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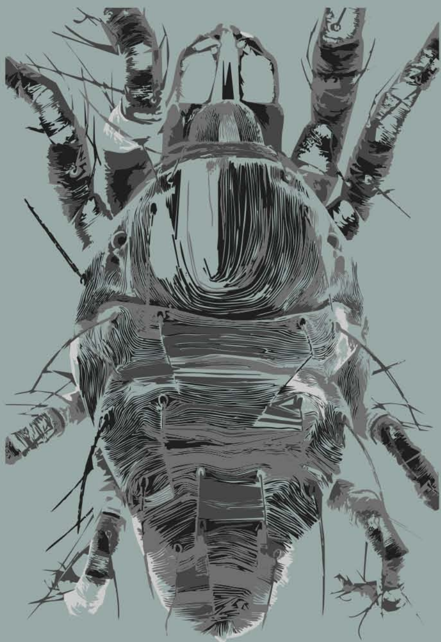

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RESEARCH ARTICLE

Prevalence and density of *Demodex* mites (Acari: Demodecidae) in patients with seborrheic dermatitis

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ABSTRACT: This study was conducted to determine the prevalence and density of *Demodex* mites in patients with seborrheic dermatitis. The study included 37 patients and 35 healthy controls who were diagnosed with seborrheic dermatitis by clinical examination. The sample materials were taken from the cheek, nasolabial and jaw areas of the participants using the standard superficial skin biopsy method and examined for the presence and number of *Demodex* mites under light microscopy. *Demodex* spp. mites were detected in 34 (91.9%) of the patients and in 20 (60%) of the controls. *Demodex folliculorum* was detected in 34 of 37 patients (mean 15.7/cm^2; total 535) and *D. brevis* (mean 0.6/cm^2; 20 total) in six patients. *Demodex folliculorum* was detected in 20 of 35 healthy controls (mean 2.7/cm^2; total 56) and *D. brevis* (mean 0.5/cm^2; total 1) in one of the 35 healthy controls. When patients and controls were compared in terms of *Demodex* prevalence and density, the differences were statistically significant. In conclusion, *Demodex* mites are more prevalent in patients with seborrheic dermatitis in Erzincan Province of Turkey. This condition may be related to the amount of sebum in patients with seborrheic dermatitis, however, this issue should be supported by further studies in which sebum levels are measured and ilarger number of patients are involved.

Keywords: *Demodex*, seborrheic dermatitis, sebum, epidemiology, Erzincan, Turkey.
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INTRODUCTION

Demodex mites (Acari) are microscopic organisms belonging to the family Demodecidae of the order Trombidiformes. Two species of *Demodex* mites are known from humans: *Demodex folliculorum* Simon and *Demodex brevis* Akbulutova (Desch and Nutting, 1972; Rufli and Mumcuoglu, 1981). *D. folliculorum*, which has a long opisthosoma, lives in hair follicles alone or in groups, while *D. brevis* which has a shorter and pointed opistosome, usually lives as a single in the sebaceous glands (Rufli and Mumcuoglu, 1981). *Demodex* mites have a cigar-shaped body, a chitinous exoskeleton, piercing mouthparts and four pairs of legs with a pair of claws at the terminal end. With their piercing mouthparts and their enzymes, they feed on the contents of the follicular epithelial cells and sebum (Desch and Nutting, 1977; Rufli and Mumcuoglu, 1981).

Seborrheic dermatitis is a chronic and inflammatory skin disease that affects parts of the body rich in sebaceous glands such as the scalp and face, manifested by erythematous, yellowish, oily and squamous plaques (Aksoy et al., 2012; Güleç, 2014). Most dermatologists have called seborrheic dermatitis ''dermatitis of areas with sebum" and have reported that an increase in the amount of sebum has an important role in the pathogenesis of seborrheic dermatitis (İnalöz and Kırtak, 2002; Güleç, 2014). Numerous epidemiological studies have been conducted in various dermatological patients (e.g., with acne vulgaris, rosacea, pityriasis folliculorum, perioral dermatitis, and eczema), in ophthalmological patients with symptoms such as blepharitis dandruf, and keratoconjunctivitis, in patients with diabetes, renal failure, and cancer), as well as in healthy individuals (Forton, 2012; Durmaz et al., 2015; Zeytun and Yazıcı, 2019; Sarı et al., 2019; Yılmaz and Akkaş, 2020; Zeytun and Karakurt, 2019; Erdal and Albayrak, 2022). However, studies on *Demodex* mites in patients with seborrheic dermatitis are quite limited (Basta-Juzbasic et al., 2002; Karıncaoğlu et al., 2009; Güleç, 2014; Tehrani et al., 2014; Aktaş Karabay and Aksu Çerman, 2020; Erdal and Albayrak, 2022). Since the main food sources of *Demodex* mites are follicular epithelial cells and sebum, there is a very high probability that there may be a relationship between seborrheic dermatitis and *Demodex* mites. The aim of this study was to determine the prevalence and density of *Demodex* mites in patients with seborrheic dermatitis in Erzincan province.

MATERIALS AND METHODS

The study included 37 patients diagnosed with seborrheic dermatitis and 35 healthy controls without any dermatological symptoms based on the clinical examination at the Dermatology Clinic of Erzincan Binali Yıldırım University Mengücek Gazi Training and Research Hospital. Patients who had dermatological or systemic diseases other than seborrheic dermatitis, who had undergone dermatological surgery, and who received systemic or topical treatment were not included in the study. Ethical approval for the study was obtained from the Clinical Research Ethics Committee of Erzincan Binali Yıldırım University and all participants read and signed the informed consent form in accordance with the Helsinki Declaration.

Samples were taken from the cheek, nasolabial and chin areas of the participants using the Standard Superficial

Skin Biopsy (SSSB) method. The areas to be sampled were cleaned with alcohol and dried. An area of 1-cm^2 was drawn on one side of the glass slide, a drop of cyanoacrylate was dripped on the other side and lightly pressed the surface to be sampled, and after about a minute it was gently removed. A drop of Hoyer medium was placed onto the sample material, and sealed with a cover glass. The slides were examined by the same researcher at 4X, 10X, 40X magnifications under a light microscope (Leica DM750, Switzerland). The identification of *Demodex* mites was made by the same researcher using the relevant literature (Desch and Nutting 1972, 1977). *Demodex* mites were photographed using a DIC (Differential Interference Contrast) equipped research microscope (Olympus BX53, Japan). The mean density of *Demodex* mite was calculated by dividing the total number of *Demodex* mites by the number of participants where *Demodex* mites were found.

The statistical analysis of the data was performed using the SPSS 23.0 (Statistical Package for Social Sciences; Chicago, IL, USA) program. The Kolmogorov-Smirnov test was used to determine the suitability of the variables for normal distribution. The Mann-Whitney U and Kruskall-Wallis tests were used to comparisons between the groups. The Chi-square test was used to evaluate the categorical data. The prevalence and density of *Demodex* mites rates were calculated using maximum likelihood estimation method with 95% confidence intervals (CI). A P value of less than 0.05 was considered statistically significant.

RESULTS

A total of 72 participants, including 37 patients (23 female, 14 male, mean age 25.9), and 35 healthy controls (24 female, 11 male, mean age 25.8), were included in the study (Table 1).

Table1. Age and sex of patients and controls.

	Patients (n: 37)	**Controls (n: 35)**
Age (years)		
Mean ± SD	25.9 ± 11.3	25.8 ± 8.6
Median (min. – max.)	26 (12 - 56)	24 (13 - 45)
Sex		
Female	23/37 (62.2%)	24/ 35 (68.6%)
Male	14/37 (37.8%)	11/35 (31.4%)

SD: standard deviation; min: minimum; max: maximum.

Demodex spp. positivity was detected in 34 (91.9%) of the patients and in 20 (60%) of the controls. *D. folliculorum* was detected in 34 patients (total 535, mean 15.7/cm^2), *D. brevis* was detected in 6 patients (total 20, mean 0.6/cm^2). *D. folliculorum* was detected in 20 of the healthy controls (total 56, mean 2.7/cm^2) and *D. brevis* was detected in 1 (total 1, mean 0.5/cm^2) (Fig. 1). When patients and controls were compared in terms of *Demodex* prevalence and density the differences were statistically significant (Tables 2 and 3).

Figure 1. A. *Demodex* spp. (at 40x magnification), **B.** *D. folliculorum* (at 40x magnification.

Table 2. Prevalence of *Demodex* mites in patients and controls.

	Patients (n: 37)	Controls (n: 35)	*p* value[a]
Prevalence of *Demodex*			
D. folliculorum	34/37 (91.9%) (95% CI: 83-100%)	20/35 (57.1%) (95% CI: 40-74%)	0.001
D. brevis	6/37 (16.2%) (95% CI: 4-29%)	1/35 (2.9%) (95% CI: 3-9%)	0.056
Demodex spp.	34/37 (91.9%) (95% CI: 83-100%)	21/35 (60.0%) (95% CI: 43-77%)	0.001

CI: confidence interval.
[a] Chi square test.

Table 3. Density of *Demodex* mites in patients and controls.

	Patients (n: 34)	Controls (n: 21)	*p* value[b]
Mean density of *Demodex*[a] [mean (min-max)]			
D. folliculorum	15.7 (1-65) (CI: 9.02-22.45)	2.7 (0-8) (CI: 1.60-3.74)	0.002
D. brevis	0,6 (0-7) (CI: 0.04-1.13)	0.5 (0-1) (CI: 0.05-015)	0.147
Demodex spp.	16.3 (1-65) (CI: 9.39-23.26)	2.7 (1-8) (CI: 1.66-3.76)	0.002
Total density of *Demodex*[a]			
D. folliculorum	535	56	-
D. brevis	20	1	-
Demodex spp.	555	57	-

CI: confidence interval; min: minimum; max: maximum.
[a] For the calculation of the density of *Demodex*/cm^2 only the *Demodex* positive patients and controls have been taken into accounts.
[b] Mann-Whitney U test.

The relationship between the age and gender characteristics of the participants and the prevalence and density of *Demodex* are given in Tables 4 and 5. It was found that the prevalence of *Demodex* was almost the same in male and female patients, but the density of *Demodex* was greater in males than in females. In addition, the prevalence and density of *Demodex* were found to be higher in adolescent patients than in adult patients.

DISCUSSION

In the present study, *Demodex* spp. positivity was detected in 34 (91.9%) of the patients and in 20 (60%) of the controls. *Demodex folliculorum* was detected in 34 of 37 patients (mean 15.7/cm^2; total 535) and *D. brevis* (mean 0.6/cm^2; 20 total) in 6 patients. *D. folliculorum* was detected in 20 of 35 healthy controls (mean 2.7/cm^2; total 56) and *D. brevis* (mean 0.5/cm^2; total 1) in one of the 35 healthy controls. When patients and controls were compared in terms of *Demodex* prevalence and density, the differences were found to be statistically significant.

In a study conducted in Croatia and investigating the role of *D. folliculorum* in the development of rosettiform dermatitis, it was reported that *D. folliculorum* was detected in 59% of 132 patients. When oral tetracycline was administered to these patients for 1-4 months, a decrease in the number of *D. folliculorum* was achieved, and an improvement in papular and pustular lesions was reported (Basta-Juzbasic et al., 2002). In Iran, it was reported that 63.4% of patients with seborrheic dermatitis and 57.9% of controls were *Demodex* positive (Tehrani et al., 2014).

Table 4. The relationship between the prevalence of *Demodex* and age and sex of participants.

	Prevalence of *Demodex*		
	Patients (n: 37)	**Controls (n: 35)**	***p* value[a]**
Age (year)			
Adolescent (≤ 20)	15/15 (100%) (95% CI: 90-100%)	5/11 (45.5%) (95% CI: 10-81%)	0.005
Adult (≥ 21)	19/22 (86.4%) (95% CI: 71-100%)	16/24 (66.7%) (95% CI: 46-87%)	
Total	34/37 (91.9%) (95% CI: 83-100%)	21/35 (60.0%) (95% CI: 43-77%)	
Sex			
Female	21/23 (91.3%) (95% CI: 79-100%)	15/24 (62.5%) (95% CI: 42-83%)	0.015
Male	13/14 (92.9%) (95% CI: 77-100%)	6/11 (54.5%) (95% CI: 19-90%)	
Total	34/37 (91.9%) (95% CI: 83-100%)	21/35 (60.0%) (95% CI: 43-77%)	

CI: confidence interval.
[a] Chi square test.

Table 5. The relationship between the density of *Demodex* mites and age and sex of participants.

	Mean density of *Demodex*[a] [mean (min-max)]		
	Patients (n: 34)	**Controls (n: 21)**	***p* value[b]**
Age (year)			
Adolescent (≤ 20)	16.6 (1-64) (CI: 4.75-28.45)	2.2 (1-7) (CI: 1.13-5.53)	0.019
Adult (≥ 21)	16.1 (1-65) (CI: 6.86-25.35)	2.9 (1-8) (CI: 1.68-4.07)	
Total	16.3 (1-65) (CI: 9.39-23.26)	2.7 (1-8) (CI: 1.66-3.76)	
Sex			
Female	15.0 (1-48) (CI: 7.23-22.77)	1.8 (1-6) (CI: 0.86-2.74)	0.002
Male	18.5 (1-65) (CI: 3.76-33.17)	5.0 (3-8) (CI: 2,80-7.20)	
Total	16.3 (1-65) (CI: 9.39-23.26)	2.7 (1-8) (CI: 1.66-3.76)	

CI: confidence interval; min: minimum; max: maximum.
[a] For the calculation of the density of *Demodex*/cm^2 only the *Demodex* positive patients and controls have been taken into accounts.
[b] Kruskal-Walllis test.

In Turkey, Karıncaoğlu et al. (2009) reported that *D. folliculorum* was found in 50% of 38 patients with seborrheic dermatitis (mean 8.16/cm^2) and 13.1% of 38 controls (mean 1.03/cm^2). In the same study, it has been reported that the density of *D. folliculorum* is greater in patients than in controls, and *D. folliculorum* may play a direct or indirect role in the etiology of seborrheic dermatitis. In a study investigating the prevalence of *Demodex* in different dermatological diseases, it was reported that *Demodex* positivity was detected in 6.7% of patients with seborrheic dermatitis (Erdal and Albayrak, 2022). In another study, it was reported that *D folliculorum* positivity was detected in 20 of 41 patients (48.8%) with seborrheic dermatitis and in two of 77 (2.6%) controls. In the same study, it was stated that *Demodex* mites tend to be found on facial areas with seborrheic dermatitis and *Demodex*-induced inflammation may contribute to the pathogenesis of seborrheic dermatitis (Aktaş Karabay and Aksu Çerman, 2020). In a study conducted to investigate the role of *D. folliculorum* in the etiology of seborrheic dermatitis, it was noted that *D. folliculorum* was detected in 25.5% of patients and 19.6% of controls. In the same study, the mean density of *D. folliculorum* was reported as 1.69/cm^2 in patients and 1.24/cm^2 in controls, and it was also noted that *D. folliculorum* was denser in non-lesion rather than in lesion areas (Güleç, 2014).

In our study as well as in studies conducted by other groups, it was found that *Demodex* mites are prevalent and more dense in patients with seborrheic dermatitis. These results indicate that there may be a relationship between seborrheic dermatitis and *Demodex* mites, and that seborrheic dermatitis may prepare the ground for *Demodex* infestation. This may be due to the fact that the main food source of *Demodex* mites is sebum. However, this theory needs to be supported by further studies, in which the amount of sebum is measured.

The fact that *Demodex* mites can also be found in healthy individuals and do not cause any clinical symptoms however, can lead to confusion. Many researchers have noted that *Demodex* mites destroy follicular and sebaceous epithelial cells with piercing mouthparts, disrupt the skin barrier and form lymphocyte infiltrates around the follicle, causing an immune response to the allergens of the mite when it penetrates the dermis. In addition, it has been reported that *Demodex* mites can increase in number and become opportunistic pathogens if the immune system is suppressed or insufficient (Forton 2012; Forton et al., 2015; Aytekin et al., 2017; Zeytun and Ölmez, 2017). Some researchers have reported that individuals with the HLA-A2 haplotype are three times more resistant to demodecosis, while individuals with the HLA-CW2 and HLA-CW4 haplotypes are five times more likely to develop demodecosis. It has also been reported that the density of *Demodex* increases due to an increase in lymphocyte and NK apoptosis in these individuals (Akilov and Mumcuoglu, 2003, 2004; Mumcuoglu and Akilov, 2005). Therefore, the fact that some patients and controls may be asymptomatic despite being *Demodex* positive may be related to the genetic characteristics of these individuals and the HLA haplotypes they have. However, additional studies are needed on this issue.

While *Demodex* mites are not found in newborns, they can be found widely in both gender in infantile, childhood, puberty and adult stages. In this study, it was found that the prevalence of *Demodex* was almost the same in male and female patients, but the density of *Demodex* was greater in males than in females. In other studies, it has been reported that the prevalence and density of *Demodex* is greater in males (Okyay et al., 2006; Durmaz et al., 2015; Tilki et al., 2017; Zeytun et al., 2017; Karakurt ve Zeytun, 2018), more in females (Özdemir et al., 2005; Zeytun 2017; Zeytun ve Ölmez, 2017) , or equal in males and females (Zhao et al., 2011). This situation which differs between the studies, may be related to the attention paid by the participants to personal care and hygiene.

In many studies, it has been reported that the prevalence and density of *Demodex* increases with age (Beekeeper et al., 2005; Inceboz et al., 2009; Kasemsuwan et al., 2017; Lopez-Ponce et al., 2017; Fox et al., 2017; Zeytun 2017; Zeytun and Ölmez 2017; Zeytun et al., 2017). However, in our study, it was found that the prevalence and density of *Demodex* were higher in adolescent than in adult patients. This may be associated with increased sebum secretion of adolescents.

