously considered. The finding of other first records from Kosovo and North Macedonia also greatly expands their area of distribution. For example, the following species were only known from a limited number of localities until now: *Erioptera* (*Erioptera*) *fusculenta and Rhypholophus bifurcates. Tipula* (*Savtshenkia*) *gimmerthali gimmerthali***,** which was found in North Macedonia, is also reported for the first time from the Western Balkans.

There are many under investigated areas in the Balkan Peninsula with respect to craneflies and future studies will most certainly reveal many other rare species.

Systematic list of the found species with distributional data, number of male and female specimens and other collection details. First records are indicated with an asterisk (KS - Kosovo, NM - North Macedonia).

***Erioptera* (*Erioptera*) *fusculenta* Edwards, 1938 * NM** (Fig. 2.)

Material examined: Republic of North Macedonia (S6 Tabanovc), 21.09.2016, 1 ♂, leg.: Bilalli, A., Musliu, M., and Ibrahimi, I.

Distribution: Austria (Vienna), Belgium, Bulgaria, Czech Rep., Denmark, Estonia, France, Germany, Great Britain, Hungary, Italy (incl. Sicily), Lithuania, Moldovia, Montenegro, Netherlands, Poland, Portugal, Romania, Serbia, Slovakia, Sweden, Switzerland, Turkey (European part: widespread), Ukraine; Russia: RUE (Bashkortostan Rep.), North Caucasus; Georgia, Armenia, Azerbaijan, Turkey (Asiatic part), Israel, Turkmenistan (Oosterbroek, 2021).

Habitat: It is a common species, occurring in a range of different habitats with a preference for wet habitats (Boardman, 2007; Kolcsar et al, 2013; Starý & Delmastro, 2001; Ujvárosi, 2005). We found this species in a riverbed vegetation, dominated by willows [*Salix*].

Flight period: month (s) 4 - 12 (Kolcsar, Soos, Torok, Graf, Rakozy, & Keresztes, 2017; Starý & Freidberg, 2007).

Altitude: 16 - 2195 m (Obona, Stary, Manko, Hrivniak, & Papyan 2016; Ozgul, Koc, & Stary, 2006).

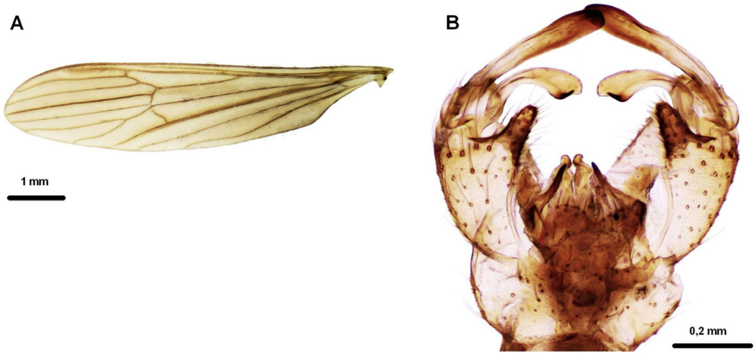

Fig. 2. Photograph of the wing and morphological structures of the male terminalia of *Erioptera fusculenta* Edwards, 1938. A. left wing of the male; B. male terminalia, dorsal view.

Geranomyia fuscior **Stary, 2012 * KS** (Fig. 3.)

Material examined: Kosovo (S1 Bollosicë), 15.08.2016, 1 ♂, leg.: Ibrahimi, H.

Distribution: Albania, Libya, Portugal (Stary, 2012).

Habitat: This species is reported as common from saltmarsh habitats (Stary, 2012). During our investigation we found this species near a mountainous eucrenal freshwater habitat surrounded by mixed vegetation, dominated by high woods, mainly beech [*Fagus*] and herbaceous plants along the watercourse.

Flight period: month(s) 4 - 7 (Stary, 2012), while during this investigation we found it in August.

Altitude: 24 m (Stary, 2012), during our investigation we found this species at 1330 m a.s.l.

Limonia macrostigma **(Schummel, 1829) * KS** (Fig. 4.)

Material examined: Kosovo (S3 Stanqiq), 09.10.2017, 1 ♂, leg.: Bilalli, A. and Musliu, M.

Distribution: Austria, Belarus (Minsk region), Belgium, Bulgaria, Croatia, Czech Rep., Denmark, Finland, France (incl. Corsica), Germany, Great Britain, Greece (incl. Evvoia [Evia]), Hungary, Iceland, Ireland, Italy (incl. Sicily), Latvia, Lithuania, Macedonia, Netherlands, Norway, Poland, Romania, Serbia, Slovakia, Slovenia, Spain (Gerona, Guipuzcoa, Lerida, Lugo), Sweden, Switzerland, Turkley (European part: Edirne, Kikrlareli), Ukraine, Russia: RUN, RUW, RUC (Mordoviya Rep., Tverskaya oblast), Saratovskaya oblast), North Caucasus, Morocco (High Atlas), Georgia, Armenia, Azerbaijan, Turkey (Asiatic part: Aydin, Denizli, Eskisehir, Isparta, Mugla, Marmara region), Cyprus, Russia: WS (Altay), FE (Primorskiy kray), Kazakhstan, Uzbekistan, Tajikistan, Kyrgyzstan, Mongolia, North Korea, Pakistan (Oosterbroek, 2021).

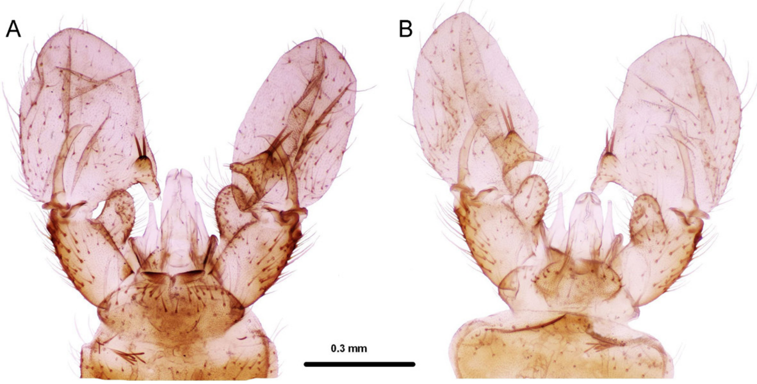

Fig. 3. Photograph of the morphological structures of the male terminalia of *Geranomyia fuscior* Starý, 2012. A. male terminalia, dorsal view; B. male terminalia, ventral view.

Habitat: species with a wide range of habitats, both terrestrial and aquatic, can attain relatively high densities in spring habitats, citing various sources (Salmela, 2001). We found this species nearby the freshwater habitats.

Flight period: month(s): 3 - 11 (Mederos, Claramunt-Lopez, & Eiroa, 2019; Kolcsar et al, 2013).

Altitude: 368 - 2350 m (Kolcsar, Ivkovic, & Ternjej, 2015; Starý & Oosterbroek, 2008).

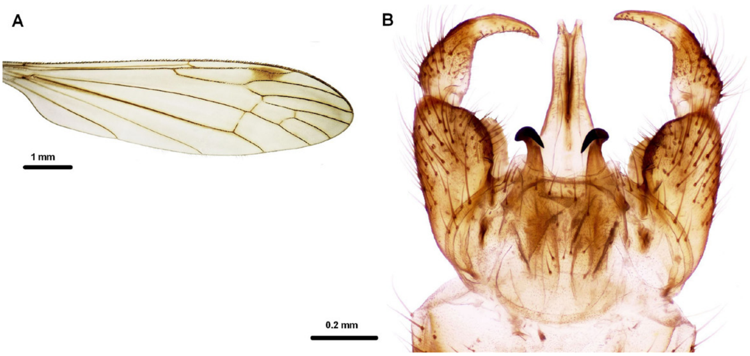

Fig. 4. Photograph of the wing and morphological structures of the male terminalia of *Limonia macrostigma* (Schummel, 1829). A. right wing of the male; B. male terminalia, dorsal view.

Rhypholophus bifurcatus **Goetghebuer, 1920 * KS** (Fig. 5.)

Material examined: Kosovo (S3 Stanqiq) 09.10.2017, 1 ♂, 2 ♀♀, leg.: Bilalli, A. and Musliu, M.; Kosovo (S4 Gajre) 02.10.2016, 7 ♂♂, leg.: Bilalli, A. and Musliu, M.; Serbia (S8 Jestrebac, Majorva Cesma), 21.11.2016, 1 ♂, leg.: Ibrahimi, H. and Bilalli, A.

Distribution: Austria, Belgium, Bulgaria, Czech Rep., France (incl. Corsica), Germany, Great Britain, Greece (Evritania), Hungary, Ireland, Italy (Calabria), Lithuania, Netherlands, Romania, Serbia, Slovakia, Switzerland, Turkey (European part: Kirklareli), Ukraine, Russia: RUW, Turkey (Asiatic part: Balikesir, Canakkale, aeli), Georgia (Oosterbroek, 2021).

Habitat: found in lowland calcareous woodlands, in a damp deciduous forest with undergrowth largely of *Aegopodium podagraria* and forest floor with much dead wood (Boardman, 2007; Dek & Oosterbroek, 2013). We found it nearby streamlet habitats.

Flight period: month(s) 8 - 11 (Ashe, O'Connor, Chandler, Stubbs, Vane-Wright, & Alexander, 2007; Hubenov, 2015; Koc, Ozgul, Hasbenli, 2016; Podenas, Geiger, Haenni, & Gonseth, 2006; Stary & Oosterbroek, 2008).

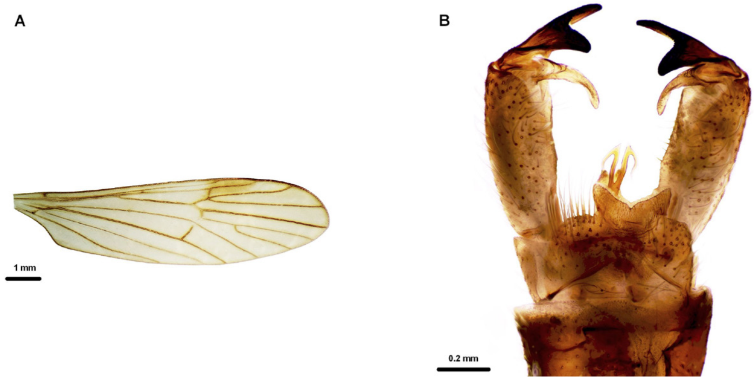

Fig. 5. Photograph of the wing and morphological structures of the male terminalia of *Rhypholophus bifurcatus* Goetghebuer, 1920. A. right wing of the male; B. male terminalia, dorsal view.

***Tipula* (*Savtshenkia*) *benesignata* Mannheims, 1954 * KS** (Fig. 6.)

Material examined: Kosovo (S2 Dërmjak) 2.10.2016. 1 ♂, leg.: Bilalli, A. and Musliu, M.; Kosovo (S4 Gajre) 2.10.2016. 1 ♂, leg.: Musliu, M. and Bilalli, A.

Distribution: Austria, Belgium (Ardennes), Croatia, Czech Rep., Finland, France (Alps, Auvergne), Germany, Greece (incl. Evvoia [Evia]), Hungary, Italy (north), Luxembourg, Montenegro, Norway, Romania, Slovakia, Slovenia, Sweden, Switzerland, Ukraine, Russia: NET (Kareliya, Leningradskaya oblast), CET (Moskovskaya oblast), North Caucasus, Turkey (Asiatic part: Bursa, Canakkale), Kyrgyzstan (Tien Mts) (Oosterbroek, 2021).

Habitat: found in riversides within moist forests, semiaquatic substrata from a cold spring habitat. Larvae abundant in water margin zone of an oligotrophic lake, developing in microhabitats with dense cover of mosses; extensive notes on feeding and gut contents, species is possibly a poly-saprophage with elements of bryophagy and facultative predation (Koc et al, 2015; Przhiboro, 2003, 2009). We also collected this species from nearby riverside habitats within moist forests.