As shortcomings of our study it can be mentioned that the sample size was small and the amount of sebum in patients was not measured. Therefore, it is necessary to support the issue with further studies in which sebum levels are measured and involving a larger number of patients.

Authors' contributions

Erhan Zeytun: Project manager, laboratory works (collection of samples, preparation of samples, microscopic examinations, identification of mites), writing - reviewing & editing, methodology, investigation, visualization, formal analysis (supporting), statistics. **Mustafa Yazıcı:** Clinical examination, selection of patients and controls, formal analysis (lead), writing - reviewing and editing, methodology, investigation.

Statement of ethics approval

Ethical approval was obtained from the Clinical Research Ethics Committee of Erzincan Binali Yıldırım University (Permission No: 2016-08/07).

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Conflict of interest

The authors declared that there is no conflict of interest.

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RESEARCH ARTICLE

Multivariate analysis of the effects of site factors on the distributions of raphignathoid mites (Acari: Raphignathoidea)

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ASBTRACT: This study was carried out to examine the relationships between the distributions of raphignathoid mite (Acari: Raphignathoidea) species and their temporal and environmental site factors (i.e. season, habitat type, and altitude) in Pülümür Valley and its immediate environs, Turkey. Data was collected from 306 samples from the various locations in the study area. 70 raphignathoid mite species were identified. The most common raphignathoid species, genus, and family are *Neognathus terrestris*, *Eustigmaeus,* and Stigmaeidae, respectively. It has been also found that the greatest number of raphignathoid mite specimens has been encountered in autumn, followed by spring, summer, and winter, respectively.

Before applying the statistical analysis, rare species (i.e., the species having less than 5% frequency value) were omitted from the data matrix. Thus, the first (original) matrix size was reduced from 70×306 to 20×242. Elevation is a continuous variable whereas seasons and habitat types are nominal data. Therefore, each of the seasons (winter, spring, summer, and autumn), and each of habitat types [i.e., litter, soil, soil and organic components, mixed material consisting of moss and liken, and the others (manure and ant nest)] were inserted as binary data [present (1), absent (0)] in the data matrix.

Canonical Correspondence Analysis (CANOCA) was applied to define the species-site relationships. Findings indicate that *Caligonella haddadi*, *Neognathus terrestris*, *Cryptognathus lagena*, *Raphignathus gracilis,* and *Stigmaeus devlethanensis* are significantly associated with moss and lichen habitat whereas litter, grassy and mossy soil are more suitable habitat types for *Favognathus amygdalus*, *F. cucurbita*, *Raphignathus kuznetzovi*, *Eustigmaeus dogani*, *E. pinnatus*, *E. segnis*, *Ledermuelleriopsis aminiae*, *L. ayyildizi,* and *Storchia robusta*. In addition to this, three species *Favognathus cucurbita*, *Eustigmaeus segnis,* and *Ledermuelleriopsis plumosus* are positively and six species *Caligonella humilis*, *Neognathus terrestris*, *Favognathus amygdalus*, *Raphignathus gracilis*, *Raphignathus kuznetzovi* and *Ledermuelleriopsis aminiae* are negatively related to elevation.

Keywords: Mite, multivariate methods, ordination techniques, habitat, environmental factors.
Zoobank: https://zoobank.org/2ECC595A-6AB1-40FC-BD21-EB47B207EB57

INTRODUCTION

The mites classified in the subclass Acari are members of the small arthropods. Raphignathoidea Kramer is a superfamily belonging to the mite suborder Prostigmata in the order Trombidiformes. This group currently consists of 1087 species in 69 genera within 12 families. Presently, this superfamily is represented in Turkey by 217 species in 26 genera of 8 families (Doğan, 2019; Beron, 2020).

The superfamily Raphignathoidea contains many free-living predators, but a few are herbivores feeding on moss and pollen, and others parasites of insects (Fan and Zhang, 2005; Beron, 2020). Some of the predatory forms are suitable biological control agents of spider mites (Tetranychidae), eriophyid mites (Eriophyidae), and scale insects (Coccoidea) in agriculture and forestry (Fan and Zhang, 2005; Beron, 2020). Like other organisms, raphignathoid mites have important relationships with their environment, but these relationships are not yet known due to a lack of research. Although there are many taxonomic and faunistic studies on raphignathoid mites, the researches on ecology and distribution of the mites are limited (Doğan, 2019). Only Somuncu and Koç (2012), Akyol and Koç (2016), Koç and Poyraz Tınartaş (2017) have surveyed seasonal distributions of raphignathoid mites.

Multivariate analysis is concerned with the simultaneous statistical analysis of multiple variables. Those methods can be divided into two general groups as classification (clustering) methods and ordination techniques. The goal of classification methods is to establish a set of meaningful groups of similar objects by investigating relationships between objects. Ordination techniques developed on the basis of Gradient analysis consist of two types, direct type and indirect type (Whittaker, 1962). In the indirect type, changes in living organisms are studied apart from environmental factors while environmental factors are investigated only in the data interpretation step. In direct type, changes in species are studied directly through study environmental factors (Khansari et al., 2016). One of the most commonly used direct methods of species ordination is Canonical Correspondence Analysis (CANOCA) (Özkan et al., 2009). Thus, in this present study, we used CANOCA for exploring the between the distributions of raphignathoid mites and their temporal and environmental site factors.

MATERIALS AND METHODS

Site description

The study area (39°35'26.0"N 39°52'19.5"E – 39°06'04.4"N 39°33'18.7"E) is on the route of the road connecting the province of Tunceli to Erzincan, and also covers the Pülümür Valley which is situated among mountains with an altitude of 3,000 meters. With its rich biodiversity and untouched nature, it exhibits a different beauty in every season of the year (Işık, 2012; Köksal and Ulaşoğlu, 2012; Babacan et al., 2017). The study area has a continental climate with hot, dry summers and cold, snowy winters. Majority of the area covers by travertine deposits, coarse clastic deposits, and gypsiferous clastic deposits. Basaltic extrusive rocks, diabase and the intrusive igneous rocks are also present (Afshar, 1965). It is the intersection point of the Euro-Siberian, Iran-Turanian, and Mediterranean plant geographies. Oak forests commonly cover in the study area and its surroundings, and there are sparse plants in the area such as Scots Pine, juniper, rosehip, hawthorn, elm, willow, and tamarisk (Babacan et al., 2017; Armağan, 2020).

Field survey and extraction of mites

Sampling studies were carried out after obtaining legal permissions from the General Directorate of Agricultural Research and Policies (50411936-604.02-E.2200901) and the General Directorate of Nature Conservation and National Parks (72784983-488.04-44455), two units of TR Ministry of Agriculture and Forestry. The samplings were performed monthly in the research area between October 2018 and September 2019. Totally 306 samplings were made in the area and a Global Position System (GPS) was used for taking coordinates and altitudes of the sampling sites. All collected samples were carried to the laboratory in a plastic bag. Mite specimens were extracted from the samples collected for 7 days with the aid of Berlese-Tullgren funnels. Raphignathoid mites were picked using a micropipette under a Leica EZ4 stereo microscope, then cleared in 60% lactic acid and mounted on microscopic slides in Hoyer's medium. The specimens were examined and counted by using a Leica DM 4000B phase-contrast microscope. It was then identified to species level using the published paper (i.e., Summers and Schlinger, 1955; Summers, 1962; Summers and Chaudhri, 1965; Luxton, 1973; Wood, 1973; Kuznetsov, 1978; Meyer and Ueckermann, 1989; Fan, 2000, 2004; Fan et al., 2003a,b, 2016, 2019; Fan and Zhang, 2004, 2005; Doğan, 2008).

Data set

In total 70 mite species were determined after field survey and laboratory works (Table 1). The frequency and the abundance values of the species, genus, and families are given in Figure 1.

Many of the species have low frequency values. Rare species (i.e., the species less than 5% frequency value throughout the data set) were removed to reduce bias in the analysis. The remaining 20 mite species were taken for the analysis. Thus, the first (original) matrix size was reduced from 70×306 to 20×242. In the study, the used explanatory variables are elevation, seasons, and habitat types.

Elevation is a continuous variable whereas the others are nominal variables. Therefore, each season and each habitat type were inserted as binary data [present (1), absent (0)] in the data matrix. Site factors and species were coded and given in Tables 1-2.

Table 1. The species list of the study area and their codes.

Species	Family	Codes
Barbutia anguineus (Berlese)	Barbutiidae	S1
Caligonella haddadi Bagheri & Maleki	Caligonellidae	S2
Caligonella humilis (Koch)		S3
Molothrognathus bahariensis Khanjani & Ueckermann		S4
Molothrognathus crusis Summers & Schlinger		S5
Molothrognathus kamili Doğan		S6
Molothrognathus phytocolus Meyer & Ueckermann		S7
Molothrognathus terrulentus Meyer & Ueckermann		S8
Neognathus eupalopus Meyer & Ueckermann		S9
Neognathus pusillus Doğan & Doğan		S10
Neognathus spectabilis (Summers & Schlinger)		S11
Neognathus terrestris (Summers & Schlinger)		S12
Neognathus ueckermanni Bagheri, Doğan & Haddad		S13
Cryptognathus ayyildizi Akyol & Koç	Cryptognathidae	S14
Cryptognathus lagena Kramer		S15
Cryptognathus summersi Robaux		S16
Favognathus amygdalus Doğan & Ayyıldız		S17
Favognathus bafranus Doğan		S18

Table 1 (continued).

Favognathus cucurbita (Berlese)	Cryptognathidae	S19
Favognathus dakotaensis (McDaniel & Bolen)		S20
Favognathus kamili Dönel & Doğan		S21
Favognathus rosulatus Doğan & Doğan		S22
Saniosulus deliquus Doğan, Bingül & Doğan	Eupalopsellidae	S23
Raphignathus collegiatus Atyeo, Baker & Crossley	Raphignathidae	S24
Raphignathus gracilis (Rack)		S25
Raphignathus hecmatanaensis Khanjani & Ueckermann		S26
Raphignathus kuznetzovi Doğan & Ayyıldız		S27
Raphignathus ueckermanni Koç & Kara		S28
Raphignathus zhaoi Hu, Jing & Liang		S29
Cheylostigmaeus tarae Khanjani	Stigmaeidae	S30
Cheylostigmaeus urhani Dönel & Doğan		S31
Cheylostigmaeus n. sp.		S32
Eustigmaeus anauniensis (Canestrini)		S33
Eustigmaeus capitatus Stathakis, Kapaxidi ve Papadoulis		S34
Eustigmaeus collarti (Cooreman)		S35
Eustigmaeus dogani Khanjani, Fayaz, Mirmoayedi & Ghaedi		S36
Eustigmaeus erzincanensis Doğan		S37
Eustigmaeus jiangxiensis Hu, Chen & Huang		S38
Eustigmaeus nahidae Gheblealivand & Bagheri		S39
Eustigmaeus pinnatus (Kuznetsov)		S40
Eustigmaeus rhodomela (Koch)		S41
Eustigmaeus sculptus Doğan, Ayyıldız & Fan		S42
Eustigmaeus segnis (Koch)		S43
Eustigmaeus setiferus Bagheri, Saber, Ueckermann, Ghorbani & Bonab		S44
Eustigmaeus turcicus Doğan & Ayyıldız		S45
Ledermuelleriopsis aminiae Nazari & Khanjani		S46
Ledermuelleriopsis ayyildizi Doğan		S47
Ledermuelleriopsis plumosus Willmann		S48
Ledermuelleriopsis toleratus Kuznetsov		S49
Mediolata aegyptiaca (Zaher & Soliman)		S50
Prostigmaeus amplius Doğan, Doğan & Bingül Türk		S51
Stigmaeus bifurcus Bingül, Doğan & Dilkaraoğlu		S52
Stigmaeus creber Barilo		S53
Stigmaeus devlethanensis Akyol & Koç		S54
Stigmaeus erzincanus Doğan, Bingül, Dilkaraoğlu & Fan		S55
Stigmaeus fidelis Kuznetsov		S56
Stigmaeus furcatus Dönel & Doğan		S57
Stigmaeus glabrisetus Summers		S58
Stigmaeus livschitzi Kuznetsov		S59
Stigmaeus longipilis (Canestrini)		S60
Stigmaeus mitrofanovi Khaustov		S61
Stigmaeus pilatus Kuznetsov		S62
Stigmaeus pulumurensis Doğan & Doğan		S63
Stigmaeus siculus (Berlese)		S64
Stigmaeus tolstikovi Khaustov		S65
Storchia ardabiliensis Safasadati, Khanjani, Razmjou & Doğan		S66
Storchia hendersonae Fan & Zhang		S67
Storchia robusta (Berlese)		S68
Villersia sudetica Willmann		S69
Zetzellia mali (Ewing)		S70

Data analysis

Multivariate methods have been widely used for community data to detect the community pattern and explore the species-site relationships (Ter Braak, 1987; Martin and Bouchard, 1993; Jeglum and He, 1995; Pinto et al., 2006; Fontaine et al., 2007). The effects of environmental characteristics on community patterns are directly quantified by CANOCA. In this way, sampling sites and community members are directly ordinated under the constraint of the site or environmental variables (Legendre and Legendre, 1998; Makerenkov and Legendre, 2002).

In the present paper, canonical correspondence analysis based on linear regression (CANOCA) was applied (Legendre and Legendre, 1998). Site scores obtained from CANOCA were related to the site factors and the species using Pearson correlation and Spearman rank correlation. All the analyses were conducted using Paleontological Statistics (PAST) software version 1.89 (Hammer et al., 2001).

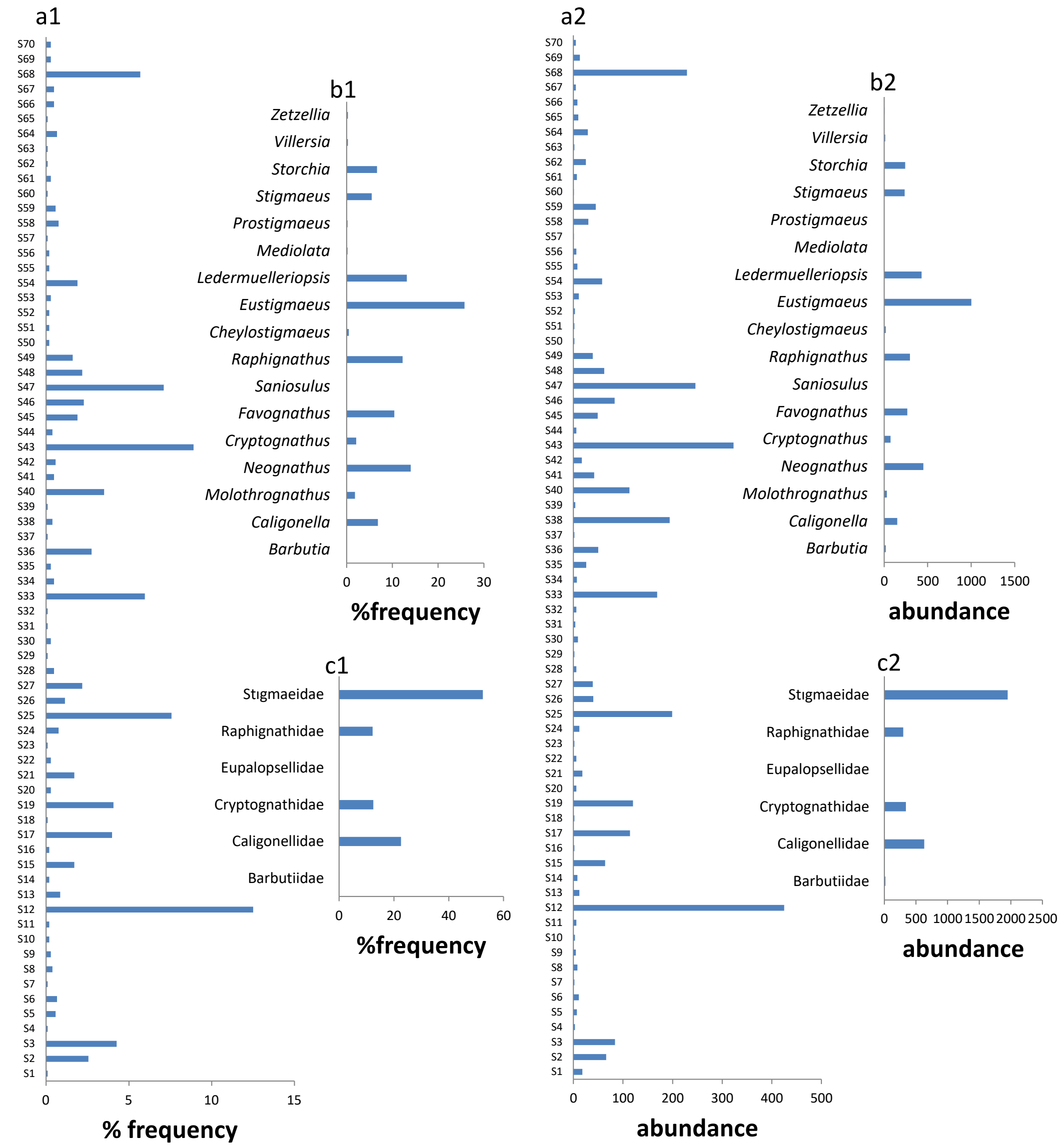

Figure 1. The frequency (1) and abundance (2) values of the species (a), genus (b), and families (c).

Table 2. The codes of site factors.