Flight period: month (s) 8 - 11 (Heiss, Graf, Keresztes, Kolcsar, Torok, & Vogtenhuber, 2016; Hofsvang, Olsen, Oosterbroek, & Boumans, 2019).

Altitude: 52 - 1900 m (Koc et al, 2015; Tillier & Oosterbroek, 2019; Ujvárosi, 2003).

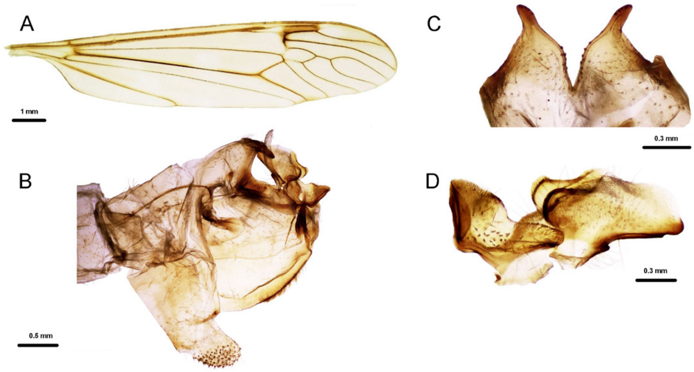

Fig. 6. Photograph of the wing and morphological structures of the male terminalia of *Tipula* (*S.*) *benesignata* Mannheims, 1954. A. right wing of the male; B. male terminalia, lateral view; C. tergite 9, posterior edge, dorsal; D. inner gonostylus , outer-lateral view.

***Tipula* (*Savtshenkia*) *gimmerthali gimmerthali* Lackschewitz, 1925 * NM** (Fig. 7.)

Material examined: Republic of North Macedonia (S5 Tanushë) 25.09.2016. 1 ♂, leg.: Bilalli, A., Musliu, M. and Ibrahimi, H.

Distribution: Austria, Czech Rep., Finland, France (Alps, Auvergne), Germany, Great Britain, Italy (north), Latvia, Norway, Romania, Spain (Granada), Sweden, Switzerland, Ukraine, Russia: NET (Murmanskaya oblast, Arkhangelskaya oblast), SET, Mongolia (Oosterbroek, 2021).

Habitat: mires, springs and headwater streams with a preference for calcareous soils (Salmela, 2011; Stubbs, 2008). We found it near a small stream.

Flight period: month (s) 8 - 10 (Heiss et al, 2016; Salmela, 2008; Tillier & Oosterbroek, 2019).

Altitude: above 300 - 2650 m (Lantsov, 2007; Reusch & Heiss, 2012; Stubbs, 2003; Tillier & Oosterbroek, 2019).

***Tipula* (*Schummelia*) *variicornis variicornis* Schummel, 1833 * NM** (Fig. 8.)

Material examined: Republic of North Macedonia (S7 Dolno Sonje) 28.9.2016, 1 ♀, leg.: Ibrahimi H.

Distribution: Austria, Belarus, Belgium, Bosnia-Herzegovina, Bulgaria, Czech Rep., Denmark, Estonia, Finland, France, Germany, Great Britain, Greece, Hungary, Ireland, Italy, Lithuania, Luxembourg, Montenegro, Netherlands, Norway, Poland, Romania, Serbia, Slovakia, Slovenia, Spain (Lerida), Sweden, Switzerland, Turkey (European part: Kirklareli), Ukraine, Russia: NET, CET (Chuvash Rep., Mayi El Rep., Moskovskaya oblast), SET, Georgia, Armenia, Azerbaijan, Turkey (Asiatic part: Ankara, Bursa, Canakkale, Kocaeli), Russia: WS (incl. Altay, Tyva), ES, FE (Sakhalin (incl. Moneron), Kuril Is), Kazakhstan (east), Japan (Honshu) (Oosterbroek, 2021).

Habitat: Occasionally in springs or spring brooks and small rivers; larvae may dwell in terrestrial, semiaquatic or hygropetric habitats, citing various sources (Salmela, 2001). We found it in wet habitats, near a small river.

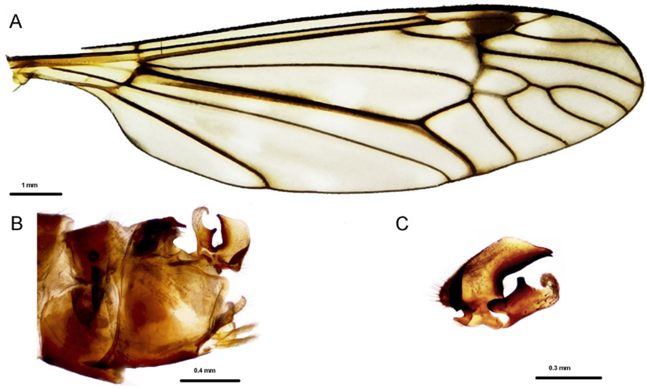

Fig. 7. Photograph of the wing and morphological structures of the male terminalia of *Tipula* (*S.*) *gimmerthali gimmerthali* Lackschewitz, 1925. A. right wing of the male; B. male terminalia, lateral view; C. inner gonostylus, outer-lateral view.

Flight period: month(s) 4 - 8 (Oosterbroek, 2008; Quindroit, 2020; Salmela and Autio, 2007).

Altitude: 500 - 1850 m (Dufour, 2003; Merkel-Wallner, Kehlmaier, & Heiss 2011; Oosterbroek, 2008; Koc and Oosterbroek, 2001).

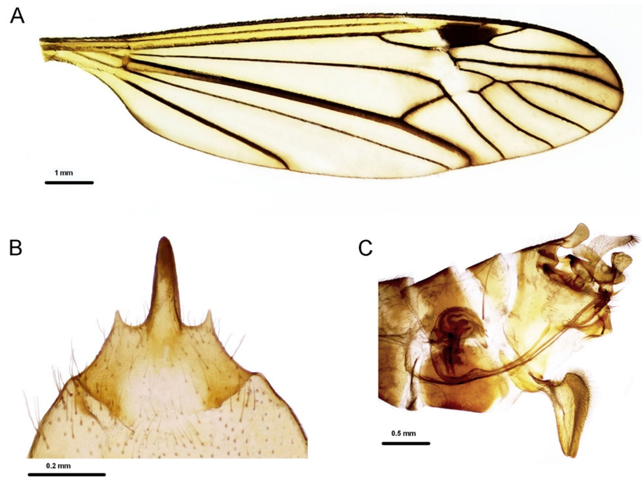

Fig. 8. Photograph of the wing and morphological structures of the male terminalia of *Tipula (S.) variicornis variicornis* Schummel, 1833. A. right wing of the male; B. tergite 9, posterior edge, dorsal; C. male terminalia, lateral view.

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Received: September 30, 2020 *Accepted: June 03, 2021*

J. Entomol. Res. Soc., 23(2): 153-156, 2021
Doi: 10.51963/jers.v23i2.1959
Research Article
Online ISSN:2651-3579

A New Genus and Species Record of Geometrid Moth (Lepidoptera) from Turkey

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ABSTRACT

Kresnaia beschkovi (Ganev, 1987), which has a restricted distribution in Europe and south-western Asia, is recorded for the first time from Turkey. The species is active at night and was collected in oak forest by a UV light trap in 2018 from Batman province. It has been determined with extremely low population in the cold month. Figures of the adult male and its genitalia are illustrated. The new distributional data and ecological notes are discussed.

Key words: Fauna, *Kresnaia, Kresnaia beschkovi*, Lepidoptera, Ennominae, Turkey.

Seven, E. (2021). A new genus and species record of Geometrid Moth (Lepidoptera) from Turkey. *Journal of the Entomological Research Society*, 23(2), 153-156.

INTRODUCTION

Agriopis beschkovi was described in 1987 by Ganev and later, it was transferred by Leraut (2009) to the genus *Kresnaia*. The species is diagnosed on the male holotype and male paratypes from south-western Bulgaria. However, the female of the species was described and published after a long time by Petschenka, Tavakoli, & Trusch (2006) from west of Iran, on the external characters and genitalia morphology. The distribution area of the species is quite limited in Europe and it was not known in Anatolia (Koçak & Kemal, 2018; Müller et al, 2019; Seven, 2019). In this paper, the monotypic species *Kresnaia beschkovi* (Ganev, 1987) is new reported in the Turkish fauna.

Kresnaia beschkovi is active at night and attracted to light. The species is univoltine and fly from mid-November to early December (Müller et al, 2019). In western Iran the larvae feed from early March to until mid-May. The adults occur in December and January in the oak forests. The larvae are monophagous and feed on trees and shrubs of *Quercus brantii* and *Q. infectoria* (Fagaceae) in western Iran (Petschenka et al, 2006).

MATERIAL AND METHOD

The investigated material was collected in 2018 from Sason district of Batman province, south-eastern Turkey. The specimen was captured by a simple UV light trap, killed by ethyl acetate, pinned, labeled, and stretched as museum material according to standard entomological methods. External morphology of the species was photographed with a Fujifilm Finepix HS30 EXR digital camera. Preparations of male genitalia was carried out following Robinson (1976), embedded as permanent slides in Euparal and photographed with a Nikon SMZ1000 stereomicroscope. Original description (Ganev, 1987) and studies of Petschenka et al, 2006; Leraut, 2009; Müller et al, 2019 were followed for identification and taxonomy of the species. The examined material is deposited in the collection of Batman University (BTU), Faculty of Science and Arts, Department of Biology, Entomology Laboratory, Turkey.

RESULTS

***Kresnaia* Leraut, 2009**

Kresnaia Leraut, 2009, Moths of Europe, Volume 2, Geometrid moths, p. 122. Type species: *Agriopis beschkovi* Ganev, 1987.

***Kresnaia beschkovi* (Ganev, 1987)** (Fig. 1.)

Agriopis beschkovi Ganev, 1987: Entomofauna 8(18): 273-275, figured (p. 174), Kressna Gorge, south-western Bulgaria. Holotype: male.

Material examined. South-eastern Turkey, Batman, Sason, Kelhasan Mt., 1160 m, 38°18’26” N, 41°23’37” E, 17.11.2018, 1♂, g. prep. 605, leg. E. Seven, in BTU.

Diagnosis. Male: Wingspan 30 mm. Antennae bipectinate. Head quite small, ground colour grey, eyes well developed. Proboscis and labial palpi small. Forewing comparatively narrow, background grey, mottled with dark grey scales. Post and antemedial lines distinct and darker grey. Postmedial line with light grey edging. Medial line dark grey, scattered. Hindwing paler and proportionally broad.

Male genitalia. Uncus long, apically slightly curled, tip round, at base wide. Gnathos forming ventrally two unfused strips. Tegumen quite long. Valva narrow, elongate, in centre slightly narrower, at base wider, tip rounded. Costa sclerotized. Vinculum well developed. Saccus rounded, at base flattened. Juxta quite small, bifid. Aedeagus narrow, long, curved. Vesica with small cornuti.

Phenology. The male specimen of *Kresnaia beschkovi* (Ganev, 1987) was collected in November. The average temperature in long measurement period (1959-2019) for this month is about 9.5 °C and the mean precipitation is 54.8 mm in Batman province (Republic of Turkey Ministry of Agriculture and Forestry, 2020). The collection field, Sason district (Kelhasan Mt.) is a cooler area. The captured sample of *K. beschkovi* shows a same activity pattern as reported by the collection dates mentioned by Ganev (1987) and Petschenka et al, (2006).

Habitat. The known and collection locations of *Kresnaia beschkovi* (Ganev, 1987) are similar. In Europe, it occurs on slopes including *Fraxinus ornus* (Oleaceae), *Juniperus excelsa, J. oxycedrus* (Cupressaceae), *Pistacia terebinthus* (Anacardiaceae), *Paliurus spina-christi* (Rhamnaceae), *Quercus pubescens*, *Q. virgiliana* (Fagaceae) and, flies from 200 up to 585 m (Müller et al, 2019). In western Iran, it inhabits in subtropical *Quercus* forests from 1100 up to 1750 m (Petschenka et al, 2006). The species is caught in *Quercus* forest with *Paliurus spina-christi*, *Pistacia* and *Juniperus* species from 1160 m in a mountainous region from south-east Anatolia Region of Turkey.

Distribution. South-western Bulgaria (Kressna gorge), northern Greece, western Iran (Lorestan and Kermanshah) (Ganev, 1987; Petschenka et al, 2006; Leraut, 2009; Müller et al, 2019), and south-eastern Turkey (new discovered). Müller et al. (2019) in the distribution of the species mentioned as ‘South-east European-Anatolian’. However, they did not provide any reference records and unmarked on the map for Anatolia.

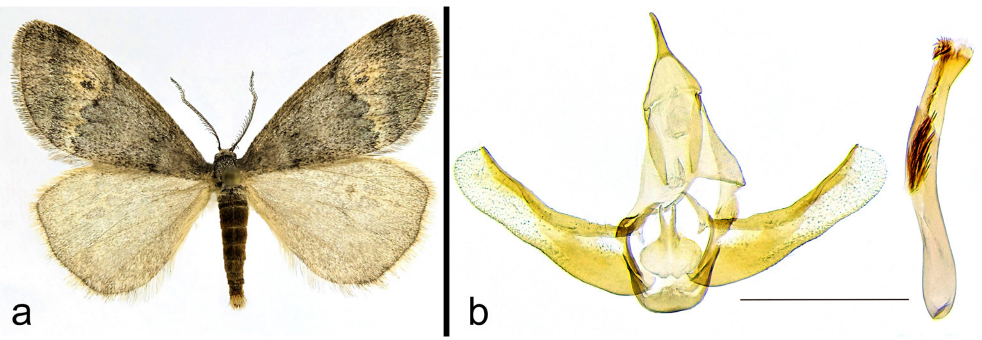

Fig. 1. Male of *Kresnaia beschkovi* (Ganev, 1987): a. adult, b. genitalia capsule and aedeagus (g. prep 605, scale bar: 1 mm)

DISCUSSION

There is no similar and closely related species of *Kresnaia beschkovi* (Ganev, 1987) in Europe and Turkey. It could be clearly distinguished from its external and internal morphological characters. Definable from the genus *Agriopis* Hübner, 1825 primarily by its forewing lines, color of wings and, long uncus, apically rounded valva, two bunches of small cornuti in the vesica of male genitalia structure. The included in a multi-gene analysis, COI data suggest an isolated phylogenetic lineage and, genetic data not suggesting any closer relationship with any Palaearctic Ennominae Duponchel, 1845 genus for *Kresnaia* Leraut, 2009 (Müller et al, 2019).

Kresnaia beschkovi is an extremely local species and limited distribution in Europe (Müller et al, 2019). It has also very small population in south-eastern Turkey for the present. However, it is a pest species, the larvae defoliate the oak plants in Iran (Petschenka et al, 2006). The species has been noted to be the dominant species, compared to other oak-feeding moth species. Known parasites of the species are fungi and Hymenoptera (Ichneumonidae) (Petschenka et al, 2006).

Being active during the cold months and low population of the species are probably cause the difficulties in determining its range. The presence of the species in Bulgaria, Greece, western Iran and southeastern Turkey, suggesting that it is likely to be found in other regions of Turkey. The species could possibly extend its distribution to northern Iran, northern Iraq, and north-eastern Syria.

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Received: October 07, 2020 Accepted: July 11, 2021

J. Entomol. Res. Soc., 23(2): 157-172, 2021
Doi: 10.51963/jers.v23i2.2006

Research Article
Online ISSN:2651-3579

Contributions to the Knowledge on Aquatic/Semi-Aquatic Coleoptera (Insecta) Fauna of Turkey with First Records in Turkish Thrace

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ABSTRACT

In the present study, adult specimens belonging aquatic/semi-aquatic coleopteran collected from 1986 to 2002 in Turkish Thrace were evaluated taxonomically. Altogether, a total of 23 species belonging to the families Dytiscidae, Haliplidae, Noteridae, Gyrinidae, Helophoridae and Hydrophilidae were determined. A total of 12 species *Hydaticus* (*Hydaticus*) *aruspex* Clark, 1864, *Aulonogyrus concinnus* (Klug 1834), *Cercyon* (*Cercyon*) *littoralis* Gyllenhal 1808, *Gyrinus* (*Gyrinus*) *distinctus* Aubé 1836, *G.* (*Gyrinus*) *substriatus* Stephens 1829, *Haliplus* (*Liaphlus*) *flavicollis* Sturm 1834, *Helophorus* (*Helophorus*) *grandis* Illiger 1798, *Hydrochara flavipes* (Steven 1808), *Laccobius* (*Laccobius*) *minutus* (Linnaeus 1758), *Laccophilus hyalinus* (De Geer 1774), *Platambus maculatus* (Linnaeus 1758), *Rhantus* (*Rhantus*) *suturalis* (MacLeay 1825) were determined for the first time from Turkish Thrace. The aquatic habitat distributions of the species were also compared by the statistically using Shannon-Wiener diversity index and Bray-Curtis similarity index.

Key words: Coleoptera, aquatic, fauna, first record, biodiversity, Turkish thrace.

Aydın, G.B., Çamur-Elipek, B., & Topkara, E.T. (2021). Contributions to the knowledge on aquatic/semi-aquatic Coleoptera (Insecta) fauna of Turkey with first records in Turkish thrace, *Journal of the Entomological Research Society*, 23(2), 157-172.

INTRODUCTION

Coleoptera is the largest order of insects contains terrestrial, semiaquatic and aquatic species which of nearly 5,000 adapt to an aquatic habitat all over the world (Franciscolo, 1979; Ribera, 2002; Audisio & Vigna, 2010). Although the majority of members are terrestrial, a great number of coleopteran beetles adapted to aquatic environments. A lot of them can be also found in nearly aquatic habitat because of life cycles. Some coleopterans are aquatic as both larval and adult stages, while the others are semi-aquatic because of they can enter to aquatic environments for feeding, spawning, etc. All aquatic suborders as Myxophaga, Adephaga, and Polyphaga present in Turkey (Löbl, 1994; Lupi, Jucker, & Rocco, 2014; Ertorun, 2018).

Although, there are a lot of faunistic studies performed on the aquatic beetles including Turkish Thrace Region (Guéorguiev, 1981; Hansen, 1987, 2004; Holmen, 1987; Angus, 1988; Schödl, 1991; Angus, 1992; Jäch, 1998; Boukal, 2007; Aydın & Çamur-Elipek, 2019), none of them are focused on aquatic/semi-aquatic coleopteran fauna of Turkish Thrace region only. With this study, it was aimed to contribute the distribution knowledge of Coleopteran fauna in Turkey.

MATERIALS AND METHODS

In this study, the collected material from aquatic habitats including lakes, ponds, streams, dam lakes, coastal lagoons in Turkish Thrace were evaluated. The collected material sampled by using a hand mud ladle and a plankton mesh net with a diameter of 1-2 mm pore were fixed and preserved in 70% ethanol. The adult aquatic/semi-aquatic coleopteran specimens were found at a total of 35 localities (Fig. 1 and Table 1). The sampling localities were numbered and shown in Figure 1. The obtained material was deposited in 25 cc glass bottles containing 70% ethanol until to their identification in the laboratory. The morphological characters and aedeagophores of the specimens were examined to identification of the species. The aedeagophores were dissected out under a stereomicroscope and they kept waiting in 10% KOH solution for 1-2 hours (Mart, İncekara, & Karaca, 2010). The adult specimens were identified to species level utilizing the literaures Smetana (1980), Holmen (1987), Friday (1988), van Vondel (1991, 1992), Angus (1992), Schödl (1993), Komarek (2003), Nilsson (2003), Foster (2009), İncekara et al, (2011), Yılmaz, Aslan, & Ayvaz (2014). Also, the sampling localities were grouped as their habitat types as stagnant water, running water, and coastal lagoon (Table 2). The results were evaluated by statistically using Shannon-Wiener diversity index and the Bray-Curtis similarity index (Krebs, 1999). All species were confirmed using Fauna Europaea database, for European Turkey (Turkish Thrace Region) (de Jong et al, 2014) and the related literatures. The materials were stored and have been converted into museum material at the Biology Department of Trakya University, Hydrobiology Laboratory, Edirne, Turkey.

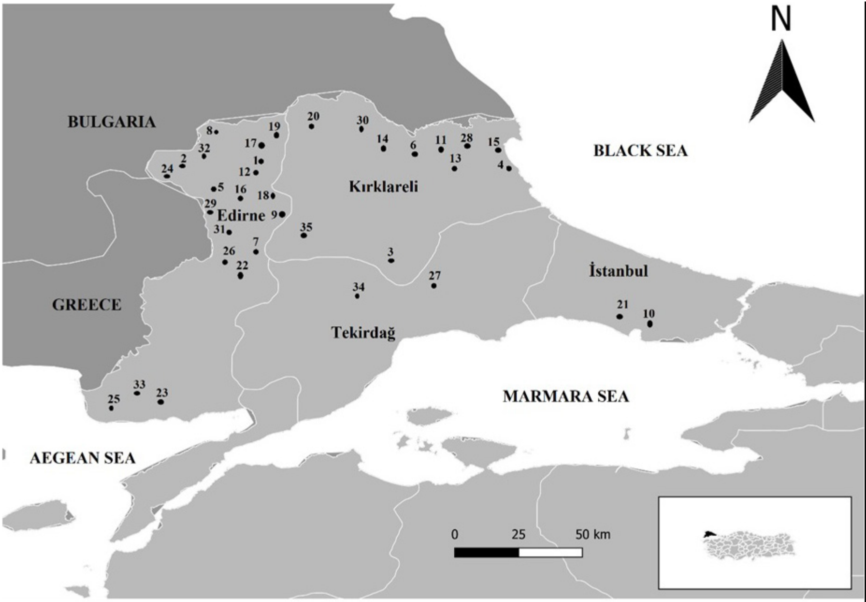

Fig. 1. The sampling localities in Turkish Thrace (the numbers show the locality numbers in Table1).

Table 1. Locality names and sampling dates.