Habitat types	**Codes**
Litter	HT1
Soil	HT2
Litter, grassy and mossy soil	HT3
Moss and lichen	HT4
Others (manure, ant nest)	HT5
Seasons	**Codes**
Winter	WTN
Spring	SPR
Summer	SMR
Autumn	ATM
Elevation (meter)	**ELEV**

RESULTS

In total 3241 raphignathoid mite specimens within 70 species belonging to six families were determined (Fig. 1). The frequency value of the rarest species (i.e., S1, S4, S7, S18, S23, S29--31, S37, S39, S57, S60, S62-63, and S65) corresponds to a value of 0.09%. The most common species are S12 (12.50%), S43 (8.90%), S25 (7.58%) and S47 (7.10%). In addition to, the rarest genera are *Barbutia* Oudemans (0.09%), *Saniosulus* Summers (0.09%), *Mediolata* Canestrini (0.18%), and *Prostigmaeus* Kuznetzov (0.18%), and the rarest families are Barbutiidae Robaux (0.09%) and Eupalopsellidae Willmann (0.09%). The most common genus and family are *Eustigmaeus* Berlese (25.75%) and Stigmaeidae Oudemans (52.46%), respectively (Fig. 1). Looking at the abundance values in Figure 2, the species S12, S33, S43, S47, and S68 are mostly found in the habitat HT3. The most abundant species in HT3 is S43 with 233 individuals. S43 is also the most abundant species in HT1 with 41 individuals. Similarly, S12 is also the most abundant species in HT4 with 184 individuals. HT2 and HTP5 are the least preferred habitats, with the highest number of individuals not exceeding 17 individuals (S46) in HT2 and 10 individuals (S68) in HT5 (Fig. 2). According to the abundance values (Fig. 2), the species S12, S43, and S47 are mostly found in the season ATM. The most abundant species in ATM is S12 with 175 individuals. S12 and S43 are also the most abundant species in the season SPR with 108 and 125 individuals, respectively. Also, S12 is the most abundant species in the season WNT with 93 individuals. S43 is also the most abundant species in the season SMR with 67 individuals (Fig. 2).

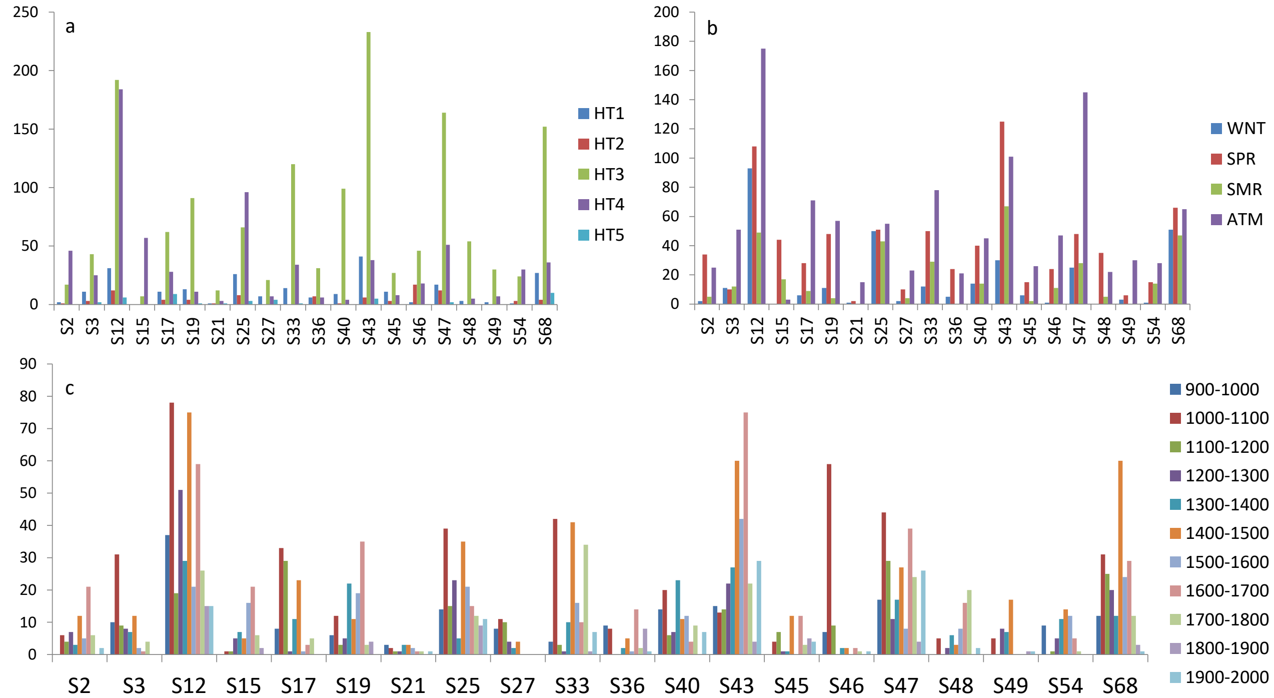

Figure 2. Total abundance values of the species according to habitat types (a), seasons (b) and elevation belts (c).

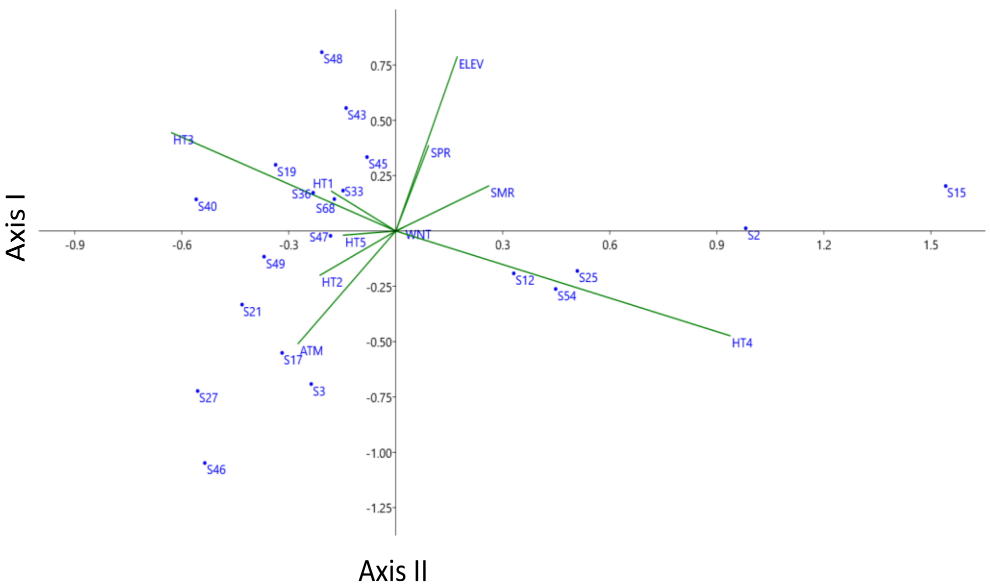

Figure 3. CANOCA results.

The p-values (calculated probabilities) of the first five axes are less than 0.01 after 999 permutations. Eigenvalues of those axes are 0.1826, 0.1523, 0.07099, 0.04716 and 0.03631 respectively. The cumulative percent eigenvalue of the first two axes is 62.97%.

A two-dimensional CANOCA ordinate of the site factors and the species is shown in Figure 3. The correlation results of the site factors and the species with CANOCA axes are given in Tables 3-4. HT3 and HT4 have very strong correlations with CANOCA axes, in particular, with Axis 1 at the level of 0.001.The relationship of SMR with Axis 1 is statistically significant, but this relationship is considerably weaker than the relationship between HT3 and HT4 with the first axis. We, therefore, interpreted Axis 1 as habitat type. The second axis can be interpreted as climatic tolerance because elevation has the greatest correlation coefficient of Axis 2. Besides, ATM and SPR are strongly associated with the Axis 2 at the level of 0.001 and 0.01, respectively (Table 3). The species being positively correlations with Axis 1 are S2, S12, S15, S25, and S54. From the remanding species, negatively correlated species with this Axis are S17, S19, S27, S36, S40, S43, S46, S47, and S68. As can be also seen from the ordination diagram of CANOCA (Fig. 3), it is clear that habitat preferences of S2, S12, S15, S25, and S54 correspond to HT4 whereas HT3 is more suitable habitat types for S17, S19, S27, S36, S40, S43, S46, S47, and S68. Three species S19, S43, and S48 are positively and six species S3, S12, S17, S25, S27, and S46 are negatively associated with Axis 2 at the varied significant levels less than 0.05 (Fig. 1 and Table 4). According to these results and total abundance values of the species shown in Fig. 2c, it can be said that S3, S12, S17, S25, S27, and S46 survive in the warmer sites, especially between 1000 and 1100 meters of the study area. On the contrary, S19, S43, and S48 are likely to resist to cold climatic conditions and refrain from the warmer sites because those species are more abundant between 1600 and 1700 meters.

Table 3. Spearman rank correlation coefficients among nominal site variables and CANOCA axes scores and, Pearson correlation coefficient of elevation with CANOCA axes scores.

	Axis 1		Axis 2	
	c	p	c	p
WNT	0.087	0.179	-0.005	0.944
SPR	-0.059	0.361	0.187	0.003
SMR	0.136*	0.034	0.107	0.096
ATM	-0.086	0.182	-0.246	0.000
HT1	-0.062	0.336	0.089	0.166
HT2	-0.109	0.091	-0.054	0.402
HT3	-0.263	0.000	0.237	0.000
HT4	0.396	0.000	-0.275	0.000
HT5	-0.068	0.294	-0.011	0.866
ELEV	0.086	0.183	0.393	0.000

Table 4. Pearson correlation coefficients between the species and CANOCA axes.

	Axis 1		Axis 2	
	c	p	c	p
S2	0.288	0.000	-0,022	0,736
S3	-0.059	0.360	-0.345	0.000
S12	0.226	0.000	-0.252	0.000
S15	0.625	0.000	0.051	0.429
S17	-0.130	0.043	-0.225	0.000
S19	-0.148	0.022	0.141	0.028
S21	-0.108	0.093	-0.078	0.228
S25	0.206	0.001	-0.195	0.002
S27	-0.127	0.049	-0.173	0.007
S33	-0.121	0.060	0.114	0.077
S36	-0.151	0.019	-0.031	0.635
S40	-0.273	0.000	0.079	0.221
S43	-0.174	0.007	0.503	0.000
S45	0.016	0.802	0.105	0.104
S46	-0.168	0.009	-0.391	0.000
S47	-0.152	0.018	-0.074	0.251
S48	-0.080	0.218	0.165	0.010
S49	-0.107	0.096	-0.042	0.512
S54	0.183	0.004	-0.054	0.404
S68	-0.152	0.018	0.052	0.421

DISCUSSION

According to the frequency values given in Figure 1, the most common raphignathoid species, genus, and family are *Neognathus terrestris*, *Eustigmaeus,* and Stigmaeidae, respectively, in the research area. These results are not surprising. Although Caligonellidae is a small group of raphignathoid mites, *N. terrestris* which is a member of this family, is very common. It is also known that Stigmaeidae is the most abundant and most diverse family in Raphignathoidea, and that *Eustigmaeus* is one of the most common genera in this family (Fan et al., 2016). Seasonal distributions of some mites have been investigated in different countries by several researchers (i.e., Stamou and Sgardelis, 1989; Lee et al., 1993; Gergócs et al., 2011; Önen and Koç, 2011; Wehner et al., 2018). In this context, two studies generated in Turkey have been received attention. In the first study performed by Somuncu and Koç (2012) in Seferihisar, İzmir, 598 individuals have been detected in the sampling area, and it has been revealed that the greatest number (%44.6) of raphignathoid mites were collected in spring, following by winter (%35.7), autumn (%16.2) and summer (%3.3), respectively (Somuncu and Koç, 2012). The second study was conducted by Koç and Poyraz Tınartaş (2017) in Gölmarmara, Manisa province. In that study, it has been determined that the greatest number of raphignathoid mite specimens has been encountered in autumn (%49), followed by summer (19%), winter (17%), and spring (15%), respectively. In our study, 324 (12.7%), 360 (14.1%), 783 (30.7%), and 1083 (42.5%) individuals of the raphignathoid mites were collected from the season winter, summer, spring, and autumn, respectively and, the highest numbers of individuals are found in autumn and spring. The seasonal distribution of the mite individuals in our study is in agreement with those of previous works. The variability in other seasons may have been originated from regional differences and/or temporal differences of sampling.

Members of the superfamily Raphignathoidea are collected generally from edaphic habitats, especially moss- and grass-covered substrates, litters, barks, and lichens (Fan and Zhang, 2005). According to our findings obtained from CANOCA, moss, and lichen are suitable habitats for *Caligonella haddadi*, *Neognathus terrestris*, *Cryptognathus lagena*, *Raphignathus gracilis,* and *Stigmaeus devlethanensis*; however, litter, grassy and mossy soil are more suitable for *Favognathus amygdalus*, *F. cucurbita*, *Raphignathus kuznetzovi*, *Eustigmaeus dogani*, *E. pinnatus*, *E. segnis*, *Ledermuelleriopsis aminiae*, *L. ayyildizi,* and *Storchia robusta*. Although habitat preferences of some mites have been known (i.e., Barendse et al., 2002; Salmane and Brumelis, 2010; Wehner et al., 2016; Manu et al., 2018), as far as we know, those of raphignathoid mites has never been investigated statistically in detail until now.

The other significant findings obtained from CANOCA indicate that *Caligonella humilis*, *Favognathus amygdalus*, *F. kamili*, *R. kuznetzovi,* and *Ledermuelleriopsis aminiae* prefer lower altitudes corresponding to the warmer sites of the study area. On the other hand, *Eustigmaeus segnis, E. turcicus* and *Ledermuelleriopsis plumosus* are likely to resist to cold climatic conditions since they can present relatively high altitudes.

Authors' contributions

Mervenur Ceylan: Creating datasets, data curation, formal analysis. **Salih Doğan:** Supervision, project administration, resources investigation, methodology, writing - review & editing. **Kürşad Özkan:** Conceptualization, visualization, verification, data curation, methodology, formal analysis, writing - original draft, writing - review & editing.

Statement of ethics approval

Not applicable.

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Conflict of interest

We declare that there is no conflict of interest.

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RESEARCH ARTICLE

New records of soil-inhabiting mesostigmatic mites (Acari: Mesostigmata) in Turkey

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ASBTRACT: This paper reports on four species, in three genera within two families (Ameroseiidae, Digamasellidae) of soil-inhabiting mesostigmatic mites in Turkey: *Ameroseius lidiae* Bregetova; *Ameroseius sculptilis* Berlese; *Kleemannia nova* Nasr and Abou-Awad and *Dendrolaelaspis lobatus* (Shcherbak and Chelebiev). The important diagnostic characters of each species are reviewed to facilitate species delimitation. The genus *Dendrolaelaspis* Lindquist is reported for the first time from Turkey.

Keywords: Taxonomy, first record, Parasitiformes, Gamasina, Monogynaspida, Ascoidea, Dendrolaelapinae, Palaearctic realm.
Zoobank: https://zoobank.org/58871FD7-628F-44F4-9A80-38879511504C

INTRODUCTION

Mesostigmata is a large and a cosmopolitan order of mites that includes approximately 11,500 valid species, which is about 20% of all known mite species (Beaulieu et al., 2011). The representatives of this order are characterized by an unusually diverse variety of lifestyles and habitats, but the majority of species are free-living predators. Mesostigmatic mites are found in soil, litter, rotting wood, compost, manure, carrion, nests, house dust and similar detritus-based niches. They are also associated with plants and fungi (Lindquist et al., 2009).

The mite family Ameroseiidae is presently classified in the superfamily Ascoidea of the order Mesostigmata. The most recent taxonomic work on the family was by Mašán (2017), who comprehensively revised the generic concepts and morphological attributes of this family. The family, which includes about 138 described species sorted into 12 genera (Mašán, 2017), comprises free-living mites that dwell in the soil, litter, organic matter, stored food, or dust, but most species are fungivorous (Flechtmann, 1985; Moustafa and El-Hady, 2006), which, based on the few species studied (Moustafa and El-Hady, 2006), can be biological control agents for management of various soil-borne plant pathogenic fungi (e. g., *Rhizoctonia solani* Kühn). This fact points to ameroseiids may playing an important role in the balance of the soil ecosystem.

The family Digamasellidae is well known as a group of predatory mites generally found in soil and litter, as well as in manure and compost. The family comprises about 277 nominal species placed into 12 genera that are recorded worldwide (Shcherbak, 1980; Castilho, 2012; Faraji et al., 2021). Many members of family are found in decaying wood, bracket fungi, and the galleries of bark beetles (Hirschmann, 1960; McGraw and Farrier, 1969; Shcherbak, 1980; Hirschmann and Wiśniewski, 1982a,; Karg, 1993). The classification of the digamasellids is unstable as a result of continued confusion about the definition and status of some of its genera. Different concepts of genera and subgenera have been used by different authors (e.g., Lindquist, 1975; Evans and Till, 1979; Shcherbak, 1980; Hirschmann and Wiśniewski, 1982a, 1982b; Karg, 1993). We herein follow Lindquist (1975) and subsequent authors (e.g. Castilho et al., 2012) who classified Digamasellidae into relatively few genera.

Free-living mesostigmatic mites in Turkey have been reported by various authors (see Erman et al., 2007; Çakmak et al., 2011). Nevertheless, the families Ameroseiidae and Digamasellidae remain poorly studied and before the present study, only eight and four species of Ameroseiidae and Digamasellidae had been reported from Turkey, respectively (Erman et al., 2007; Çakmak et al., 2011; Qayyoum et al., 2016; Khalili-Moghadam and Saboori, 2021). In this paper, we add to that of the Turkish fauna by reporting four species in three genera from these two families.

MATERIALS AND METHODS

Soil samples were collected from various localities at Turkey, in searching for edaphic mites. Mites were extracted from soil using Berlese-Tullgren funnels, then cleared in lactic acid solution and mounted in Hoyer's medium (Walter and Krantz, 2009). Microphotographs were taken with an AxioCam 506 camera (Carl Zeiss, Germany) equipped with differential interference contrast (DIC). Most images were captured in stacks (with the focal depth manually controlled). Selected images were combined using Helicon Focus 7.6.4 Pro (Helicon Soft Ltd., 2000). The nomenclature used for the dorsal idiosomal chaetotaxy follows that of Lindquist and Evans (1965), the notations for leg and palp setae follow those of Evans (1963a, b), and other anatomical structures mostly follow Evans and Till (1979).

RESULTS

Family Ameroseiidae Evans

Genus *Ameroseius* Berlese

Ameroseius Berlese, 1904: 258.

Type species: *Seius echinatus* Koch, 1839 (= *Acarus corbicula* Sowerby, 1806), by original designation.

Diagnosis. The diagnosis of *Ameroseius* used here is based on that of Mašán (2017).

***Ameroseius lidiae* Bregetova**

(Figure 1)

Ameroseius lidiae Bregetova, 1977: 161.

Ameroseius lidiae — Kazemi and Rajaei, 2013: 65; Khalili-Moghadam and Saboori, 2014: 675; Khalili-Moghadam and Saboori, 2021: 410.

Ameroseius (*Ameroseius*) *lidiae* — Hajizadeh et al., 2013: 150.

More information about the synonyms of this species are available in Mašán (2017: 51).

Specimens examined. Two females; 36°20'01.9"N, 34°00'03.3"E, Sökün, Silifke, Mersin, Turkey; 20 January 2015; coll. K. Yalçın; soil-litter in commercial strawberry field. One female; 37°18'33"N, 34°45'48"E, Akçatekir, Pozantı, Adana, Turkey; 3 February 2015; coll. I. Doker; moss in *Pinus* sp. Forest. One female; 36°19'29.4"N, 34°03'16.0"E, Arkum, Silifke, Mersin, Turkey; 23 February 2015; coll. K. Yalçın; soil-litter in commercial strawberry field.

Remarks. *Ameroseius lidiae* was described from Ukraine and Tajikistan (holotype: Ukraine, estuary of Dnieper River; paratype: Tajikistan hollow of willow tree) (see Bregetova, 1977). The description provided by Bregetova (1977) lack some of the most important details and do not provide enough information for accurate and consistent species identification. Recently, the species fully redescribed by Khalili-Moghadam and Saboori (2014). The species has also been recorded from China, Hungary, Iran, Kazakhstan, Moldavia, Russia, Saudi Arabia, Slovakia, Spain, Syria, Uzbekistan (Khalili-Moghadam and Saboori, 2021) and it is now recorded in Turkey for the first time, from soil-litter. Morphological characters of our specimens agree very well with the redescription given by Khalili-Moghadam and Saboori (2014), also with supplementary information presented by Mašán (2017). *Ameroseius lidiae* is easily recognized by the dorsal shield entirely reticulated and with 29 pairs of somewhat slender setae (Fig. 1A), seta *j1* is about two times as wide as *j2* (Figs 1A, 1C), the tip of setae *j6* and *J2* extended at most to the midpoint of the distance between the base of *j6*-*J2* and *J2*-*J4*, respectively, and *J4* obviously not reaching posterior margin of dorsal shield (Fig. 1A); sternal shield almost smooth (or faintly reticulated), except some irregular lines anteriorly (Figs 1B, 1D), bearing two pairs of smooth setae, setae *st3* located on two small plates adjacent to posterior margin of sternal shield and *st4* on soft cuticle near hyaline flap of genital shield (Figs 1B, 1D); genital shield reticulate, with nearly parallel margins (Figs 1B, 1D), anal shield suboval, with delicate reticulation on surface and bearing only three circum-anal setae (Figs 1B, 1E); six pairs of opisthogastric setae present (Figs 1B, 1E), metapodal platelets small, elongate and narrow (Fig. 1B); deutosternal groove with seven rows of 1– 2 denticles, the denticles of 5th and 6th rows not discernible (Fig. 1F); cheliceral digits terminally with no hyaline appendages, fixed cheliceral digit with an apical tooth and three robust teeth and movable digit with one small subapical tooth (Fig. 1G).

***Ameroseius sculptilis* Berlese**

(Figure 2)

Ameroseius sculptilis Berlese, 1916: 47.

Ameroseius sculptilis — Khalili-Moghadam and Saboori, 2021: 412.

Ameroseius (*Ameroseius*) *sculptilis* — Hajizadeh et al., 2013: 150.

More information about the synonyms of this species are available in Mašán (2017: 51).

Specimens examined. Three females; Gölbaşı, Adıyaman, Turkey; 29 May 2014; coll. I. Döker and C. Kazak; unknown plant belongs to family Asteraceae. One female; Kuluşağı, Malatya, Turkey; 30 May 2014; coll. I. Döker and C. Kazak; *Anchusa* sp. (Boraginaceae).

Remarks. *Ameroseius sculptilis* was described from Italy (Berlese, 1916) where it was found in moss. The description of this species is brief and both the description and illustrations lack many important details. Bregetova (1977) considered that *Ameroseius pulcher* Westerboer (in Westerboer and Bernhard, 1963) is a junior synonym of *A. sculptilis*. However, Bregetova (1977) did not provide any explanation for this decision, nor did she provide the details of the examined specimens. *Ameroseius pulcher* was described from Germany (Westerboer and Bernhard, 1963) where it was found in rotting grass. Recently, Mašán (2017) has confirmed this synonymy by examination of type series of both species, we here follow Mašán (2017). *Ameroseius sculptilis* has also been recorded from Bulgaria, Iran, Japan, Norway, Russia, Slovakia (Khalili-Moghadam and Saboori, 2021) and it is now recorded in Turkey for the first time, from soil-litter. Morphological characters of our specimens agree very well with the supplementary information presented by Mašán (2017) for this species. *Ameroseius sculptilis* is easily recognized by the dorsal shield strongly reticulated, between *j6* and *J2* with subtriangular sculptural pattern (Fig. 2A), and with 29 pairs of mostly serrated setae, seta *j1* thickened (Fig. 2C), most *j*–*J* setae not reaching the base of the subsequent seta in the series (Fig. 2A), sternal shield almost smooth (or faintly reticulated), except some irregular longitudinal lines laterally (Figs 2B, 2D), bearing two pairs of smooth setae, setae *st3* located on two small

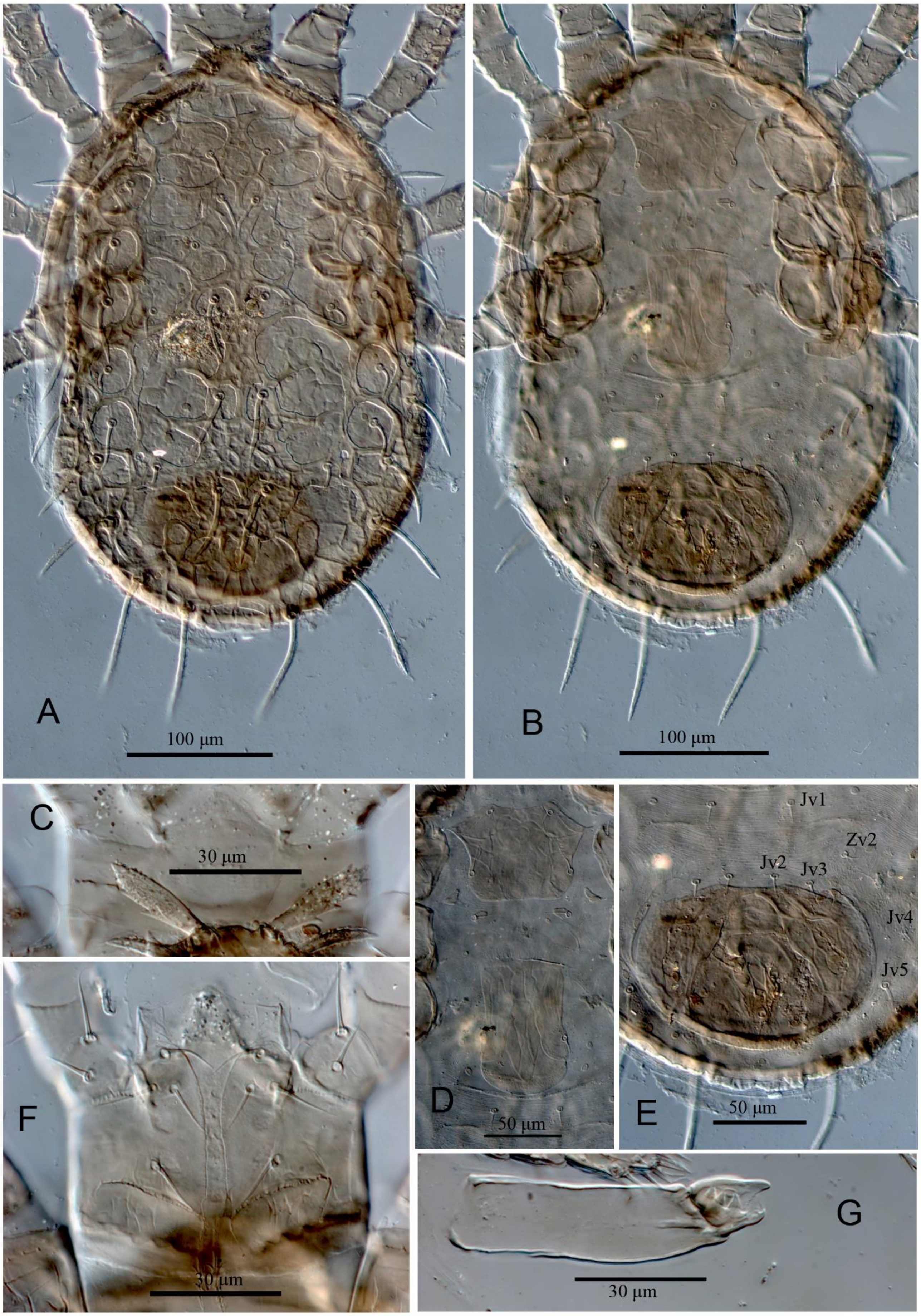

Figure 1. DIC micrographs of *Ameroseius lidiae* Bregetova, 1977, adult female. **A.** Idiosoma in dorsal view, **B.** Idiosoma in ventral view, **C.** Vertical setae *j1* enlarged, **D.** Sternal and genital shields, **E.** Anal shield, **F.** Subcapitulum, **G.** Chelicera.

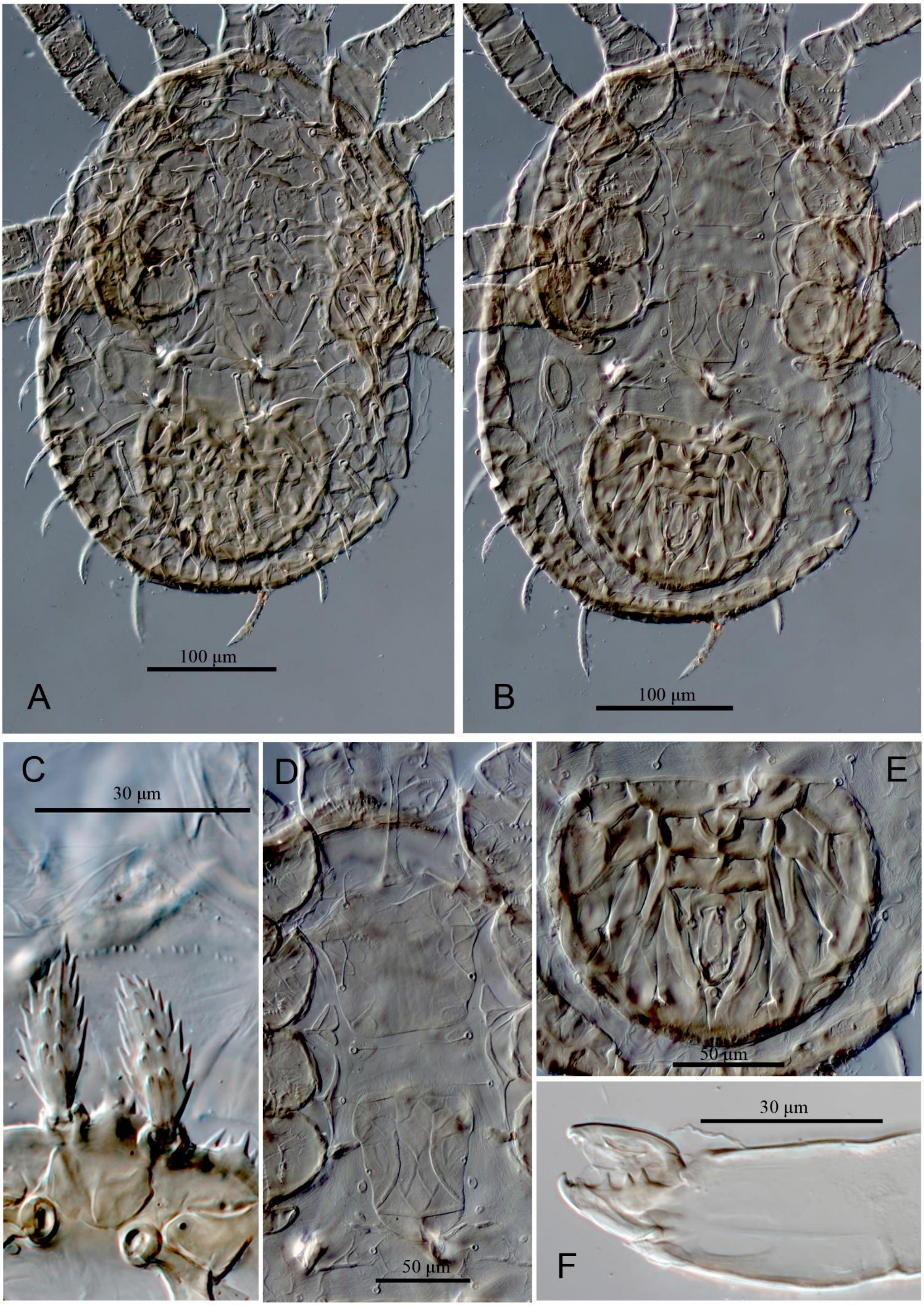

Figure 2. DIC micrographs of *Ameroseius sculptilis* Berlese, 1916, adult female: **A.** Idiosoma in dorsal view; **B.** Idiosoma in ventral view; **C.** Vertical setae *j1* enlarged; **D.** Sternal and genital shields; **E.** Anal shield; **F.** Chelicera.

plates adjacent to posterior margin of sternal shield and *st4* on soft cuticle near hyaline flap of genital shield (Figs 2B, 2D); genital shield reticulate, with nearly parallel margins (Figs 2B, 2D), anal shield subpentagonal, coarsely reticulate on surface, bearing only three circum-anal setae (Figs 2B, 2E); six pairs of opisthogastric setae present (Fig. 2B), metapodal platelets enlarged and rounded (Fig. 2B); fixed cheliceral digit with an apical tooth and three robust teeth and movable digit with one small subapical tooth (Fig. 2F).

Genus *Kleemannia* Oudemans

Kleemannia Oudemans, 1930: 135.

Type species: *Zercon pavidus* C. L. Koch, 1839, by original designation.

More information about the synonyms of this genus are available in Mašán (2017: 51).

Diagnosis. The diagnosis of *Ameroseius* used here is based on that of Mašán (2017).

***Kleemannia nova* Nasr and Abou-Awad**

(Figure 3)

Kleemannia nova Nasr and Abou-Awad, 1986: 75.

Ameroseius (*Kleemannia*) *novus* — Hajizadeh et al., 2013: 150.

Ameroseius nova — Kazemi and Rajaei, 2013: 65.

Kleemannia nova — Mašán, 2017: 90; Khalili-Moghadam and Saboori, 2021: 419.

Specimen examined. One female; 36°20'01.9"N, 34°00'03.3"E, Sökün, Silifke, Mersin, Turkey; 20 January 2015; coll. K. Yalçın; soil-litter in commercial strawberry field.

Remarks. *Kleemannia nova* was described from Egypt (Nasr and Abou-Awad, 1986) where it was found in manure and has also been recorded from Iran, Morocco, Peru (Khalili-Moghadam and Saboori, 2021) and it is now recorded in Turkey for the first time, from soil-litter. Morphological characters of our specimen agree very well with the description given by Nasr and Abou-Awad (1986), also with supplementary information presented by Mašán (2017) for this species. *Kleemannia nova* is easily recognized by the dorsal shield entirely reticulated and with 29 pairs of flattened, feather-shaped setae (*z6* present) (Fig. 3A), setae *j1* fan-shaped and marginally serrate (Figs 3A, 3E); pseudo-metasternal platelets enlarged and well developed (Figs 3B, 3C); setae *Jv2* and *Jv3* located on anteromedial surface of ventrianal shield and setae *Jv4* absent (Figs 3B, 3C); anterior margin of epistome with pointed central projection (Fig. 3E); deutosternal groove with seven rows of 1– 2 denticles, except 6th and 7th rows with 4– 5 denticles (Fig. 3D); fixed cheliceral digit with an apical tooth and four robust teeth and movable digit with one small subapical tooth (Fig. 3F).

Family Digamasellidae Evans

Genus *Dendrolaelaspis* Lindquist

Dendrolaelaps (*Dendrolaelaspis*) Lindquist, 1975: 16.

Dendrolaelaspis — Shcherbak, 1980: 175.