NO	Locality	Sampling Dates
1	Süloğlu Stream-Edirne	21.09.1986-25.05.1987
2	Tunca River-Edirne	02.05.1991
3	Lahana Village-Kırklareli	24.09.1986
4	Hamam Lake-Kırklareli	15.03.1999
5	Güllapoğlu Stream-Edirne	15.05.1996-12.05.1999
6	Çağlayan-Kırklareli	10.09.1987
7	Uzunköprü Dereköy Stream-Edirne	13.08.1991
8	Ahi Village Pond-Edirne	09.03.1991
9	Değirmenci Stream-Edirne	18.09.1986
10	Küçükçekmece Lake-İstanbul	27.09.1997
11	Armutveren Village-Kırklareli	18.10.1996
12	Süloğlu Dam Lake-Edirne	24.05.2002
13	Yenice Village-Kırklareli	16.06.1987
14	Bizim Pond-Kırklareli	18.10.1996
15	Erikli Lake-Kırklareli	15.03.1999
16	Kemalettin Dam Lake-Edirne	14.11.1987
17	Süloğlu-Edirne	25.05.1987
18	Söğütlüdere-Edirne	29.06.1996

No	Locality	Sampling Dates
19	Vaysal Stream-Edirne	01.06.1991
20	Kofçaz-Kırklareli	10.06.1987
21	Büyükçekmece Lake-İstanbul	27.09.1997
22	Uzunköprü-Edirne	13.08.1991-23.12.1995
23	Çandırdağı-Edirne	01.09.1996
24	Kemalköy Pond-Edirne	09.03.1991
25	Sultaniçe Village-Edirne	31.08.1996
26	Oğulpaşa Stream-Edirne	01.06.1989
27	Arzulu Stream-Tekirdağ	21.09.1996
28	Dupnisa Cave-Kırklareli	17.06.2002
29	Musabeyli Pond-Edirne	13.05.1996-24.05.2002
30	Dereköy Pond-Kırklareli	25.04.1986
31	Gölbaba Pond-Edirne	30.08.1991
32	Kalkansöğüt Pond-Edirne	01.04.1991
33	Gala Lake-Edirne	01.06.1991
34	Çene Village-Tekirdağ	21.09.1996
35	Babaeski-Kırklareli	24.09.1986

Table 2. The groups for the habitat types with the locality numbers

Locality Type	Locality Number
Stagnant water	3,6,8,10,11,12,13,14,16,17,18,20,21,22,23,24,25,29,30,31,32,33,34,35
Running water	1,2,5,7,9,19,26,27,28
Coastal lagoon	4,15

RESULTS

A total of 113 individuals belonging 23 species were determined in this study (Table 3). The genus *Laccophilus* was found to have the most abundant species comprising about 33% of the all determined species. Except the species *Agabus* sp., *Agabus* (*Gaurodytes*) *bipustulatus* (Linnaeus 1767), *Agabus* (*Gaurodytes*) *nebulosus* Forster, 1771, *Hydroglyphus geminus* (Fabricius 1792), *Laccophilus minutus* (Linnaeus, 1758), *Hydroporus pubescens* (Gyllenhal 1808), *Peltodytes caesus* (Duftschmid 1805), *Noterus clavicornis* (De Geer 1774) *Helophorus* (*Rhopalohelophorus*) *brevipalpis* Bedel 1881, *Helophorus* (*Helophorus*) *aquaticus* (Linnaeus 1758) and *Berosus* (*Berosus*) *affinis* Brullé 1835, the others were determined as the first records for Turkish Thrace. The uncertain distribution area in Turkey of two species (*A. nebulosus* and *L. minutus*) was presented in the study.

Table 3. The Coleoptera species identified from Turkish Thrace with their sampled locality numbers (●First record for Turkish Thrace).

Taxa	Locality Number	Taxa	Locality Number
Dytiscidae		**Noteridae**	
Agabus (Gaurodytes) bipustulatus (Linnaeus, 1767)	5,7,11,14	*Noterus clavicornis* (De Geer, 1774)	1, 4, 15, 17, 23, 25, 27, 30
Agabus sp.	5	**Gyrinidae**	
Agabus (Gaurodytes) nebulosus Forster, 1771	12	*Gyrinus (Gyrinus) substriatus* Stephens, 1829 ●	29
Hydaticus (Hydaticus) aruspex Clark, 1864 ●	4, 10	*Gyrinus (Gyrinus) distinctus* Aubé, 1836 ●	28
Hydroglyphus geminus (Fabricius, 1792)	9, 12, 32	*Aulonogyrus concinnus* (Klug, 1834) ●	9
Laccophilus hyalinus (De Geer, 1774) ●	1, 3, 9, 12, 19, 20, 29,30,35	**Helophoridae**	
Laccophilus minutus (Linnaeus, 1758)	1, 9, 12, 18, 21, 22, 29	*Helophorus (Helophorus) grandis* Illiger, 1798 ●	1, 12, 13, 24, 26
Hydroporus pubescens (Gyllenhal, 1808)	8	*Helophorus brevipalpis brevipalpis* Bedel, 1881	29
Platambus maculatus (Linnaeus, 1758) ●	6	*Helophorus (Helophorus) aquaticus* (L., 1758)	5
Rhantus (Rhantus) suturalis (MacLeay, 1825) ●	1	**Hydrophilidae**	
Haliplidae		*Berosus (Berosus) affinis* Brullé, 1835	16,31
Haliplus (Liaphlus) flavicollis Sturm, 1834 ●	35	*Cercyon (Cercyon) littoralis* Gyllenhal, 1808 ●	33
Peltodytes caesus (*Duftschmid, 1805)*	34	*Laccobius (Laccobius) minutus* (Linnaeus, 1758) ●	9
		Hydrochara flavipes (Steven, 1808) ●	2

The determined species and their sampling localities were presented below (ex: example):

Family Dytiscidae

Agabus (Gaurodytes) bipustulatus (Linnaeus, 1767)

Material examined: Güllapoğlu Stream-Edirne (loc. 5), 15.05.1996, 1 ex., 12.05.1999, 2 ex.; Uzunköprü Dereköy Stream-Edirne (loc. 7), 13.08.1991, 1 ex.; Armutveren Village-Kırklareli (loc. 11), 18.10.1996, 1 ex.; Bizim Pond-Kırklareli (loc. 14), 18.10.1996, 1 ex.

Distribution in Turkey: Antalya, Isparta, Muğla (Kıyak, Darılmaz, Salur, & Canbulat, 2007), Artvin,Rize (Erman & Erman, 2008), Ankara (Hızarcıoğlu, Kıyak, & Darılmaz, 2010), Black Sea Region (Topkara & Balık, 2010), Çorum, Yozgat (Darılmaz, Salur, & Mesci, 2010), Kayseri (İncekara, Polat, Darılmaz, Mart, & Taşar, 2010), Balıkesir, Çanakkale (Topkara & Ustaoğlu, 2014), Erzincan (Darılmaz, Jäch, & Skale, 2012), Sivas (Darılmaz et al, 2014), Denizli (Topkara & Ustaoğlu, 2015), Gaziantep, Hatay, Kahramanmaraş, Kilis, Osmaniye (Darılmaz, Polat, & İncekara, 2018).

Agabus (Gaurodytes) nebulosus Forster, 1771

Material examined: Süloğlu Dam Lake-Edirne (loc. 12), 24.05.2002, 1 ex.

Distribution in Turkey: Adana, Bursa, Isparta, İstanbul Sinop, Trabzon (Guéorguiev, 1981), Afyon, Antalya, Aydın, Burdur, Denizli, Muğla (Kıyak et al, 2007), Samsun (İncekara, Darılmaz, Mart, Polat, & Karaca, 2009a), Ankara (Hızarcıoğlu et al, 2010), Çorum (Darılmaz et al, 2010), Kayseri (İncekara et al, 2010), İzmir (Topkara, Ustaoğlu, & Balık, 2011), Erzincan (Darılmaz et al, 2012), Tokat (Darılmaz, Polat, İncekara, & Mart, 2015), Sivas (Darılmaz et al, 2014), Adana, Hatay, Osmaniye, Kahramanmaraş, Gaziantep (Darılmaz et al, 2018). Although this species has been reported by Guéorguiev (1981) from İstanbul, certain sampling locality (European Part or Asian Part) has not been detailed.

Agabus sp.

Material examined: Güllapoğlu Stream-Edirne (loc. 5), 15.05.1996, 1 ex.

Hydaticus (Hydaticus) aruspex Clark, 1864

Material examined: Küçükçekmece Lake-İstanbul (loc. 10), 27.09.1997, 2 ex.; Hamam Lake-Kırklareli (loc. 4), 15.03.1999, 1 ex.

Distribution in Turkey: It was not found any distribution knowledge in Turkey on this species. The distribution area of this species is reported from Nearctic to Paleartic in the world is as follows; America, Canada, Belarus, Czechia, Sweden, Denmark, England, Finland, France, Germany, Hungary, Lithuania, Netherlands, Kazakhstan, Mongolia, Poland, Russia, Sluvenia, Ukraine, China, Japan (Zaitsev, 1972; Nilsson & Holmen, 1995; Bameul, 1997; Alarie, 2016; Temreshev, 2018; Prokin et al, 2020).

Hydroglyphus geminus (Fabricius, 1792)

Material examined: Değirmenci Stream-Edirne (loc. 9), 18.09.1986, 5 ex.; Süloğlu Dam Lake-Edirne (loc. 12), 24.05.2002, 2 ex.; Kalkansöğüt Pond-Edirne (loc. 32), 01.04.1991, 3 ex.

Distribution in Turkey: Edirne (Guéorguiev, 1981; Aydın & Çamur-Elipek, 2019), Aksaray (Darılmaz & Kıyak, 2006), Muğla (Kıyak et al, 2007), Artvin, Rize (Erman & Erman, 2008), Ankara (Hızarcıoğlu et al, 2010), Black Sea Region (Topkara & Balık, 2010), Çorum,Yozgat (Darılmaz et al., 2010), Kayseri (İncekara et al., 2010), Erzincan (Darılmaz et al, 2012), Balıkesir,Çanakkale (Topkara & Ustaoğlu, 2014), Sivas (Darılmaz et al, 2014), Denizli (Topkara & Ustaoğlu, 2015), Gaziantep, Hatay, Kahramanmaraş, Osmaniye (Darılmaz et al, 2018).

Laccophilus hyalinus (De Geer, 1774)

Material examined: Süloğlu Stream-Edirne (loc. 1), 21.09.1986, 2 ex.; Lahana Village-Kırklareli (loc. 3), 24.09.1986, 2 ex.; Değirmenci Stream-Edirne, (loc. 9), 1 ex.; Süloğlu Dam Lake-Edirne (loc. 12), 24.05.2002, 3 ex.; Vaysal Stream-Edirne (loc. 19), 01.06.1991, 2 ex.; Musabeyli Pond-Edirne, (loc. 29), 24.05.2002, 5 ex.; Dereköy Pond-Kırklareli (loc. 30), 25.04.1986, 1 ex.; Babaeski-Kırklareli (loc. 35), 24.09.1986, 2 ex.

Distribution in Turkey: Kırşehir (Darılmaz & Kıyak, 2006), Antalya, Isparta, Burdur, Konya (Kıyak et al, 2007), Artvin (Erman & Erman, 2008), Ankara (Hızarcıoğlu et al, 2010), Black Sea Region (Topkara & Balık, 2010), Çorum (Darılmaz et al, 2010), Kayseri (İncekara et al, 2010), Erzincan (Darılmaz et al, 2012), Balıkesir, Çanakkale (Topkara & Ustaoğlu, 2014), Sivas (Darılmaz et al, 2014), Adana, Hatay, Osmaniye, Kahramanmaraş, Gaziantep (Darılmaz et al, 2018).

Laccophilus minutus (Linnaeus, 1758)

Material examined: Süloğlu Stream-Edirne (loc. 1), 21.09.1986, 9 ex.; Değirmenci Stream-Edirne (loc. 9), 18.09.1986, 1 ex.; Süloğlu Dam Lake-Edirne (loc. 12), 24.05.2002, 1 ex.; Söğütlüdere-Edirne (loc. 18), 29.06.1996, 1 ex.; Büyükçekçemece Lake-İstanbul (loc. 21), 27.09.1997, 2 ex.; Uzunköprü-Edirne (loc. 22), 23.12.1995, 1 ex.; Musabeyli Pond-Edirne (loc. 29), 13.05.1996, 4 ex.

Distribution in Turkey: Aksaray (Darılmaz & Kıyak, 2006), Antalya, Isparta, Burdur, Aydın (Kıyak et al, 2007), Artvin, Rize (Erman & Erman, 2008), Ankara (Hızarcıoğlu et al, 2010), Black Sea Region (Topkara & Balık, 2010), Çorum, Yozgat (Darılmaz et al, 2010), Kayseri (İncekara et al, 2010), Erzincan (Darılmaz et al, 2012), Balıkesir, Çanakkale (Topkara & Ustaoğlu, 2014), Sivas (Darılmaz et al, 2014), Hatay, Kahramanmaraş, Adana, Kilis, Osmaniye, Gaziantep (Darılmaz et al, 2018). Although this species has been reported by Guéorguiev (1981) from İsaklı (undetailed locality), Erman & Erman (2008) has been reported this species as uncertain sampling locality (Afyon, Denizli or Tekirdağ).

Hydroporus pubescens (Gyllenhal, 1808)

Material examined: Ahi Village Pond-Edirne (loc. 8), 09.03.1991, 1 ex.