Dendrolaelaps (*Dendrolaelaspis*) Hirschmann and Wisniewski, 1982a: 137.

Type species: *Digamasellus angulosus* Willmann, 1936, by original designation.

Diagnosis. The concept of *Dendrolaelaspis* used here is based on that of Lindquist (1975).

***Dendrolaelaspis lobatus* (Shcherbak and Chelebiev)**

(Figure 4)

Dendrolaelaps (*Dendrolaelaspis*) *lobatus* Shcherbak and Chelebiev, 1977: 471.

Dendrolaelaspis lobatus — Shcherbak, 1980: 180; Karg and Schorlemmer,

2009: 69.

Dendrolaelaps (*Dendrolaelaspis*) *lobatus* — Hirschmann and Wisniewski, 1982a: 144.

Specimen examined. One female; 36°19'29.4"N, 34°03'16.0"E, Arkum, Silifke, Mersin, Turkey; 23 February 2015; coll. K. Yalçın; soil-litter in commercial strawberry field.

Remarks. Lindquist (1975) erected *Dendrolaelaspis* as a subgenus of *Dendrolaelaps* Halbert *sensu lato* and designated *Digamasellus angulosus* Willmann as its type species. Shcherbak (1980) raised most of the groups considered as subgenera of *Dendrolaelaps sensu lato* including *Dendrolaelaspis*, to the generic level and listing them in subfamily Dendrolaelapinae Hirschmann. The genus comprises about 19 nominal species that are recorded worldwide (Castilho, 2012). *Dendrolaelaspis lobatus* was described from Kazakhstan (Shcherbak and Chelebiev, 1977) where it was found in compost. Morphological characters of our specimen agree very well with description given by Shcherbak and Chelebiev (1977), also with supplementary information presented by Shcherbak (1980) for this species. The species has been recorded in Europe and Asia and is now recorded from Turkey for the first time from the soil-litter. *Dendrolaelaspis lobatus* is easily recognized by the shape and length of opisthonotal setae which are almost spatulate (club-shaped), except setae *J1* and Z1 needle-like, *Z4* scimitar-like, *J4* spine-like, and *J5* rod-shaped (Fig. 4A), anterior margin of the sternal shield hardly conspicuous (Fig. 4B), ventrianal shield bearing five pairs of smooth preanal setae (*Jv1–3, Zv2–2*) (Fig. 4B), post-anal seta club-shaped (Fig. 4B), hypostomal groove with five transverse rows of denticles, each row with 18–30 small denticles, posterior row extending outward from hypostomal groove (Fig. 4C); epistome triramous, central prong shorter than lateral prongs, each

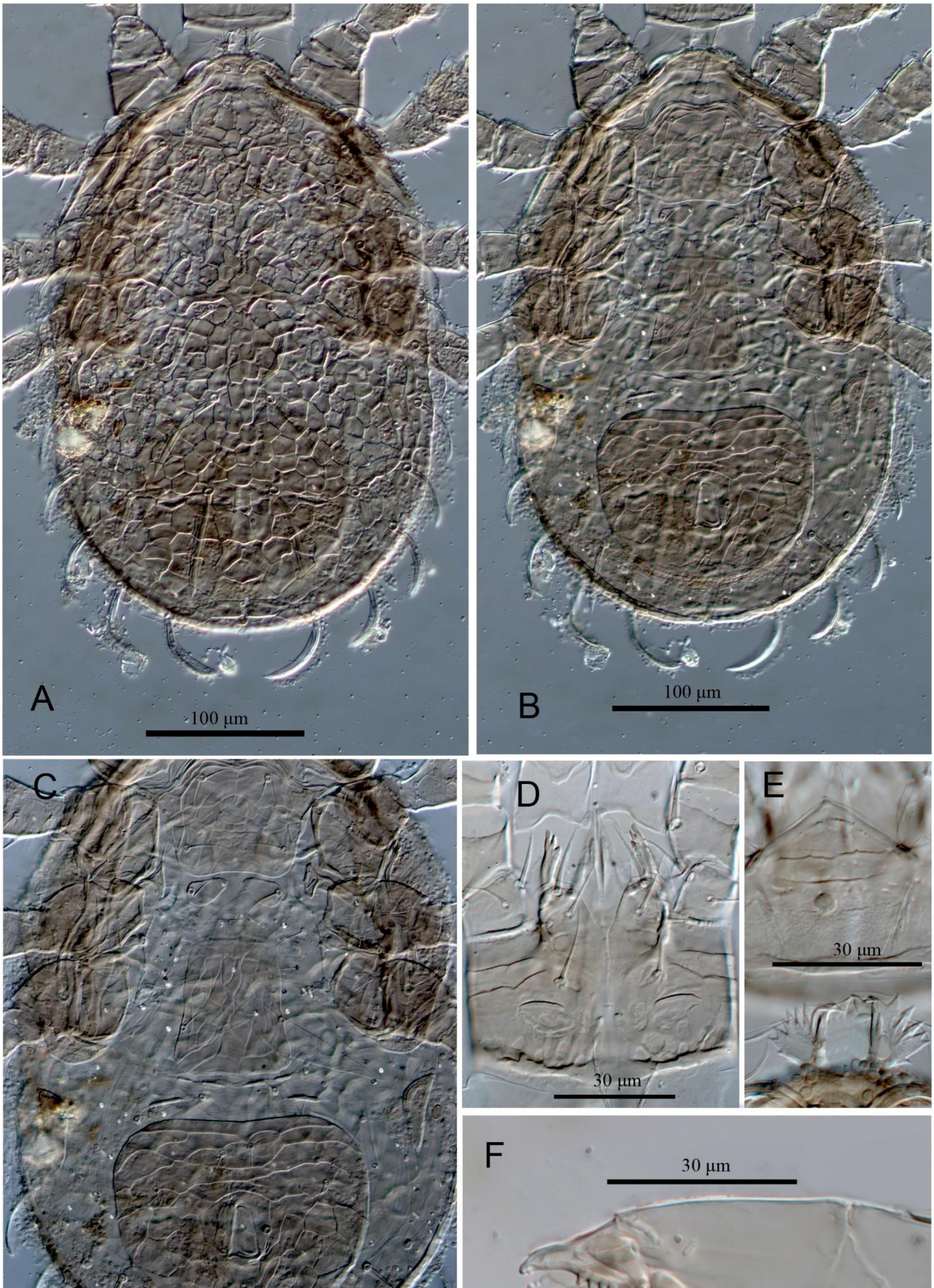

Figure 3. DIC micrographs of *Kleemannia nova* Nasr and Abou-Awad, 1986, adult female: **A.** General view dorsally; **B.** General view ventrally; **C.** Idiosoma in ventral view; **D.** Subcapitulum; **E.** Vertical setae *j1* enlarged and epistome; **F.** Chelicera.

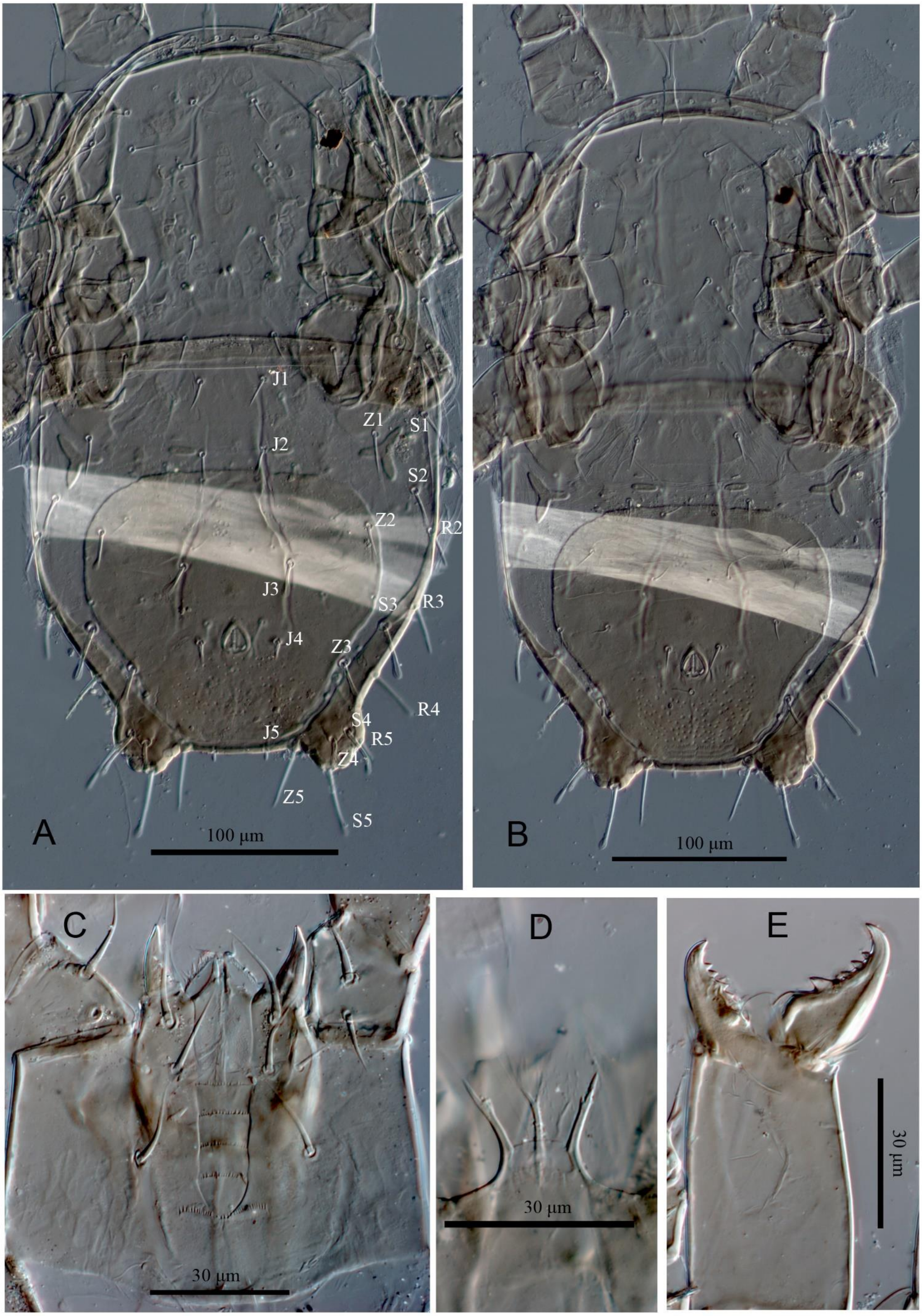

Figure 4. DIC micrographs of *Dendrolaelaspis lobatus* (Shcherbak and Chelebiev), adult female: **A.** Idiosoma in dorsal view; **B.** Idiosoma in ventral view; **C.** Subcapitulum; **D.** Epistome; **E.** Chelicera.

of these with single barb along their inner margins (Fig. 4D), fixed digit of chelicera with an offset distal tooth (gabelzhan), followed by five variously sized teeth, movable digit of chelicera with four well-spaced teeth in addition to apical hook (Fig. 4E).

Authors' contributions

Omid Joharchi: Species determination, writing – original draft. **İsmail Döker:** Species collector, writing – review & editing. **Kemal Yalçın:** Species collector. **Cengiz Kazak:** Species collector, writing – review & editing.

Statement of ethics approval

Not applicable.

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Conflict of interest

No potential conflict of interest was reported by the authors.

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RESEARCH ARTICLE

First record of the family Nosybeidae (Acari, Oribatida) from Turkey: *Lamellocepheus personatus*

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ASBTRACT: In this study, on the basis of the specimens collected from Artvin province, Turkey, *Lamellocepheus personatus* (Berlese, 1910) belonging to the family Nosybeidae was recorded as new for the Turkish fauna. Its morphological features were given with the scanning electron microscope images, and also distribution and ecology discussed.

Keywords: Soil mite, *Lamellocepheus*, new record, Artvin, Turkey.
Zoobank: https://zoobank.org/1FC216E8-613A-428B-A963-165B781112FF

INTRODUCTION

Oribatid mites are one of the most abundant and diverse species of soil mesofauna. They play an important role in the decomposition processes in the soil. Globally, 11.325 oribatid species and subspecies are known, of these 3911 occupying the Palaearctic region (Subias, 2004). The number of known species of Turkish oribatid mites is around 250 (Özkan et al., 1988, 1994; Erman et al., 2007; Baran et al., 2018).

The family Nosybeidae recorded for the first time from Turkey is represented by two genera and 12 species worldwide (Subias, 2004). Only one of them, *Lamellocepheus personatus*, is known from Europe in the Palaearctic region. *Lamellocepheus* belonging to the family Nosybeidae is distributed in the southern Palearctic and Ethiopian regions and includes two species: *Lamellocepheus genavensis* (Mahunka, 1993) (*Nosybea*) from Madagascar and *Lamellocepheus personatus* from Europe. In this study, it is aimed to contribute to the knowledge of the oribatid fauna of Turkey and the distribution of the determined taxon.

MATERIALS AND METHODS

Soil and litter samples containing oribatid mites were collected from Artvin Province in 1992 and extracted using a Berlese funnel apparatus. Mites were sorted from the samples under a stereomicroscope. After the mite samples were cleaned, they were first pre-treated for light microscopy and subsequently for scanning electron microscopy. Terminology followed Norton and Behan-Pelletier (2009).

RESULTS

Family: Nosybeidae Mahunka, 1993

Genus: *Lamellocepheus* Balogh, 1961

Type species: *Tectocepheus personatus* Berlese, 1910

Lamellocepheus personatus (Berlese, 1910)

Description (Figures 1-4)

Length: 280-290 µm, width: 160-164 µm (n =2).

Prodorsum with coarsely granulated cerotegument. Rostrum incised in the middle. Rostral, lamellar and interlamellar setae short and smooth. Lamellae long, straight, originate in front of the bothridia and without translamella. Sensilli leaf-shaped, barbed, about 30 µm in length. Bothridium opening anteriorly.

Dorsosejugal suture slightly protruding in the middle. Ten pairs of short and smooth marginal notogastral setae present. Two pairs of them *c*2 and *la* arising on small tubercles. In the anterior middle region of the notogaster, a wide depression present. Notogastral cuticle covered by coarsely granulated cerotegument.

Ventral region with fine granulation. Pedotectum I large, pedotectum II small; tutorium a long and small blade without free tip. The epimeres IV with strong lateral and posterior enantiophysis. Epimeral setal formula: 3-1-3-2. On both sides of the genital plates with longitudinal ridges. Genital and anal plates are approximately the same length and width (35 µm) and the distance between them is 14 µm. Five pairs of genital, one pair of aggenital, two pairs of anal and two pairs of adanal setae present. Lyrifissures *iad* situated paraanally. All legs monodactylous.

DISCUSSION

Lamellocepheus personatus (Berlese, 1910) is distributed in Europe (Italy, Switzerland Austria Azerbaijan and Georgia) (Weigmann and Murvanidze, 2003; Subías 2004). *Lamellocepheus personatus* is found in warm southern subalpine biotopes in Austria, Switzerland and northern Italy and forest litter in warm-temperate climate in Georgia. In this study, it was found in soil and litter from mixed forest.

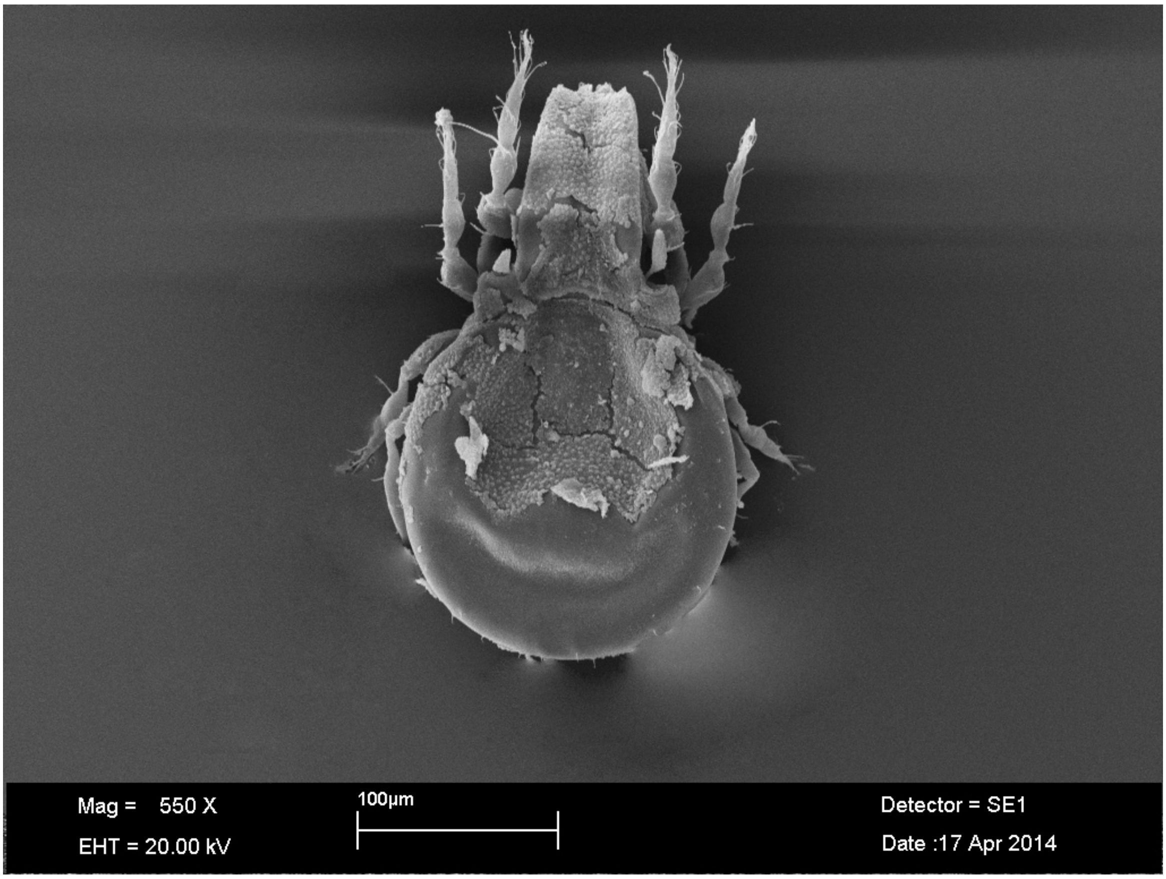

Figure 1. *Lamellocepheus personatus* (Berlese, 1910): Dorsal view.

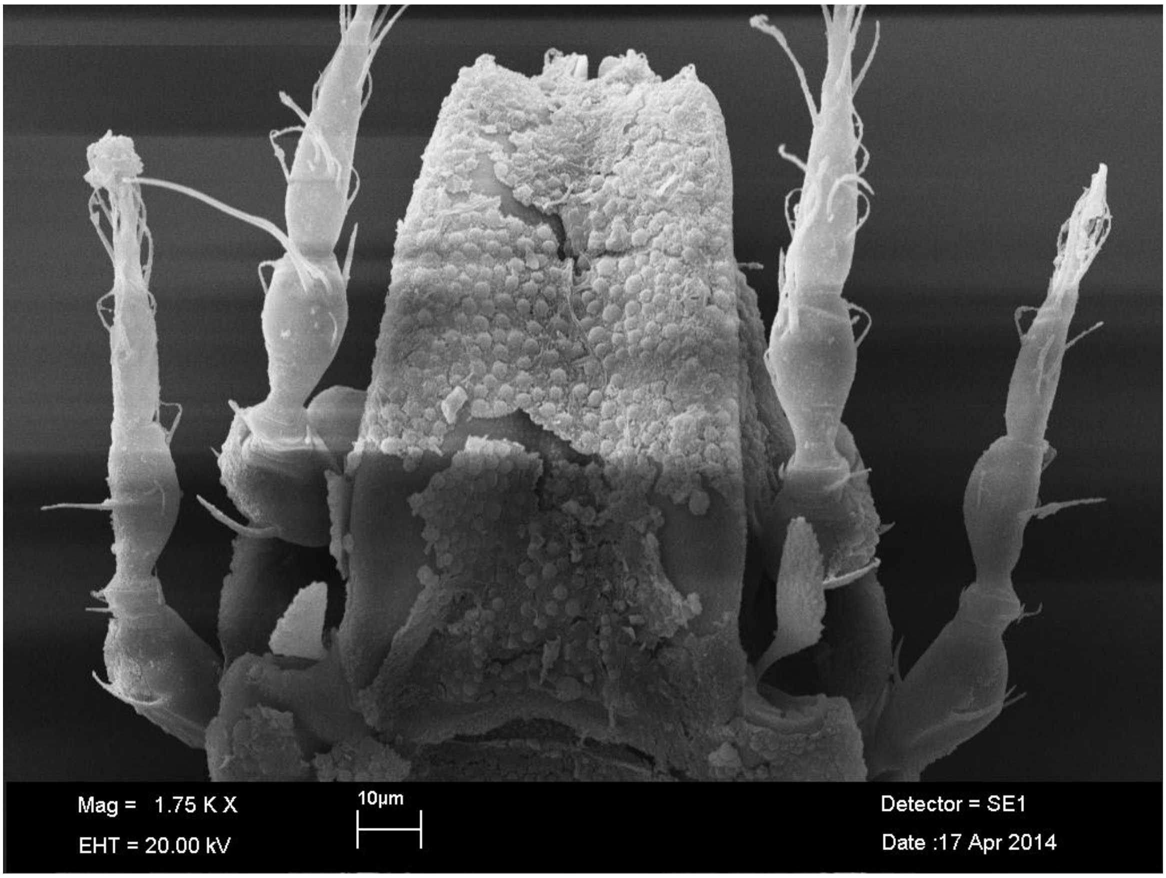

Figure 2. *Lamellocepheus personatus* (Berlese, 1910): Prodorsum.

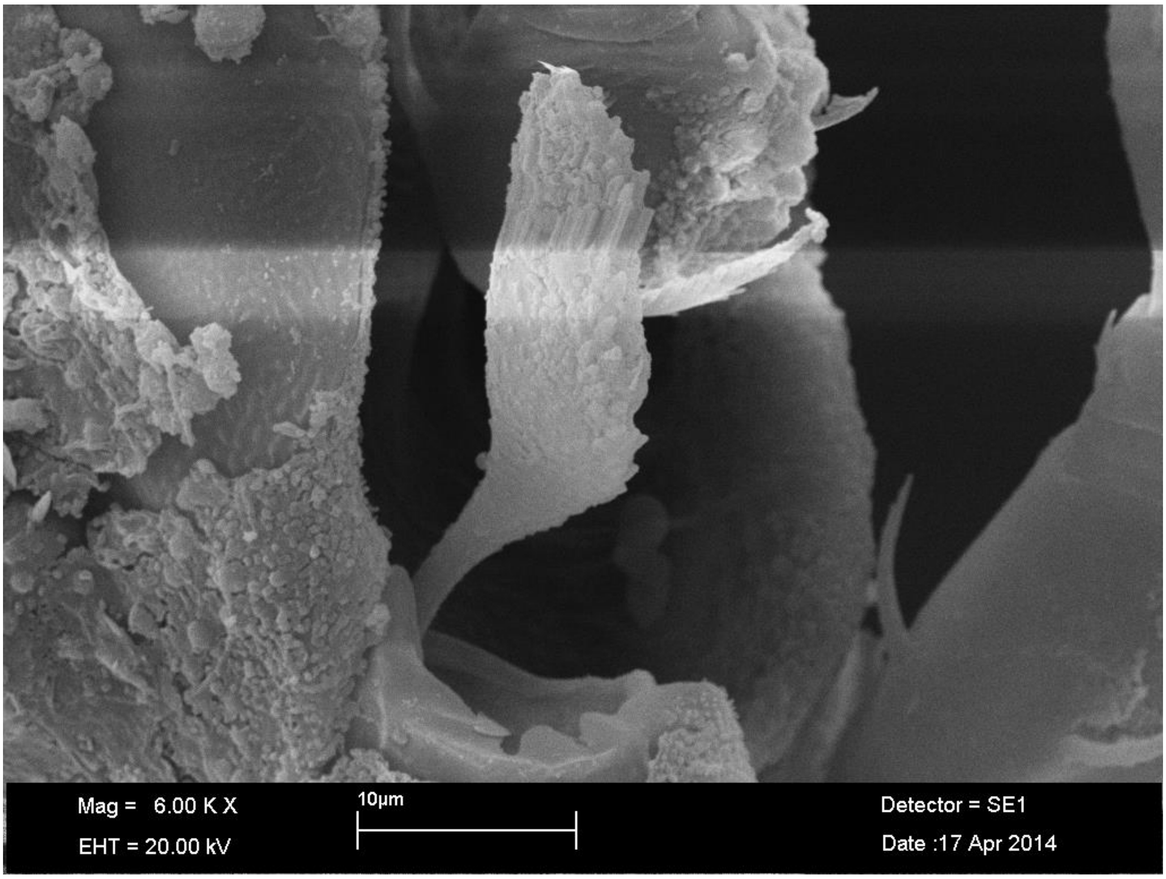

Figure 3. *Lamellocepheus personatus* (Berlese, 1910): Sensillus.

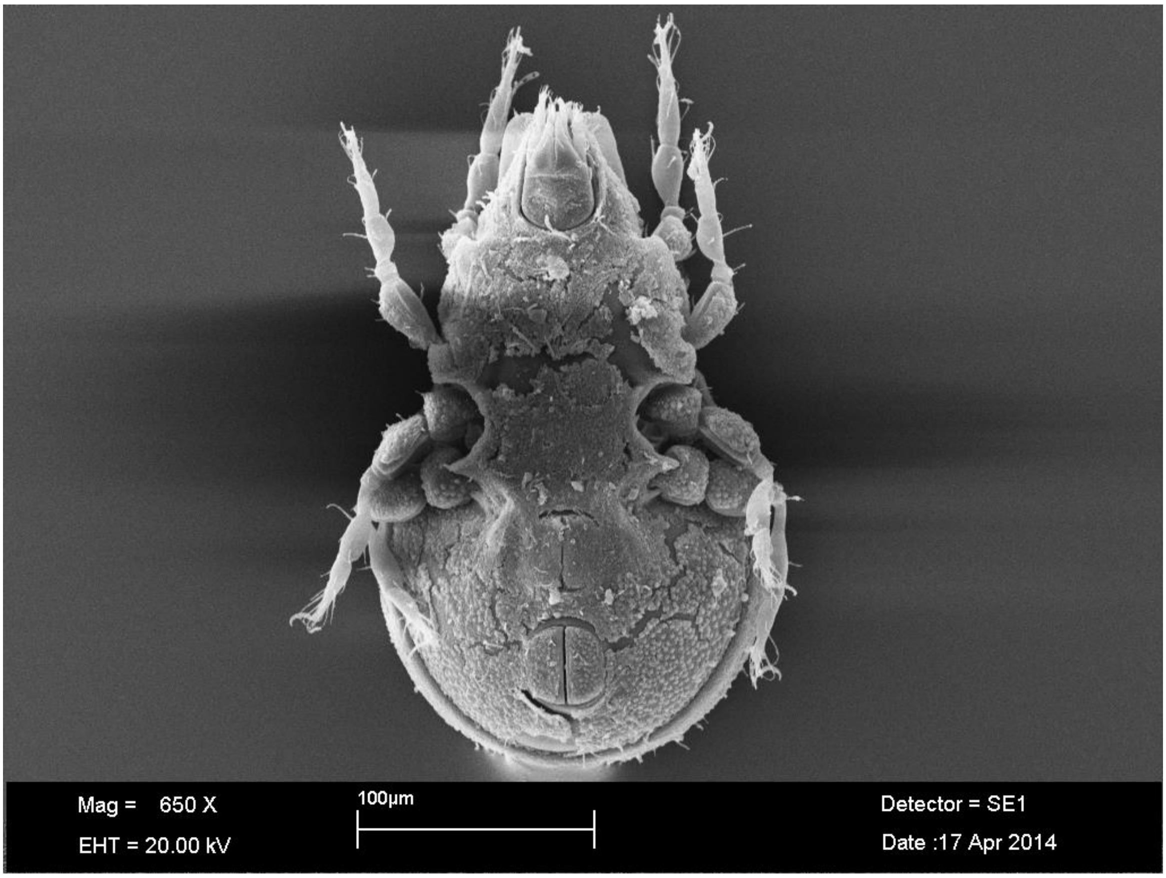

Figure 4. *Lamellocepheus personatus* (Berlese, 1910): Ventral view.

The species has been described by Berlese (1910) as *Tectocepheus personatus*. This species was previously placed under families Tectocepheidae and Charassobatidae by most authors (Balogh, 1961; Grandjean, 1964; Mahunka and Mahunka-Papp, 1995; Weigmann and Murvanidze (2003). Later, Mahunka and Mahunka-Papp (2009) transferred it into the family Nosybeidae. The taxonomic status and family placement of *Lamellocepheus* and *Lamellocepheus personatus* (Berlese, 1910) has been discussed and evaluated in detail byColloff (2019). We agree with Colloff (2019) and Subías (2004) regarding the taxonomic status and place of the species.

The body length of this species are given as 345-420 µm by Weigmann and Murvanidze (2003). The dimensions of the specimens found in Turkey (280-290 µm ×160-164 µm) are smaller than previous measurements. These dimensional differences can be considered within the variation limits. In terms of the other morphological features, the Turkish specimens are in conformity with the descriptions given by the various authors.

Authors' contributions

Ayşe Toluk: Analysis, conceptualization, data curation methodology, visualization, writing-original draft, writing-review and editing. **Nusret Ayyıldız**: Investigation, analysis, conceptualization, data curation methodology, visualization, writing-original draft, writing-review and editing.

Statement of ethics approval

Not applicable.

Conflict of interest

None.

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RESEARCH ARTICLE

First record of the genus *Leonardiella* (Acari: Trachyuropodidae) from Turkey

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ABSTRACT: Specimens of *Leonardiella riccardiana* (Leonardi, 1895) are found for the first time in Turkey. One female and one male specimens are collected from oak and willow habitats in Sansa Gorge, Eastern Anatolia Region. Description and global distribution of the species are given, also habitus of the specimens are presented.

Keywords: Mesostigmata, mite, new occurrence, *Leonardiella riccardiana*, Eastern Anatolia Region.
Zoobank: https://zoobank.org/390A54E4-076A-406C-B231-1228DBED5441

INTRODUCTION

Mites of the family Trachyuropodidae Berlese, 1917 belongs to the superfamily Uropodoidea, subcohort Uropodiae, cohort Uropodina, suborder Monogynaspida, order Mesostigmata and superorder Parasitiformes (Lindquist et al., 2009). Members of this family generally have large idiosoma which are strongly sclerotized, covered by furrows and ridges. As a distinctive feature, T-shaped setae can be found on idiosoma of the majority of Trachyuropodidae species (Kontschán, 2021).

The genus *Leonardiella* Berlese, 1904 is an easily distinguishable taxon within the family Trachyuropodidae by the following morphological characters: idiosoma similar to triangular or pentagonal shape, enlarged marginal shields in the anterior region of idiosoma, and the presence of a pair of deep depressions in the opisthogastric region of ventral idiosoma (Kontschán, 2015, 2021; Kazemi et al., 2016). This genus currently includes fourteen species (*L. athiasae, L. canestriniana, L. cistulata, L. constricta, L. cubana, L. harteni, L. koreana, L. machadoi, L. matsuurai, L. pappi, L. riccardiana, L. septentrionalis, L. similiathiasae* and *L. whitkombi*) around the world, mostly described from tropical realms (Kontschán, 2021).

During a faunistic and taxonomic study on the soil mites in Sansa Gorge, Eastern Anatolia Region of Turkey, several soil, litter, moss and lichen materials were examined. Among them, two materials included specimens of *L. riccardiana*. In the present work, based on these specimens, the description, illustration and microscopic micrographs of *L. riccardiana*, recorded for the first time from Turkey, have been provided. Also, this is the first occurrence of the genus *Leonardiella* in Turkey.

MATERIALS AND METHODS

Different materials which include mite specimens were extracted using a Berlese-Tullgren funnel with 25 Watt fluorescent bulb for one week. One female and one male specimens of *L. riccardiana* were sorted using a stereo microscope, then cleared in 60% lactic acid and transferred to glycerine medium. Identification of *Leonardiella* specimens was done by using a light microscope and the Olympus DP25 camera was used to transfer living images to the computer system. The DP2-BSW (ver.2.1) software was used for taking measurement of various idiosomal parts of the specimens. All measurements, including scale bars of the figures are given in micrometers (μm).

Female specimen was stored 70% ethanol and male specimen was mounted on slide in Hoyer's medium using the standard method (Walter and Krantz, 2009). Both specimens were deposited in the Acarology Laboratory of Pamukkale University (PAU).

RESULTS

Family **Trachyuropodidae** Berlese, 1917

Genus ***Leonardiella*** Berlese, 1904

Trachyuropoda (*Leonardiella*) Berlese, 1904: 367.

Type species: *Uropoda canestriniana* Berlese, 1891: 4, by original designation.

Diagnosis.

Idiosoma as triangular or pentagonal shaped. Dorsal shield have straight, undulate or ring-like grooves, strongly sclerotized and ends laterally at the level of coxae IV. One pair of deep depressions present in the opisthogastric region of ventral idiosoma. Claws present on the apical parts of first legs (Kontschán, 2021).

Leonardiella riccardiana (Leonardi, 1895)

Uropoda riccardiana Leonardi, 1895: 318.

Glyphopsis riccardiana Trouessart, 1902: 40.

Trachyuropoda riccardiana Berlese, 1904: 370-372; Hirschmann & Zirngiebl-Nicol, 1964: 22, 1965: 30, 1969: 131; Zirngiebl-Nicol, 1973: 34; Karg, 1989: 153; Mašán, 2001: 238; Kontschán, 2002a: 51, 2002b: 347, 2003: 55; Constantinescu, Ivan, Călugăr & Markó, 2011: 329; Arjomandi & Kazemi, 2014: 248.

Leonardiella riccardiana Kontschán, 2007: 50, 2021: 83; Kontschán & Ujvári, 2013: 45; Kazemi, Mohammad-Dustar-Sharaf & Saberi, 2016: 210.

Materials examined: One female: soil samples under willow tree (*Salix* sp.), 39°33'48.20'' N, 40°10'9.50'' E, 1594 m a.s.l., Sansa Gorge, Turkey, 25 July 2020. One male: soil samples under oak tree (*Quercus* sp.) and moss and lichen samples from stony land, 39°33'32.10'' N, 40°1'49.10'' E, 1363 m a.s.l., Sansa Gorge, Turkey, 11 May 2020.

Description.

Female (Figs 1-2, 5-10). Length 620, width 429 (n=1).

Shape oval and pentagonal, two pairs of rounded horns present at anterior margin of idiosoma, one pair of incisions located below coxae IV, posterior margin of idiosoma rounded, colour brown.