Distribution in Turkey: Adana, Aksaray, Antalya, Bilecik, Bursa, Erzincan, Gümüşhane, Manisa, Niğde, Ordu, Sakarya, Trabzon (Guéorguiev, 1981; Darılmaz & Kıyak, 2006), Antalya, Aydın, Afyon, Burdur, Denizli, Isparta, Muğla (Kıyak et al, 2007), Bayburt, Giresun, Tokat (Darılmaz et al, 2015), Balıkesir (Topkara & Ustaoğlu, 2014), Kayseri (İncekara et al, 2010), İzmir (Topkara et al, 2011), Denizli (Topkara & Ustaoğlu, 2015), Hatay, Kahramanmaraş, Adana, Gaziantep (Darılmaz et al, 2018).

***Platambus maculatus* (Linnaeus, 1758)**

Material examined: Çağlayan-Kırklareli (loc. 6), 10.09.1987, 5 ex.

Distribution in Turkey: Burdur, Muğla (Kıyak et al, 2007), Ankara (Hızarcıoğlu et al, 2010), Black Sea Region (Topkara & Balık, 2010), Çorum (Darılmaz et al, 2010),

***Rhantus (Rhantus) suturalis* (MacLeay, 1825)**

Material examined: Süloğlu Stream-Edirne (loc. 1), 21.09.1986-25.05.1987, 2 ex.

Distribution in Turkey: Aksaray (Darılmaz & Kıyak, 2006), Rize (Erman & Erman, 2008), Ankara (Hızarcıoğlu et al, 2010), Çorum (Darılmaz et al, 2010), Kayseri (İncekara et al, 2010), Balıkesir, Çanakkale (Topkara & Ustaoğlu, 2014), Sivas (Darılmaz et al, 2014), Kahramanmaraş (Darılmaz et al, 2018).

Family Haliplidae

***Haliplus (Liaphlus) flavicollis* Sturm, 1834**

Material examined: Babaeski-Kırklareli (loc. 35), 24.09.1986, 3 ex.

Distribution in Turkey: Bolu, Kastamonu (Topkara & Balık, 2010).

***Peltodytes caesus* (Duftschmid, 1805)**

Material examined: Çene Village-Tekirdağ (loc. 34), 21.09.1996, 2 ex.

Distribution in Turkey: Aksaray (Darılmaz & Kıyak, 2006), Ankara (Hızarcıoğlu et al, 2010), Çorum, Yozgat (Darılmaz et al, 2010), Kayseri (İncekara et al, 2010), Erzincan (Darılmaz et al, 2012), Sivas (Darılmaz et al, 2014), Kahramanmaraş (Darılmaz et al, 2018), Edirne (Aydın & Çamur-Elipek, 2019).

Family Noteridae

***Noterus clavicornis* (De Geer, 1774)**

Material examined: Süloğlu Stream-Edirne (loc. 1), 25.05.1987, 1 ex.; Hamam Lake-Kırklareli (loc. 4), 15.03.1999, 1 ex.; Erikli Lake-Kırklareli (loc. 15), 15.03.1999, 2 ex.; Süloğlu-Edirne (loc. 17), 25.05.1987, 1 ex.; Çandırdağı-Edirne (loc. 23) 01.09.1996, 1 ex.; Sultaniçe Village-Edirne (loc. 25), 31.08.1996, 3 ex.; Arzulu Stream-Tekirdağ (loc. 27), 21.09.1996, 2 ex.; Dereköy Pond-Kırklareli (loc. 30), 25.04.1986, 1 ex.

Distribution in Turkey: Aksaray (Darılmaz & Kıyak, 2006), Antalya, Aydın (Kıyak et al, 2007), Ankara (Hızarcıoğlu et al, 2010), Black Sea Region (Topkara & Balık, 2010), Çorum (Darılmaz et al, 2010), Kayseri (İncekara et al, 2010), Erzincan (Darılmaz et al, 2012), Balıkesir, Çanakkale (Topkara & Ustaoğlu, 2014), Sivas (Darılmaz et al, 2014), Adana, Gaziantep, Kahramanmaraş (Darılmaz et al, 2018), Edirne (Aydın & Çamur-Elipek, 2019).

Family Gyrinidae

Gyrinus (Gyrinus) substriatus Stephens, 1829

Material examined: Musabeyli Pond-Edirne (loc. 29), 13.05.1996, 24.05.2002, 3 ex.

Distribution in Turkey: Çankırı, Düzce (Topkara & Balık, 2010), Çorum, Yozgat (Darılmaz et al, 2010), Kayseri (İncekara et al, 2010), Erzincan (Darılmaz et al, 2012), Balıkesir (Topkara & Ustaoğlu, 2014), Kahramanmaraş (Darılmaz et al, 2018).

Gyrinus (Gyrinus) distinctus Aubé, 1836

Material examined: Dupnisa Cave-Kırklareli (loc. 28), 17.06.2002, 2 ex.

Distribution in Turkey: Aksaray, Konya (Darılmaz & Kıyak, 2006), Isparta, Antalya, Denizli (Kıyak, Salur, Canbulat, & Darılmaz, 2006b), İzmir (Topkara & Balık, 2008), Düzce, Zonguldak, Kastamonu, Sinop (Topkara & Balık, 2010), Erzincan (Darılmaz et al, 2012), Balıkesir (Topkara & Ustaoğlu, 2014), Diyarbakır (Taşar, 2018).

Aulonogyrus concinnus (Klug, 1834)

Material examined: Değirmenci Stream-Edirne (loc. 9),18.09.1986, 1 ex.

Distribution in Turkey: Aksaray (Darılmaz & Kıyak, 2006), Aydın, Denizli (Kıyak et al, 2006b), Ankara (Hızarcıoğlu et al, 2010), Çorum (Darılmaz et al, 2010).

Family Helophoridae

Helophorus (Helophorus) grandis Illiger, 1798

Material examined: Süloğlu Stream-Edirne (loc. 1), 25.05.1987, 1 ex.; Süloğlu Dam Lake-Edirne (loc. 12), 24.05.2002, 1 ex.; Yenice Village-Kırklareli (loc. 13), 16.06.1987, 1 ex., Kemalköy Pond-Edirne (loc. 24), 09.03.1991, 2 ex.; Oğulpaşa Stream-Edirne (loc. 26), 01.06.1989, 1 ex.

Distribution in Turkey: Antalya (Kıyak, Canbulat, Salur, & Darılmaz, 2006a), Tokat (Polat, İncekara, & Mart, 2010), Elazığ (Mart, Tolan, Caf, & Koyun, 2014b), Burdur (Aslan, Yılmaz, Bayram, & Aslan, 2015), Denizli (Topkara & Ustaoğlu, 2015), İzmir, Manisa, Aydın (Akünal & Aslan, 2017a, 2017b), Kahramanmaraş (Erdihan, Polat, & İncekara, 2017), Diyarbakır, Mardin, Batman (Taşar, 2018).

Helophorus (Rhopalohelophorus) brevipalpis subsp. *brevipalpis* Bedel, 1881

Material examined: Güllapoğlu Stream-Edirne (loc. 5), 12.05.1999, 1 ex.; Musabeyli Pond-Edirne (loc. 29), 13.05.1996, 2 ex.

Distribution in Turkey: Kırklareli (Angus, 1988), Aksaray (Darılmaz & Kıyak, 2006), Bayburt, Giresun, Gümüşhane, Ordu, Trabzon (Mart et al, 2010), Ankara (Hızarcıoğlu et al, 2010), Black Sea Region (Topkara & Balık, 2010), Çorum (Darılmaz et al, 2010), Kayseri (İncekara et al, 2010), Kastamonu, Sakarya, Zonguldak (Topkara & Balık, 2010), Tokat, Samsun (Polat et al, 2010), Burdur (Aslan et al, 2015), İzmir, Manisa, Aydın (Akünal & Aslan, 2017a; 2017b), Kahramanmaraş (Erdihan et al, 2017), Afyon, Denizli, Kütahya, Uşak (Darılmaz & Kıyak, 2018), Diyarbakır, Batman (Taşar, 2018), Erzurum (Yıldız, Özcan, Polat, & İncekara, 2020).

Helophorus (Helophorus) aquaticus **(Linnaeus, 1758)**

Material examined: Güllapoğlu Stream-Edirne (loc. 5), 15.05.1996 1 ex., 12.05.1999 1 ex.

Distribution in Turkey: Kırklareli (Angus, 1988), Aksaray (Darılmaz & Kıyak, 2006), Kızılırmak (İncekara et al, 2009a), Tokat (Polat et al, 2010), Kastamonu (Topkara & Balık, 2010), Çorum (Darılmaz et al, 2010), Bayburt, Giresun, Gümüşhane, Ordu, Trabzon (Mart et al, 2010), Kayseri (İncekara et al, 2010), Erzincan (Darılmaz et al, 2012), Isparta (Yılmaz, Aslan, & Ayvaz, 2014), Elazığ (Mart et al, 2014b), Burdur (Aslan et al, 2015), Hakkari (Mart 2016), Kahramanmaraş (Erdihan et al, 2017), Aydın (Akünal & Aslan, 2017a, 2017b), Afyon, Denizli, Kütahya, Uşak (Darılmaz & Kıyak, 2018), Diyarbakır, Batman (Taşar, 2018), Erzurum (Yıldız et al, 2020).

Family Hydrophilidae

Berosus (Berosus) affinis **Brullé, 1835**

Material examined: Kemalettin Dam Lake-Edirne (loc. 16), 14.11.1987, 1 ex., 3 ex, Gölbaba Pond-Edirne (loc. 31), 30.08.1991, 1 ex.

Distribution in Turkey: Kırklareli (Schödl, 1991), Kayseri (İncekara et al, 2010), Adana, Antalya, Burdur, Bursa, Çanakkale, Antakya (Hatay), Içel, İstanbul, İzmir, Kayseri, Kırklareli, Kocaeli, Kastamonu, Konya, Manisa, Muğla, Ordu (Ünye), Samsun, Sakarya (İncekara et al, 2011).

Cercyon (Cercyon) littoralis **Gyllenhal, 1808**

Material examined: Gala Lake-Edirne (loc. 33), 01.06.1991, 2 ex.

Distribution in Turkey: Black Sea Region (İncekara, Mart, & Erman, 2004), Bursa (Ertorun & Tanatmış, 2009).

Laccobius (Laccobius) minutus **(Linnaeus, 1758)**

Material examined: Değirmenci Stream-Edirne (loc. 9), 18.09.1986, 3 ex.

Distribution in Turkey: Bayburt (İncekara et al, 2009a), Kayseri (İncekara et al, 2010), Erzincan (Darılmaz et al, 2012), Manisa (Akünal & Aslan, 2017a; 2017b).

Hydrochara flavipes **(Steven, 1808)**

Material examined: Tunca River-Edirne (loc. 2), 02.05.1991, 3 ex.

Distribution in Turkey: Aksaray (Darılmaz & Kıyak, 2006), Samsun (İncekara, Mart, Polat, & Karaca, 2009b), Kayseri (İncekara et al, 2010), Aydın (Akünal & Aslan, 2017a, 2017b), Kütahya, Uşak, Denizli, Afyon (Darılmaz & Kıyak, 2018), Diyarbakır (Taşar, 2018).

CONCLUSIONS AND DISCUSSION

In the present study, a total of 14 species from 5 families of Coleoptera, (Dytiscidae: 6, Haliplidae: 1, Gyrinidae. 3, Helophoridae: 1 and Hydrophylidae:3), were recorded for the first time from Turkish Thrace.

In this study, *H. aruspex*, *L. hyalinus*, *P. maculatus*, *R. suturalis* belong to family Dytiscidae; *H. flavicollis* belong to family Haliplidae; *G. substriatus*, *G. distinctus*, *A. concinnus* belong to family Gyrinidae; *H. grandis* belong to family Helophoridae; *C. littoralis*, *L. minutus*, *H. flavipes* belong to family Hydrophilidae were the first records for Turkish Thrace. Family Dytiscidae of Coleoptera including about 4,000 species in the World is known as the largest family into the suborder Adephaga (Balke, Ribera, & Vogler, 2004; Jäch & Balke, 2008; Darılmaz & Kıyak, 2009). The family Dytiscidae includes aquatic forms and a total of 137 species and 9 subspecies are reported from Turkey (Darılmaz et al, 2015). In the previous studies performed in Turkish Thrace, 4 species (*H. geminus*, *A. nebulosus*, *A. bipustulatus* and *Hydroporus planus* (Fabricius, 1782)) from this family were reported (Guéorguiev, 1981; Fery, 1999). In this study, a total of 10 species belonging family Dytiscidae were found (*H. geminus*, *A. nebulosus*, *A. bipustulatus Agabus* sp., *H. aruspex, L. hyalinus, L. minutus, H. pubescens, P. maculatus, R. suturalis*).

The family Haliplidae has 220 species in the World and a total of 16 species are reported from Turkey (Nardi, 2001; Darılmaz & Kıyak, 2009; Darılmaz et al, 2014). In this study, a total of three species into two genera (*Haliplus* and *Peltodytes*) were found in the area. Although these species have been reported from Anatolia, *H. flavicollis* is the first record for Turkish Thrace region. The family Noteridae has 250 species in the World and a total of 3 species have been reported from Turkey (Darılmaz & Kıyak, 2009).

N. clavicornis was recorded by Aydın & Çamur-Elipek, (2019) from rice fields located in Edirne, Kırklareli and Tekirdağ provinces at Turkish Thrace.

The family Gyrinidae has aquatic/semi-aquatic species which are living on the surface of the water and has 900 species in the world. A total of 13 gyrinid species are reported from Turkey (Kıyak et al, 2006b). A total of three species were recorded in the present study area and all of them (*G. substriatus, G. distinctus A. concinnus*) are the first records for Turkish Thrace region. *Helophorus* is known as the single genus of small hydrophiloid family Helophoridae with about 200 species in all over the world (Anton & Beutel, 2004). Except only one subgenus (*Empleurus*), all adult helophorids are known from aquatic or semi-aquatic ecosystems and they exist very wide distribution range of aquatic habitats (Anton & Beutel, 2004). A total of 48 species and 2 subspecies belonging to 7 subgenera are reported for Helophoridae fauna of Turkey (Yılmaz et al, 2014; Akünal & Aslan, 2017a, 2017b). A total of 7 species has been reported in previous studies performed in Turkish Thrace. In the present study was recorded 3 species belonging genus *Helophorus*. Although the records of two of them (*H. brevipalpis* and *H. aquaticus*) are known from Turkish Thrace, species *Helophorus grandis* is new records for the study area.

The family Hydrophilidae is one of the most important groups of Hydrophiloidea, the other is the family Helophoridae. Although the family Hydrophilidae has terrestrial forms, it has also 2716 known aquatic species in the world. Up to now, a total of 95 species and 4 subspecies belong to Hydrophilidae were reported from Turkey (Yılmaz, 2011; Mart, Aydoğan, & Fırat, 2014a). In the previous studies in Turkish Thrace, 12 species belonging three genera were recorded. *B. affinis* of them has been already reported from Turkish Thrace, the others are the first records for the study area. Thus the species number of Hydrophilidae in Turkish Thrace were updated to 15 species.

When considering species numbers Dytiscidae was found as the richest family with 10 species in the area (Fig. 2). It was followed by Hydrophilidae family with 4 species. While the Dytiscidae was found to have to be the most individual numbers (58% of all specimens with a total of 66 individuals), it was followed by the family Hydrophilidae (12% with 13 individuals). The family Haliplidae was to have the lowest individual numbers (4% with 5 individuals) (Fig. 2).

The sampling localities were grouped as stagnant waters, running waters and coastal lagoons to determine the aquatic habitat distributions of the species (Table 2). According to the Shannon-Wiener diversity index results, the stagnant water resources were found to have the most species richness with H'= 1.25 (Fig. 3). It was followed by running water resources by the H'=1.14 richness. The similarities of the habitats for including the species of beetles were determined by the Bray-Curtis index (Fig. 4). The highest similarity was observed between the stagnant and running water resources (50% similarity). While this relatively low similarity ratio signed that it can be the habitat preference among the species. The similarities were observed at very low rations between the stagnant water resources and coastal lagoons (19% similarity), and running water resources and coastal lagoons (23% similarity). It is suggested that the more taxonomical studies should be made to update the geographical distributions of the species.

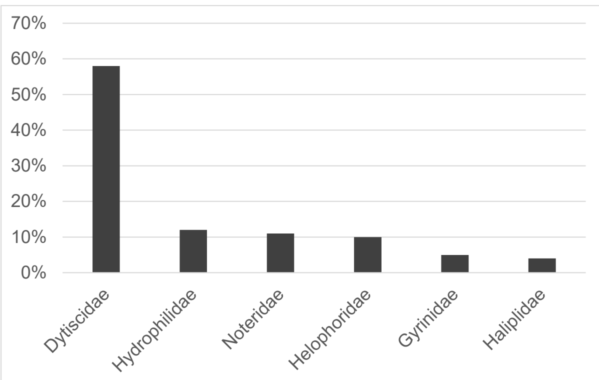

Fig. 2. The percentage of families by number of individuals.

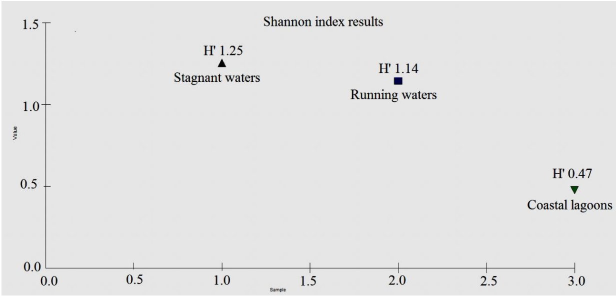

Fig. 3. Shannon-Wiener diversity index results for the species according to the habitat types.

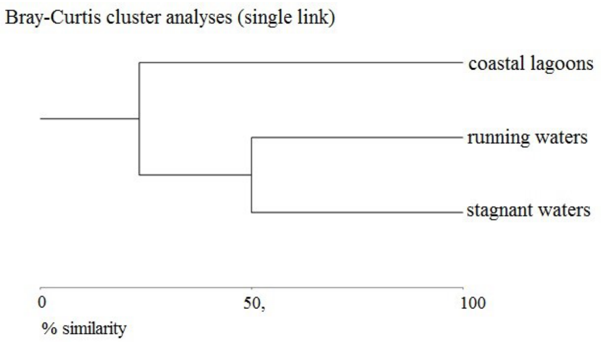

Fig. 4. Bray-Curtis similarity index results for the species according to the habitat types.

ACKNOWLEDGEMENT

The preliminary results of the experiments in this study were presented in VIII. International Symposium on Ecology and Enviromental Problems, held from 4-7 October 2017, in Çanakkale, Turkey.

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Received: January 16, 2020 *Accepted: June 03, 2021*

J. Entomol. Res. Soc., 23(2): 173-178, 2021 *Research Article*
Doi: 10.51963/jers.v23i2.2013 *Online ISSN:2651-3579*

New Distributional, Host and Plant Association Records of Saproxylic Ichneumonid Parasitoids (Hymenoptera, Ichneumonidae) in Turkey

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ABSTRACT

The present study was carried out in Diyarbakır Province (N 37°53'36.96", E 40°16'13.65", 666 m) in Southeastern Anatolia Region of Turkey in 2018-2020. *Prunus cerasifera* tree parts infested by the buprestid beetle, *Ptosima undecimmaculata*, were cut in June 2018 and February 2019 (Figs. 1-2) and *Prunus persica* infested by buprestids larvae, *Ptosima undecimmaculata* (Herbst, 1784) and *Sphenoptera* (*Tropeopeltis*) *tappesi* Marseul, 1865, respecitvely were cut and placed in plastic boxes until host and/ or their potential parasitoids were reared. Three ichneumonid parasitoids, *Dolichomitus kriechbaumeri* (Schulz, 1906), *Poemenia notata* Holmgren, 1859 and *Xorides gravenhorstii* (Curtis, 1831), were obtained. New host records were found: *P. undecimmaculata* for *D. kriechbaumeri* and *S. tappesi* for *X. gravenhorstii*. All three parasitoid species were reared from the studied plants for the first time. *P. notata* is a new record for Turkish fauna.

Key words: Pimplinae, Poemeniinae, Xoridinae, Buprestidae, new record, Turkey.

Varga, O. & Bolu, H. (2021). New distributional, host and plant association records of saproxylic ichneumonid parasitoids (Hymenoptera, Ichneumonidae) in Turkey. *Journal of the Entomological Research Society*, 23(2), 173-178.

INTRODUCTION

Ichneumonidae is one of the largest insect families represented by almost 25 000 described species, of which about 1200 species were recorded from Turkey (Yu, van Achterberg, & Horstmann, 2016). The Turkish Ichneumonidae fauna was unevenly and relatively poorly studied until the first catalogue was published by Kolarov (1995). He listed a little less than 400 species recorded mostly from Thrace and Egean regions, and Northeastern Turkey, while the Southeastern part of the country remained largely unstudied. Later, an intensive investigation of Ichneumonidae fauna of Eastern Turkey was conducted by J Kolarov, S. Çoruh and coauthors resulting in series of faunistic papers (e.g. Çoruh, 2010; Çoruh & Kolarov, 2010; Çoruh & Kolarov, 2013; Kolarov, Çoruh, Yurtcan, & Gürbüz, 2009). The seasonal dynamics, altitudinal distribution, individual diversities, biogeographical positions and host records of the Eastern Turkish Ichneumonidae were discussed by Çoruh, Kolarov, & Özbek (2014).

The aim of this paper is to provide new distributional, host and plant association records of ichneumonid parasitoids of the subfamilies Pimplinae, Poemeniinae, Xoridinae from the Southeastern Anatolia Region of Turkey.

MATERIAL AND METHODS

The present study was carried out in Diyarbakır Province (N 37°53'36.96", E 40°16'13.65", 666 m) in Southeastern Anatolia Region of Turkey in 2018-2020. *Prunus cerasifera* tree parts infested by the buprestid beetle, *Ptosima undecimmaculata*, were cut in June 2018 and February 2019 (Figs. 1-2) and *Prunus persica* infested by the buprestid species, *Sphenoptera tappesi* (Fig. 3), were cut in April 2019 and March 2020. All collected logs were stored in plastic boxes with 20x20x30 cm lids closed with thin mesh fabric at a temperature of 26±1°C, relative humidity of 65±5, and illumination of 3500 lux for 16 hours per day (Fig. 4). Totally, 84 beetle and 37 parasitoid specimens were reared.

The hymenopteran material from this study is deposited in the collection of the Schmalhausen Institute of Zoology NAS of Ukraine in Kyiv (SIZK). Image of *Poemenia notata* was taken with a Leica Z16 APO microscope equipped with Leica DFC 450 camera and processed by LAS Core software at SIZK.

RESULTS

Dolichomitus kriechbaumeri (Schulz, 1906)

Distribution: Western Palaearctic (Yu et al, 2016), Turkey (Kolarov, 1995; Bolu, 2008).

Material examined: Turkey, Diyarbakır, N 37°53'36.96", E 40°16'13.65", 666 m, ex *Prunus cerasifera* logs infested by *Ptosima undecimmaculata,* 15.06.2018-06.02.2019*,* leg. H. Bolu, 1 ♂, 2 ♀♀; idem, ex *Prunus persica* logs infested by *Sphenoptera tappesi*, 31.04.2019, 5 ♂♂, 5 ♀♀; idem, 09.03.2020, 5 ♂♂, 5 ♀♀; idem, 10.03.2020, 5 ♂♂, 4 ♀♀; idem, ex *Prunus cerasifera* logs infested by *Sphenoptera tappesi*, 10.03.2020, 2 ♂♂.

***Poemenia notata* Holmgren, 1859** (Figs. 5-6.)

Distribution: Widespread and common species in Western Palaearctic (Yu et al, 2016), new for Turkey.