Dorsal idiosoma (Figs 1, 5). Along whole inner line of the idiosoma, marginal shield is completely separated from dorsal shield by a distinct structural line (Fig. 1). Dorsal shield with one elongated and well sclerotised line. Dorsal setae T-shaped (anchor shaped), mostly placed around middle and posterior parts of idiosoma. The posterior part of the idiosoma is significantly narrowed with deep lateral and marginal incisions are located below level of coxae IV. The inner part of the idiosoma has V-shaped supported marginal furrows. The dorsal shield of idiosoma covered by oval pits in various sizes. Marginal shield large, without any setation or sculptural pattern, and the outer edge of marginal shield is wavy with several small cavities (Fig. 5).

Ventral idiosoma (Figs 2, 6-7). Sternal shield smooth (Fig. 2). Three pairs of T-shaped sternal setae are situated around genital opening. Genital shield has shallowed pits and is almost oval with a relatively thin front. One pair of deep lateral and marginal incisions are located below level of coxae IV. Posterior part of ventral shield covered with oval pits, remaining parts smooth. Anal opening small (Fig. 6). Peritreme with two loops and not clearly visible. Base of tritosternum narrow, tritosternal laciniae subdivided into four branches, two central branches apically pilose and two lateral branches marginally pilose (Fig. 7).

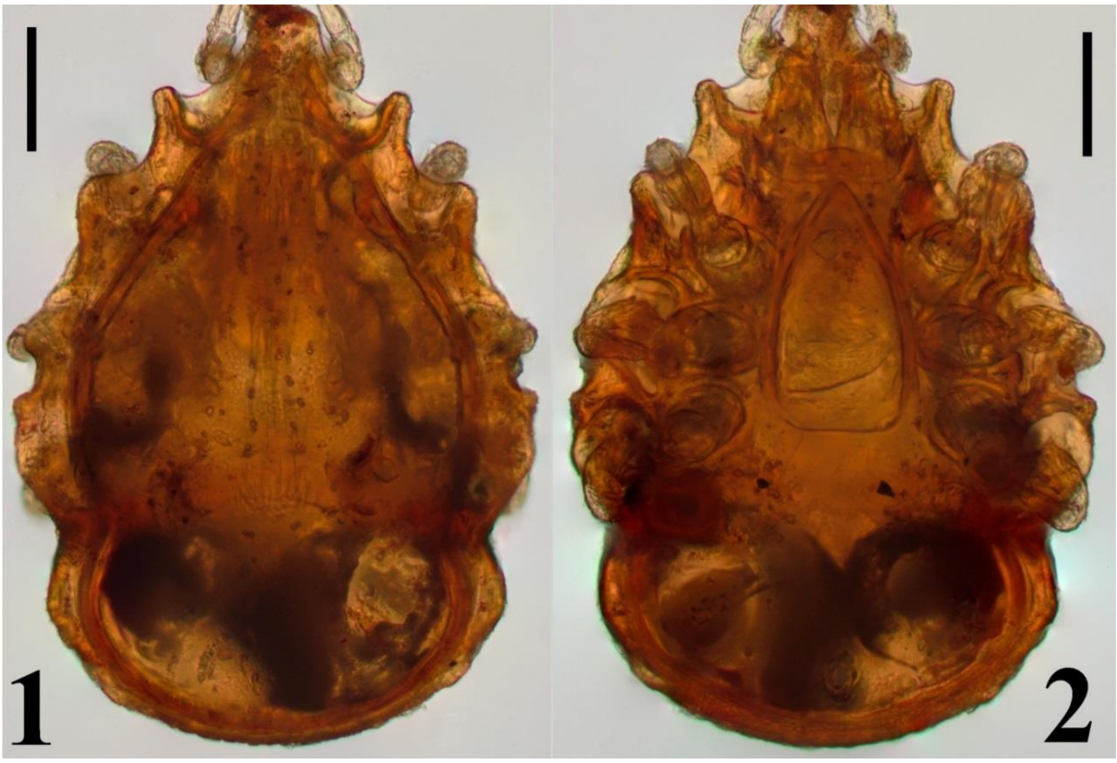
Gnathosoma (Figs 8-10). Corniculi short and horn-like shaped. Internal malae subdivided into several smooth branches. Hypostomal setae about in equal lenghts, *h1* smooth and located the anterior margin of gnathosoma, setae *h2*-*h4* marginally serrate (Fig. 8). Epistome triangular shaped and pilose (Fig. 9). Movable digit of chelicera shorter than fixed digit (Fig. 10).

Male (Figures 3-4, 11). Length 686, width 470 (n=1).

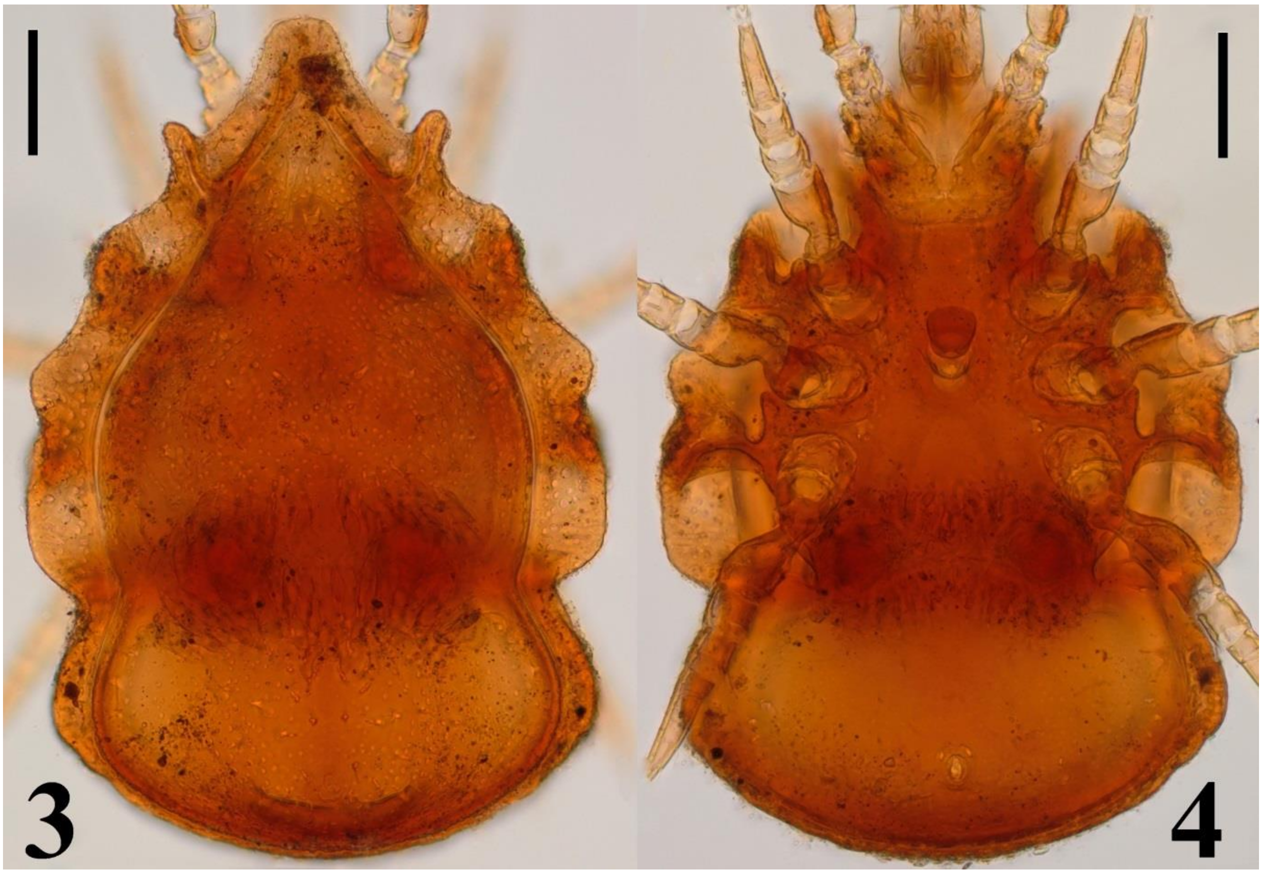
Marginal shield wide, with many oval pits unlike female specimen. Ornamentation and chaetotaxy of dorsal shield (Figs. 3-4) as in female specimen. Sternal shield covered by oval pits are mostly placed around anterior and lateral parts of genital opening. Genital shield oval and located between coxae II (Fig. 11).

Nymphs and larvae. Not found.

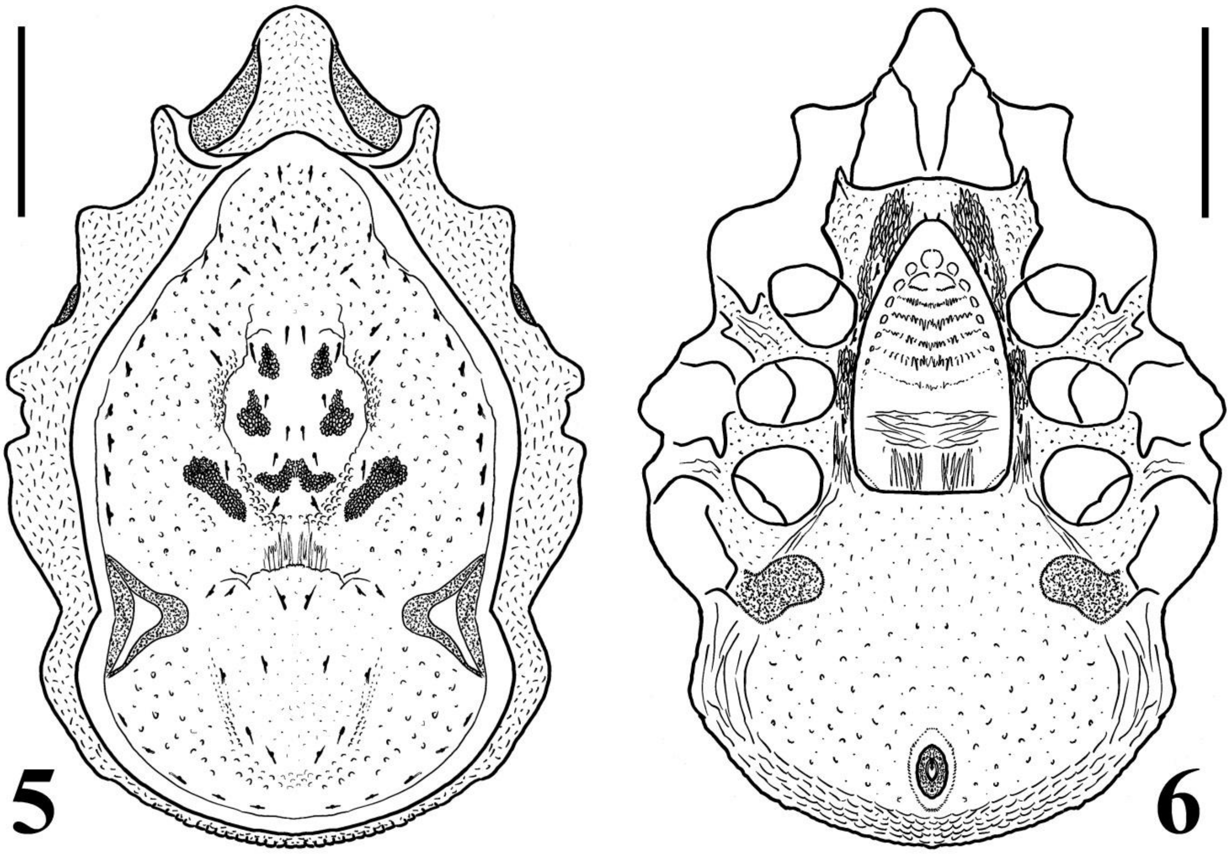
Distribution: Austria, Czechia, Hungary, Iran, Italia, Romania, Slovakia (Kontschán, 2021), Turkey (present study).



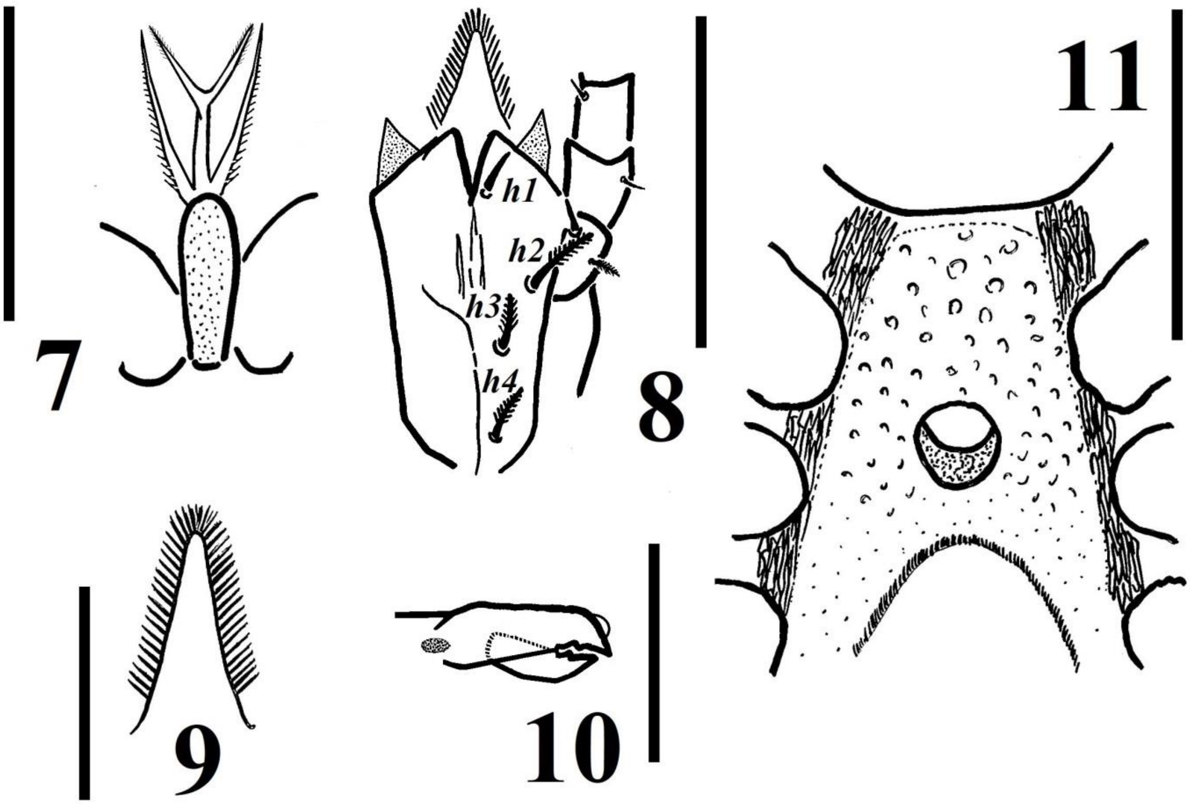
Figures 1-2. Habitus of *Leonardiella riccardiana* (female). **1.** Dorsum of idiosoma, **2.** Venter of idiosoma. Scale bars 100



Figures 3-4. Habitus of *Leonardiella riccardiana* (male). **3.** Dorsum of idiosoma, **4.** Venter of idiosoma. Scale bars 100.



Figures 5-6. *Leonardiella riccardiana* (female). **5.** Dorsal view, **6.** Ventral view. Scale bars 100.



Figures 7-11. *Leonardiella riccardiana*. **7.** Tritosternum of female, **8.** Ventral view of gnathosoma of female, **9.** Epistome of female, **10.** Chelicerae of female, **11.** Intercoxal region of male. Scale bars: 25 for 7; 50 for 9-10, 100 for 8, 11.

DISCUSSION

L. riccardiana was previously considered in the genus *Trachyuropoda* by many different authors. However, this species is currently evaluated in the genus *Leonardiella* (Kontschán, 2015).

Many characters of Turkish *L. riccardiana* specimens match those of European specimens. On the other hand, some characters (e.g. the ring-like strongly sclerotized furrow on dorsal shield) are not same as in a case *L. riccardiana* collected in Europe. However, the fact that the examined specimens were limited to only one female and one male does not enable a more detailed examination. Therefore, *Leonardiella* specimens reported from Turkey were evaluated as *L. riccardiana* in this study. In the future, a healthier decision can be reached as a result of more detailed sampling from the same localities where the specimens in this study are gathered. Even, Turkish *Leonardiella* specimens can be considered as a new species or subspecies after new data are obtained.

Comparison of idiosomal sizes of *L. riccardiana*, among the Turkish specimens and literature records as in follow (first and second numbers are the length and width of idiosoma, respectively): Hirschmann and Zirngiebl-Nicol (1969) reported 715 × 455 (female), 680 × 420 (male) and 655 × 415 (deutonymph) for Austrian and Italian specimens. Mašán (2001) reported 715 (female), 680 (male) and 655 (deutonymph) lengths for Slovakian specimens. Kontschán (2002) reported 715 (female) and 680 (male) lengths for Hungarian specimens. Kontschán (2007) reported 680-720 × 420-450 ranges to the female specimens from Hungary. According to these data, Turkish specimens are slightly smaller than European specimens in terms of idiosomal size. In addition, contrary to the literature data, it was understood that male specimen was longer than female specimen in this study.

In the light of literature records, specimens of *L. riccardiana* myrmecophile (associated with ants) mites. So far, specimens have been found in various ant nests and the presence records of *L. riccardiana* were given from the following Formicidae nests: *Formica* sp., *Lasius* sp., *Myrmica* sp., *Solenopsis* sp., *Tapinoma* sp., *Tetramorium* sp. (Štorkán, 1940; Bernard, 1968) and *Camponotus* sp. (Mašán, 2001). Also, "stenotopic" and "accidental occurrence" words are used for this species in the grassland areas of the Palaeartic European and Mediterranean countries (Constantinescu et al., 2011).