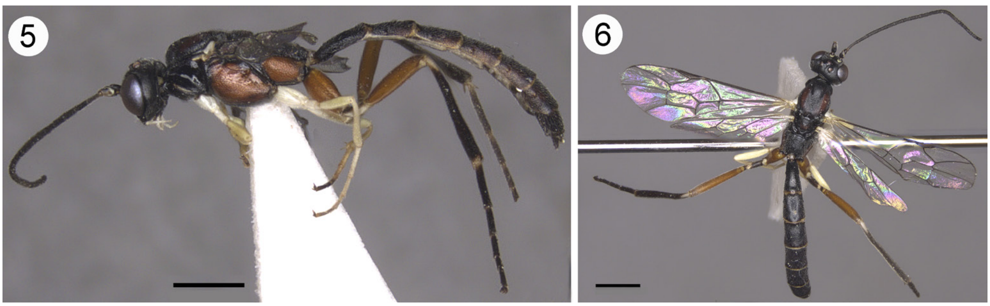
Material examined: Turkey, Diyarbakır, N 37°53'36.96", E 40°16'13.65", 666 m, ex *Prunus cerasifera* logs infested by *Ptosima undecimmaculata,* 15.06.2018-06.02.2019, leg. H. Bolu, 1 ♂.

***Xorides gravenhorstii* (Curtis, 1831)**

Distribution: Widespread and common species in Western Palaearctic (Yu et al, 2016), Turkey (Kolarov, 1995).

Material examined: Turkey, Diyarbakır, N 37°53'36.96", E 40°16'13.65", 666 m, ex *Prunus persica* logs infested by *Sphenoptera (Tropeopeltis) tappesi*, 31.04.2019, leg. H. Bolu, 1 ♂, 1 ♀.

Figs. 1-4. Rearing. 1. *Prunus cerasifera* parts infested *Ptosima undecimmaculata*. 2. Reared *Ptosima undecimmaculata* imago. 3. Reared *Sphenoptera tappesi* imago. 4. Plastic boxes with infested logs.



Figs. 5-6. *Poemenia notata*, male. 5. Lateral view. 6. Dorsal view.

CONCLUSIONS AND DISCUSSION

Three ichneumonid species (Hymenoptera: Ichneumonidae) belonging to subfamilies Pimplinae, Poemeniinae, Xoridinae were reared during this study. These species are parasitoids of coleopteran or hymenopteran insect hosts living in the dead wood (Yu et al, 2016).

Pimplinae-wasp, *Dolichomitus kriechbaumeri,* is one of twenty-five species of the genus known from Western Palaearctic (Zwakhals, 2010; Varga, 2012). Generally, most of *Dolichomitus* species are reported as ectoparasitoids of different Cerambycidae larvae. Unlike other species, *D. kriechbaumeri* is a specialized parasitoid of the buprestid beetles (e.g. Zwakhals, 2010). Several buprestid beetle species, *Anthaxia manca* (Linnaeus, 1767), *Sphenoptera tappesi* and *Trachypteris picta* (Pallas, 1773), are listed as hosts in papers of Aubert (1969), Bolu (2008) and Zwakhals (2010). In this study, we provide a new host record for *D. kriechbaumeri*, a buprestid beetle *Ptosima undecimmaculata* inhabiting *Prunus cerasifera* logs. In addition, this tree is a new plant association record for this species.

Another parasitoid of wood-boring beetles reared during this study is a member of the subfamily Xoridinae, *Xorides gravenhorstii*. It seems that this species is generalist ectoparasitoid of different saproxylic beetle larvae. It is reported as parasitoid of Ptinidae: *Hedobia pubescens* (Olivier, 1790) (Aubert, 1969), *Xestobium plumbeum* (Illiger, 1801) (Leclercq, 1945), Bostrichidae: *Psoa dubia* (Rossi, 1792), Cerambycidae: *Phymatodes (Paraphymatodes) fasciatus* (Villers, 1789) (Aubert, 1969), *Pogonocherus hispidus* (Linnaeus, 1758) (Sedivy, 1967), *Callidium aeneum* (De Geer, 1775) (Campadelli & Scaramozzino, 1994), *Molorchus umbellatarum* (Schreber, 1759) on *Malus domestica* (Borkh., 1803) (Strojnowski, 1977). In addition, two plant are reported to be associated with this species by Pisica (1969): *Alnus glutinosa* (L.) Gaerth, 1790 and *Corylus avellana* Linnaeus, 1753. Here we provide additional host and plant association records for *Xorides gravenhorstii*: the species was reared from *Prunus persica* and buprestid beetle larva for the first time.

The genus *Poemenia* from the subfamily Poemeniinae numbers only four species in Europe, of which at least two species, *P. notata* and *P. collaris* (Haupt, 1917), were reared from trap-nests inhabited by the crabronid wasps, *Passaloecus eremita* Kohl, 1893 and *P. corniger* Shuckard, 1837 (Schmidt & Zmudzinski, 1983). Jussila and Kapyla (1975) reported *P. notata* as a parasitoid of another crabronid, *Trypoxylon figulum* (Linnaeus, 1758). In addition, the first author has a specimen of *Poemenia collaris* reared from trap-nests in Ukraine. On the other hand, he saw the *P. notata* specimen reared from the buprestid species in Georgia (Varga, in prep.) and several cerambycids species, *Acanthocinus aedilis* (Linnaeus, 1758), *Arhopalus rusticus* (Linnaeus, 1758) and *Asemum striatum* (Linnaeus, 1758) are reported as hosts of *P. notata* by R. Uhthoff-Kaufmann (1991). The male specimen of *P. notata* reported in this study was reared together with *Dolichomitus* specimens from logs of *Prunus cerasifera* infested by *Ptosima undecimmaculata*. Unfortunately, little is known about biology of poemeniines and thus, direct observation of parasitoid larva is needed to confidently state about host-parasitoid interactions of the current species. Thus, in this paper we just reported the new plant association, *Prunus cerasifera*, for the observed Poemeniine wasp.

AKNOWLEDGEMENTS

The authors are deeply grateful to Prof. Göksel TOZLU (Atatürk University, Faculty of Agriculture, Department of Plant Protection, Erzurum, Turkey) for the host insect identification; and to Brian L Fisher (California Academy of Sciences, Department of Entomology, San Francisco) for access to digital imaging system temporarily provided for SIZK.

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Received: February 08, 2021 *Accepted: June 24, 2021*

J. Entomol. Res. Soc., 23(2): 179-186, 2021 *Research Article*
Doi: 10.51963/jers.v23i2.2029 *Online ISSN:2651-3579*

Cohabitation of Ant Lions *Palpares libelluloides (*Linnaeus, 1764) and *P. turcicus* Koçak, 1976 (Neuroptera, Myrmeleontidae) in Azerbaijan

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ABSTRACT

The overlapping distribution of two species of ant lions, *Palpares libelluloides* (Linnaeus, 1764) and *P. turcicus* Koçak, 1976, belonging to the *P. libelluloides* species group in Azerbaijan are examined. The peculiarities of their cohabitation in the Ordubad district are reported.

Key words: Habitat, censusing, landscape distribution, phenology.

Kerimova, I.G., Snegovaya, N.Y., & Krivokhatsky, V.A. (2021). Cohabitation of ant lions *Palpares libelluloides* (Linnaeus, 1764) and *P. turcicus* Koçak, 1976 (Neuroptera, Myrmeleontidae) in Azerbaijan. *Journal of the Entomological Research Society*, 23(2), 179-186.

INTRODUCTION

Two colorful, externally similar, species of ant lions (Figs. 1-4), were studied. Both belong to the *Palpares libelluloides* species group (Krivokhatsky et al, 2017) and are represented in Azerbaijan by the Holomediterranean (*Palpares libelluloides* (Linnaeus, 1764)) and Kura- Araksian-Anatolian (*P. turcicus* Koçak, 1976). Previously they were not found simultaneously in the same habitat, in sympatric zones, in the Caucasus and in Iran. In the Caucasus, *Palpares libelluloides* has been reported in Russia and in all Transcaucasian countries, including Turkey; *P. turcicus* is known only from Armenia, Azerbaijan, Russia, and Turkey; it was not recorded in Georgia (Krivokhatsky et al, 2017). In Iran *Palpares libelluloides* was registered in the provinces of Azarbayjan Sharghi Prov., Fars Prov., Kermanshah Prov., Lorestan Prov., Markazi Prov., Sistan and Baluchestan Prov., Tehran prov., Zanjan Prov. and W. Azarbayjan, and *P. turcicus* in Alborz Prov., Hamadan Prov., Kordestan Prov., Lorestan Prov., Markazi Prov., Tehran Prov., Zanjan Prov. and W. Azarbayjan.

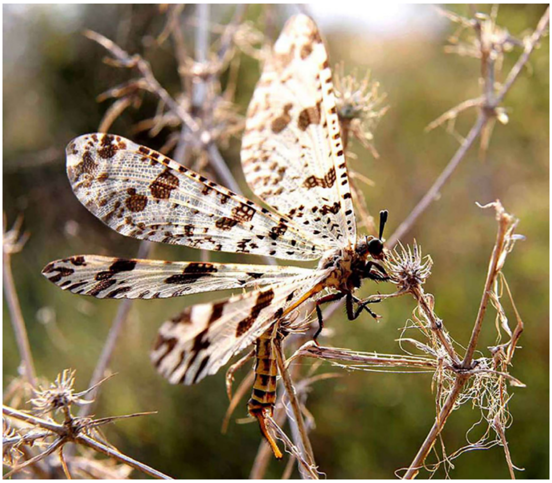

Fig. 1. *Palpares libelluloides*. Male in natural habitat (territory of the Agdara observatory in the Ordubad district. Nakhchivan. Azerbaijan. 2017) (Photo of I.G.Kerimova).

These and other pairs of species of the *P. libelluloides* group have only been reported to occur in isolation in sympatric zones according to the principle of landscape delimitation (Krivokhatsky et al, 2017; Kerimova & Krivokhatsky, 2018), and even in the last publication we had not noted areas of cohabitation of *P. libelluloides* and *P. turcicus*.

The morphotypes and ecological niches of both species are similar. Both species belong to brightly colored, large-winged predatory, diurnal bimotor strong flyers of open spaces. Larvae of both species are predators and do not build a pit in the sand but lie in wait for their prey. The isolating mechanisms that prevent species from hybridizing are not clear; specimens described as hybrids have not been identified in the collections. Therefore, it was interesting to study the distribution of these two related species in the area of their close contact.

Fig. 2. *Palpares turcicus*. Female in natural habitat (territory of the Agdara observatory in the Ordubad district. Nakhchivan. Azerbaijan. 2018) (Photo of N.Yu.Snegovaya).

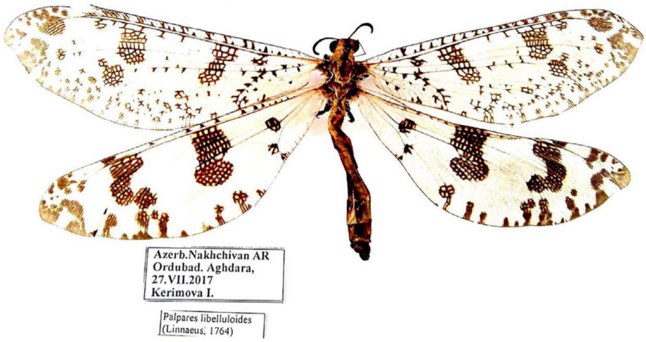

Fig. 3. *Palpares libelluloides*. Female (collection of the Institute of Zoology. National Academy of Sciences of Azerbaijan) (Photo of I.G.Kerimova).

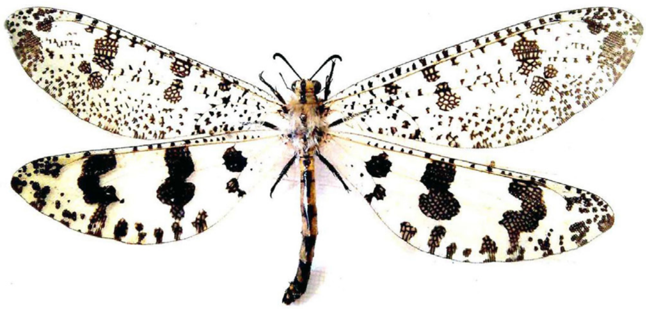

Fig. 4. *Palpares turcicus*. Female (Nakhchivan Azerbaijan. Ordubad. Agdara. 10.07.2018. (collection of the Institute of Zoology. National Academy of Sciences of Azerbaijan) (Photo of I.G.Kerimova).

It seemed earlier that the places of these species are complementary in low-mountain semi-arid landscapes in such a way that *P. libelluloides* prefers flat plains at different elevations, while *P. turcicus* prefers mountain slopes. Recently, we found an area of overlapping places with two types of habitats, which allows us to look at this geographical phenomenon under a stronger, increased ecological view and to consider biotopes occupied by closely related species. We took into account the distribution of adults only, since the way of life of the larvae has not been established yet.

In the newly discovered areas of cohabitation [Ordubad district, between the village of Tivi and the Agdara observatory (Figs. 5-7)], adults of *P. turcicus* and *P. libelluloides* occur together sympatrically, practically throughout the entire period of simultaneous flight.

Further research is required to explain the reasons for this phenomenon, which has not been previously noted in other regions.

Fig. 5. Collection sites of ant lions of the genus *Palpares* Rambur in Azerbaijan. Yellow icons-locations of *P. libelluloides*; blue icon-co-habitating siteof *P. libelluloides* and *P. turcicus*.

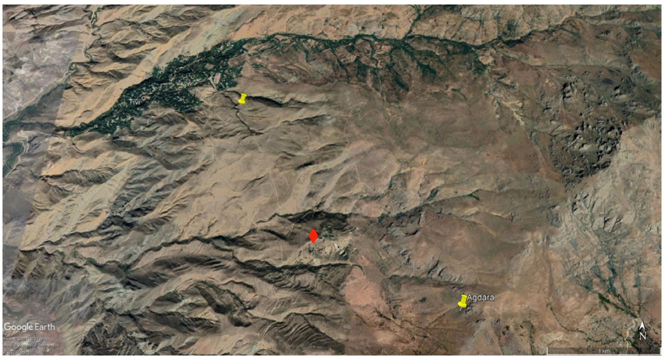

Fig. 6. Map of Tivi-Agdara sites in the area of co-habitation of *P. libelluloides* and *P. turcicus*. Red diamond-location of the light (1962 m; 39°06'37.67" N. 45°54’50.08” E). Yellow icons - lowest (1698 m; 39°07’19.28”N. 45°54’08.28” E) and highest (2363 m; 39°06’15”N. 45°55’47” E) points of habitat of *P. turcicus.*

Fig. 7. Mid-mountain landscape example found near areas of Tivi-Agdara. Red arrow-Tivi. Blue arrow-Agdara.

MATERIAL AND METHODS

The study was performed in and around the village of Tivi and the Agdara observatory of Ordubad district of the Nakhchivan Autonomous Republic. In total, more than 300 specimens of *P. libelluloides* (of which 66 were collected in the Nakhchivan Autonomous Republic, hereinafter -Nakhchivan) and 75 specimens of *P. turcicus* (all from Nakhchivan) were recorded from Azerbaijan (Table 1). There were 159 specimens of these species recorded in areas of cohabitation in the Ordubad district of Nakhchivan between the Village Tivi (site 1) and the Agdara observatory (site 2), i.e., in the altitude range from 1698 to 2363 m. The collections of both species in Azerbaijan (Table 1, Fig. 5) were made from 2012 to 2019, and the censusing in the areas of cohabitation (Figs. 6, 7) - in 2017 and 2018 (Table 2). Adults were collected using an insect net or were picked by hand from a light source between 21 and 23 o'clock. The light source was installed in Agdara (39°06'37.67'' N, 45°54'50.08'' E,1962 m a.s.l.).

The first cohabitated area of *P. turcicus* and *P. libelluloides* was located near the Village Tivi at the foot of the Zangezur ridge at an elevation of 1698 m a.s.l. Coordinates of the site are: 39°07'19.28'' N, 45°54'08.28'' E. The vegetation cover is formed by mountain xerophytic, mainly perennial plant species, as well as umbellate and cruciferous, which often reach a height of 1-1.5 m in early summer.

The second cohabitated site of both species was located in Agdara at a distance of about 10 km from the Village Tivi; the maximum elevation of the second site, where ant lions were encountered was 2363 m a.s.l. The coordinates of the site are 39°06'37.67'' N, 45°54'50.08'' E. The plant associations of this site are mainly represented by different species of *Acantholimon* Boiss., *Astragalus* L. and *Thymus* L., as well as perennial herbaceous plants, legumes and *Compositae* which continue to bloom at the end of July. Dominant shrubs are represented by *Crataegus* Tourn. ex L. at an elevation of about 2000 m to the maximum for this site 2363 m above sea level, meadow-shrub and meadow-steppe vegetation is replaced by fescue steppes, fescue shrub steppes and tragacanths formed by thorny-shrub astragals (Ibrahimov, Nabiyeva, & Salayeva, 2017). Both of these sites are used by the locals as pasture for sheep and goats.

Table 1. Localities of ant lions of the genus *Palpares* in Azerbaijan.

Collection sites, districts		Elevation (m)	Coordinates	Species	
				Palpares libelluloides	*Palpares turcicus*
		424	N 41° 03'46.61". E 49° 00'36.21	+	
		434	N 41° 03'48.37". E 49° 02'26.36"	+	
Siazan		-27.12	N 40°58'51.82". E 49°15'3.60"	+	
		517.86	N41° 03'23.50". E 49° 03'09.95"	+	
		- 14.02	N 40°58'54.62". E 49°14'39.92	+	
		157	N 41°15'38.04". E 48°52'55.65"	+	
Shabran		- 25. 82	N 41°15'27.07". E 49° 04'51.68"	+	
		625	N 41°05'27.77". E 48°56'30.04"	+	
Gobustan		4.88	N 40°06'06.85". E 49°23'20.92"	+	
Fizuli		152	N 39°26'15.25". E 47°20'08.14"	+	
Ordubad	Agdara	2363	N 39°06'15". E 45°55'47"	+	+
	Tivi	1698	N 39°07'19.28". E 45°54'08.28"	+	+
Shahbuz		1727.61	N 39°24'23.09". E 45°41'00.96"	+	
Julfa		717.19	N 38°57'38.36". E 45°37'45.54	+	
Babek		10 66	N 39°10'16.57". E 45°35'21.69"	+	
Kyurdamir		70	N 40°17'44.02". E 48°20'17.62"	+	
Zardab		-5	N 40°13'50.12". E 47°41'13.03"	+	

Table 2. Number of specimens of *Palpares libelluloides* and *P. turcicus* in the area of their cohabitation.

Sampling places	2018		2019	
	Species		Species	
	Palpares libelluloides	*Palpares turcicus*	*Palpares libellu-loides*	*Palpares turcicus*
Tivi	20	10	10	15
Agdara	60	30	25	35

In Nakhchivan, the censusing and collection of material were carried out on mid-mountain meadows and on rocky gentle slopes along the Tivi-Agdara route (Figs. 6, 7) at an elevation of 1698 to 2363 m a.s.l. In early July (from 1st through 10th), only *P.*

turcicus was recorded at the study site. The second species, *P. libelluloides*, does not appear until close to the end of July. A joint flight of both species was observed from 26 July to 3 August in 2018.

RESULT AND DISCUSSION

According to available data (Kerimova & Krivokhatsky, 2018) *P. libelluloides* is widespread in Azerbaijan, and inhabits plains at different elevations from the western coast of the Caspian Sea (height-14 m a.s.l., 2017) to the mountainous regions of Nakhchivan (elevation 2363 m above sea level). *P. libelluloides* is characterized by yellow abdomen with brown longitudinal lines. In contrast to *P. libelluloides*, basal macula in the hind wing of *P. turcicus* has a circular form and covers both sectoral and cubital forks (Krivokhatsky et al, 2017). *Palpares turcicus* was recorded by us only in the Ordubad district (village Tivi, Agdara observatory) of Nakhchivan (Figs. 5, 6), where it forms part of the Kura-Araks population, which is well known from collections made in Armenia, Azerbaijan, and Turkey (Krivokhatsky et al, 2017). Here it lives on steep and gentle treeless slopes and has never been recorded by us on the plains far from the mountains.

Flights of *P. libelluloides* in other regions of Azerbaijan begin at the end of June and last until the last two weeks in August. In Agdara, we registered the beginning of the flight period of this species in the second half of July and it continues until the beginning of August. Flights of *P. turcicus* begin in early July and continue until early August. The period of maximum abundance of adults of both species co-occurs in July (Fig. 8).

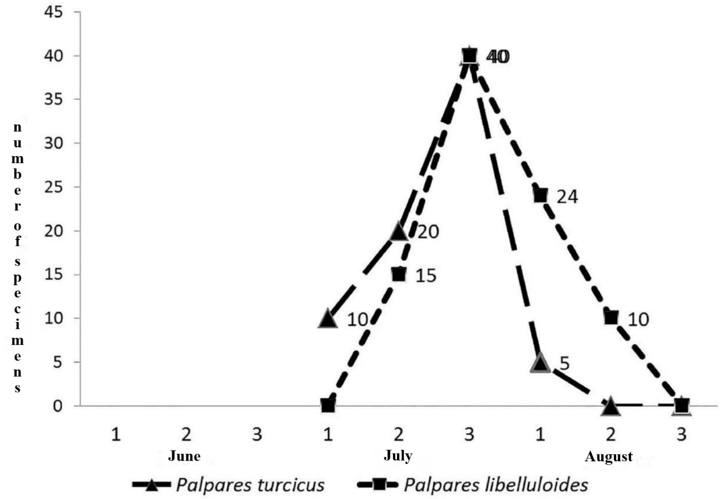

Fig. 8. Seasonal dynamics of the activity of *P. turcicus* and *P. libelluloides* in the area of cohabitation (Tivi-Agdara) according to the survey data on the routes in 2017 and 2018.

At the beginning of July, *P. turcicus* was recorded only on the survey route in Nakhchivan, with a counting density of 1-2 individuals per 10 meters of the route. Females of this species appeared here earlier than males and before the appearance of

P. libelluloides at the end of July, after which both species were found in the same areas with the same density (1-2 specimens of *P. libelluloides* or 1-2 specimens of *P. turcicus*).

During the adult stage, both species coexist in low-mountain landscapes, inhabiting both slopes and valley areas.

The sex ratio for the entire collection period in both species (*P. libelluloides*: 45 m#, 50 f#; *P. turcicus*: 46 m#, 65 f#) shows a slight predominance of females in the populations.

Thus, two species of the same genus were found together in areas studied by us in the Transcaucasia. *Palpares libelluloides* predominantly inhabited the lowlands and *P. turcicus*, predominantly inhabited the mid-mountain area. Simultaneous flight of stable populations of both species was recorded on slope biotopes for the three years they were observed.

ACKNOWLEDGEMENT

Data collection and preliminary analysis were partly carried out within the framework of the state subject ZIN No. AAAA-A19-119020690082-8.

The authors are grateful to Dr. A. P. Rasnitsyn (Moscow, Russia) and Dr. J.C. Cokendolpher (Lubbock, Texas, USA) for many useful comments that have improved the work.

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Received: March 01, 2021 Accepted: June 08, 2021

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Material examined: Ankara, Altındağ, Çubuk Dam Lake, 900 m, 29.06.1998, 1 ♂; Kalecik, 600 m, 24. 07. 2001, 2 ♀♀, Kalecik, 800 m, 25. 07. 2001, 3 ♀♀
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