Considering the distribution records of this species, middle and southern parts of Central Europe are remarkable. However, the fact that the species was reported from Iran in 2016 and from Turkey in this study suggests that the distribution area of *L. riccardiana* may be wider than known. When current distribution records are examined, it is likely that this species will be reported from Armenia, Azerbaijan, Croatia, France, Georgia, Germany, Moldova, Poland, Russia, Serbia, Slovenia, Switzerland and Ukraine in the near future.

Statement of ethics approval

Not applicable.

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Conflict of interest

No potential conflict of interest was reported by the author.

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RESEARCH ARTICLE

Mites of the family Zerconidae (Acari: Mesostigmata) from Southwestern Turkey, with description of three new species

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ASBTRACT: The diversity of zerconid mites was examined in the Marmaris National Park, which is located in Muğla province at southwestern Turkey, for a period of twelve months between May 2020 and April 2021. Ten Zerconidae species were found in the study area, three of which belonging to the genus *Prozercon* and remaining seven species belonging to the genus *Zercon*. Among them, three new species of the genus *Zercon*, *Z. dogani* **sp. nov.**, *Z. marmarisensis* **sp. nov.** and *Z. muglaensis* **sp. nov.** were described and illustrated. Also, altitute and habitat preferences of all zerconid mites collected from the study area were presented and a key to the species was given.

Keywords: Zerconids, altitude, habitat, preference, key, Marmaris National Park, Muğla Province.
Zoobank: https://zoobank.org/754FC691-F0A9-411F-970B-6E3A157549BE

INTRODUCTION

Mites of the family Zerconidae, briefly zerconids, occur only in the Holarctic region and colonize at different soil substrates. They are soil-inhabiting mites in the order Mesostigmata. In the light of literature records, Turkey is one of the well studied countries in terms of Zerconidae systematic and 131 species of zerconids have been recorded from this country so far (Bulut et al., 2021). Systematical and ecological studies are still ongoing on zerconids both in Turkey and the other zoogeographic areas in the Holarctic region, and some records were given by several acarologists in the recent years (Karaca, 2021; Kaczmarek et al., 2020, 2021; Marchenko, 2021, 2022; Moghimi et al., 2021; Urhan et al., 2021).

National parks are special areas for various scientific investigations, especially for botanist and zoologist, contain a wide variety of floral and faunal elements. Turkey is a rich country in terms of number of national parks with 44 national parks (Keçeci et al., 2021), including the Marmaris National Park which located in Köyceğiz and Marmaris counties of Muğla Province (southwestern Turkey). In the present study, Marmaris National Park (Muğla Province, southwestern Turkey) were selected for the reveal of species diversity of Zerconidae mites, and also altitudinal/habitat preferences of the specimens. According to literature records, up to now, no studies about zerconids have been performed in this area. So, field studies were conducted for 12 months in the Marmaris National Park, and different materials collected from this area, were examined. A species list for zerconid mites found in the study area were prepared, previous records of the species were noted, altitudinal/habitat preferences of the specimens were investigated, a key to all Zerconidae species were presented, and three new species of the genus *Zercon* were described.

MATERIALS AND METHODS

Soil, litter and moss samples, which include Zerconidae specimens, were collected from different habitats (especially from forestland areas) in the Marmaris National Park, Köyceğiz and Marmaris counties of Muğla Province, between May 2020 and April 2021. Sampling studies was carried out after obtaining legal permissions from the "Republic of Turkey Ministry of Forestry and Water Affairs, General Directorate of Nature Conservation and National Parks (72784983-488.04-51504)". Totally 591 samplings from 156 different sites were made in the study area.

Collecting, carrying, sorting, measuring and drawing processes as in Bulut et al. (2021). The following terminologies were used in identification processes for the specimens: Lindquist and Evans (1965), Johnston and Moraza (1991), Lindquist and Moraza (1998). A light microscope (Olympus CX41) was used for identification process of zerconid mites. Due to the light microscope used, it was not possible to discern pores, poroids, lyrifissures or pore-like structures as in a differential interference contrast microscope. Therefore, not all of these structures can be shown on the related figures.

The holotype and paratypes of the new species, as well as the other Zerconidae specimens were deposited in the Acarology Laboratory of the Department of Biology, Faculty of Science and Arts, Pamukkale University, Denizli, Turkey.

All measurements were given as micrometers (µm). Abbreviations of DN and PN were used for deutonymph and protonymph specimens, respectively.

RESULTS

After examinations of collected Zerconidae specimens from the research area, three *Prozercon* and seven *Zercon* species were identified. All the species were listed below, and some information about each species, e.g. numbers of examined specimens, short descriptions for the known species, Turkish and the world distributions of the species, altitude and habitat preferences of the specimens were given in alphabetical order herein. Also, a key for the Zerconidae mites of the Marmaris National Park was presented. With the new species, the number of zerconid mites known from Turkey has increased to 134.

Family **Zerconidae** Canestrini, 1891

Genus ***Prozercon*** Sellnick, 1943

Type species: ***Zercon fimbriatus*** C. L. Koch, 1839

Prozercon bulgariensis Ujvári, 2013

This species was the second most abundant zerconid species in terms of number of individuals in the study area.

Materials examined: 92 females, 13 males, eight DN and one PN: soil, litter and moss samples under tree heather (*Erica arborea*) and Turkish pine (*Pinus brutia*), 36°47.459' N, 28°11.515' E, 140 m a.s.l., vicinity of İçmeler neighborhood, 17 May 2020. 14 females, three males and one DN: soil and litter samples under various plants (see Table 8), 36°47.069' N, 28°12.624' E, 156 m a.s.l., vicinity of İçmeler-Turunç road, 17 May 2020. 19 females, five males, 4 DN and one PN: soil, litter and moss samples under various plants (see Table 8), 36°45.641' N, 28°12.671' E, 533 m a.s.l., vicinity of Osmaniye neighborhood, 24 October 2020. 20 females: soil, litter and moss samples under various plants (see Table 8), 36°51.543' N, 28°16.663' E, 32 m a.s.l., vicinity of Sarıana shrine, 24 October 2020. 98 females: soil, litter and moss samples under various plants (see Table 8), 36°48.933' N, 28°17.661' E, 84 m a.s.l., vicinity of Nimara cave (Cennet island), 24 October 2020. 45 females and eight males: soil, litter and moss samples under various plants (see Table 8), 36°49.931' N, 28°18.910' E, 13 m a.s.l., vicinity of Aksaz neighborhood, 12 January 2021. 46 females, three males, nine DN and one PN: soil, litter and moss samples under various plants (see Table 8), 36°53.622' N, 28°17.776' E, 510 m a.s.l., vicinity of Aksaz military zone, 12 January 2021. 73 females, 13 males and one DN: soil, litter and moss samples under various plants (see Table 8), 36°51.074' N, 28°13.102' E, 240 m a.s.l., vicinity of Marmaris-Datça road, 13 March 2021. 202 females, 24 males and two DN: soil, litter and moss samples under various plants (see Table 8), 36°45.366' N, 28°13.532' E, 529 m a.s.l., vicinity of Bozburun-Osmaniye road, 13 March 2021. 152 females and 17 males: soil, litter and moss samples under various plants (see Table 8), 36°51.491' N, 28°32.512' E, 258 m a.s.l., vicinity of Büyükkaraağaç road, 28 April 2021. 184 females, 40 males and 12 DN: soil, litter and moss samples under various plants (see Table 8), 36°51.583' N, 28°32.290' E, 291 m a.s.l., vicinity of Ekincik neighborhood, 28 April 2021.

Short desription: On podonotum, setae *j2–6*, *z2*, *z4–5*, *s1* and *s4* short, smooth and needle-like. Setae *j1*, *z6, s5* and marginal setae (*z3*, *s2–3*, *s6*, *r2* and *r4–5*) pilose or plumose. On opisthonotum, great majority of setae elongated and pilose or plumose, including marginal seta *S1*. Remaining marginal setae (*R1–6*) short, smooth and needle-like. Setae *S3–5* reaching to beyond of opisthonotum. Pores *gdS2* located between setae *Z1* and *Z2*, *gdZ3* located between setae *J4* and *Z3*, closer to *Z3*. Dorsal cavities distinct and weakly developed. Anterior margin of ventrianal shield with one pair of setae (*JV1*), glands *gv2* absent. Posterolateral tips of peritrematal shield reach to level of setae *R1–2* (Ujvári, 2013; Urhan and Karaca, 2020).

Turkish distribution: Muğla (Urhan and Karaca, 2020).

Known distribution: Bulgaria (Ujvári, 2013), Turkey (Urhan and Karaca, 2020).

Prozercon tragardhi (Halbert, 1923)

Materials examined: One female and two males: moss samples, 36°48.940' N, 28°11.511' E, 43 m a.s.l., vicinity of İçmeler neighborhood, 17 May 2020. Seven females and two males: soil and litter samples under common myrtle (*Myrtus communis*), 36°47.459' N, 28°11.515' E, 140 m a.s.l., vicinity of İçmeler neighborhood, 17 May 2020. Eight females and two males: soil and litter samples under Turkish pine (*Pinus brutia*) and Aleppo oak (*Quercus infectoria*), 36°51.171' N, 28°12.625' E, 130 m a.s.l., vicinity of Yeşilbelde neighborhood, 17 May 2020. Three females and one PN: soil and litter samples under pink rock-rose (*Cistus creticus*), 36°51.014' N, 28°12.552' E, 124 m a.s.l., vicinity of Yeşilbelde neighborhood, 17 May 2020. 25 females and two males: soil, litter and moss samples under various plants (see Table 8), 36°45.366' N, 28°13.532' E, 529 m a.s.l., vicinity of Bozburun-Osmaniye road, 13 March 2021.

Short desription: On podonotum, seta *j5* short, smooth and needle-like, remaining setae pilose or plumose. On opisthonotum, great majority of setae elongated and pilose or plumose, excluding marginal setae. All marginal setae (*S1* and *R1–6*) short, smooth and needle-like. Setae *S3–5* reaching to beyond of opisthonotum. Pores *gdS2* located between setae *Z2* and *S2*, *gdZ3* located between setae *Z3* and *S4*, closer to *Z3*. Dorsal cavities distinct and weakly developed. Anterior margin of ventrianal shield with one pair of setae (*JV1*), glands *gv2* absent. Posterolateral tips of peritrematal shield reach to level of setae *R1–2* (Bilki, 2021).

Turkish distribution: Denizli, Erzurum, Giresun, İstanbul, Kırklareli, Kütahya, Tekirdağ (Bilki, 2021), Muğla (present study).

Known distribution: Austria, Czechia, England, Germany, Hungary, Iceland, Ireland, Lithuania, Poland, Romania, Russia, Slovakia, Slovenia, Sweden, Switzerland, Turkey, Ukraine (Bilki, 2021).

Prozercon yavuzi Urhan, 1998

Materials examined: 13 females: soil, litter and moss samples under Aleppo oak (*Quercus infectoria*) and lentisk (*Pistacia lentiscus*), 36°50.321' N, 28°21.535' E, 97 m a.s.l., vicinity of Aksaz neighborhood, 24 October 2020.

Short desription: On podonotum, seta *j5* short, smooth and needle-like, remaining setae pilose or plumose. On opisthonotum, great majority of setae elongated and pilose or plumose, including marginal setae *S1* and *R1*. Remaining marginal setae (*R2–6*) short, smooth and needle-like. Seta *S4* absent. Setae *S3* and *S5* reaching to beyond of opisthonotum. Pores *gdS2* located between setae *Z2* and *S2*, *gdZ3* located between setae *J3* and *Z3–4*, closer to *Z3–4*. Dorsal cavities distinct and weakly developed. Anterior margin of ventrianal shield with one pair of setae (*JV1*), glands *gv2* absent. Posterolateral tips of peritrematal shield reach to level of setae *R1* (Urhan, 1998; Ujvári, 2008, 2011; Bilki, 2021; Bulut et al., 2021).

Turkish distribution: Aydın, Balıkesir, Denizli, İstanbul, Muğla (Bulut et al., 2021).

Known distribution: Turkey (Urhan, 1998), Greece (Ujvári, 2008, 2011).

Genus ***Zercon*** C. L. Koch, 1836

Type species: ***Zercon triangularis*** C. L. Koch, 1836

Zercon colligans Berlese, 1920

This species was the third most abundant zerconid species in terms of number of individuals in the study area.

Materials examined: 102 females, 22 males, six DN and two PN: soil, litter and moss samples under various plants (see Table 8), 36°47.459' N, 28°11.515' E, 140 m a.s.l., vicinity of Marmaris-İçmeler road, 17 May 2020. 24 females, 12 males, one DN and one PN: soil, litter and moss samples under various plants (see Table 8), 36°54.151' N, 28°16.822' E, 355 m a.s.l., Marmaris-Muğla road junction, 12 January 2021. 21 females, four males and one DN: soil and litter samples under Turkish pine (*Pinus brutia*), 36°44.883' N, 28°15.533' E, 108 m a.s.l., vicinity of Kumlubük road, 13 March 2021. 43 females, 15 males and three DN: soil, litter and moss samples under various plants (see Table 8), 36°51.633' N, 28°33.175' E, 369 m a.s.l., vicinity of Ekincik-Sultaniye road, 28 April 2021. 112 females, 35 males, 11 DN and two PN: soil, litter and moss samples under various plants (see Table 8), 36°52.286' N, 28°29.421' E, 27 m a.s.l., vicinity of Büyükkaraağaç road, 28 April 2021.

Short desription: On podonotum, all setae short, smooth and needle-like, excluding seta *j1* and marginal setae. Seta *j1* and marginal setae (*s2–3*, *s6*, *r2* and *r4–5*) finely barbed. On opisthonotum, setae *J1–2*, *Z1–2* and *S2* short, smooth and needle-like. Setae *S3* and marginal setae (*S1* and *R1–6*) finely barbed. Remaining opisthonotal setae elongated, finely barbed with hyaline endings. Only setae *S5* reaching to beyond of opisthonotum. Pores *gdS2* located between setae *Z2* and *S3*, *gdZ3* located between setae *J4* and *Z4*. Dorsal cavities distinct and strongly developed. Anterior margin of ventrianal shield with one pair of setae (*JV1*), glands *gv2* present. Posterolateral tips of peritrematal shield reach to level of setae *S1* (Bilki, 2021; Bulut et al., 2021).

Turkish distribution: Afyonkarahisar, Artvin, Aydın, Balıkesir, Çanakkale, Denizli, Edirne, Erzurum, Giresun, İstanbul, Kırklareli, Kütahya, Tekirdağ, Uşak (Bulut et al., 2021), Muğla (present study).

Known distribution: Austria, France, Iran, Ireland, Italy, Russia, Sweden, Swiss, Turkey (Bulut et al., 2021).

Zercon inonuensis Urhan, 2007

Materials examined: One male: soil and litter samples under Turkish pine (*Pinus brutia*), 36°44.983' N, 28°13.956' E, 599 m a.s.l., vicinity of Bozburun-Osmaniye road, 13 March 2021.

Short desription: On podonotum, all setae short, smooth and needle-like, excluding seta *j1* and marginal seta *s6* which are finely barbed. Seta *s1* absent. On opisthonotum, setae *J1–5, Z1–2*, *S2–3* and marginal setae (*S1* and *R1–6*) short, smooth and needle-like. Setae *Z3–5* and *S4–5* elongated, finely barbed with hyaline endings. Setae *S4–5* reaching to beyond of opisthonotum. Pores *gdS2* located between setae *Z2* and *S3*, *gdZ3* located between setae *J4* and *Z4*, closer to *Z4*. Dorsal cavities distinct and strongly developed. Anterior margin of ventrianal shield with one pair of setae (*JV1*), glands *gv2* present. Posterolateral tips of peritrematal shield reach to level of setae *S1* (Urhan, 2007; Bilki, 2021).

Turkish distribution: Afyonkarahisar, Eskişehir, İstanbul, Kütahya (Bilki, 2021), Muğla (present study).

Known distribution: Turkey (Urhan, 2007).

Zercon quadricavum Urhan, 2001

This species was the most abundant zerconid species in terms of number of individuals in the study area.

Materials examined: 33 females, two males, eight DN and three PN: soil, litter and moss samples under various plants (see Table 8), 36°45.641' N, 28°12.671' E, 533 m a.s.l., vicinity of Turunç-Osmaniye road, 24 October 2020. 141 females, 42 males, 24 DN and two PN: soil, litter and moss samples under various plants (see Table 8), 36°54.092' N, 28°17.146' E, 407 m a.s.l., Marmaris-Muğla road junction, 12 January 2021. 223 females, 62 males, 20 DN and seven PN: soil, litter and moss samples under various plants (see Table 8), 36°50.737' N, 28°12.592' E, 161 m a.s.l., vicinity of Armutalan neighborhood, 13 March 2021. 231 females, 52 males, three DN and one PN: soil, litter and moss samples under various plants (see Table 8), 36°44.877' N, 28°14.700' E, 408 m a.s.l., vicinity of Kumlubük road, 13 March 2021. 307 females, 54 males, 18 DN and 11 PN: soil, litter and moss samples under various plants (see Table 8), 36°52.802' N, 28°19.250' E, 695 m a.s.l., vicinity of sawmill, 13 March 2021. 225 females, 76 males, 16 DN and three PN: soil, litter and moss samples under various plants (see Table 8), 36°54.331' N, 28°21.502' E, 664 m a.s.l., vicinity of Büyükkaraağaç and Aksaz neighborhoods, 28 April 2021.

Short desription: On podonotum, all setae short, smooth and needle-like, excluding seta *j1* and marginal setae *r5*, *s6* which are finely barbed. On opisthonotum, setae *J1–2*, *Z1–2*, *S2* and marginal setae *R2–6* short, smooth and needle-like. Setae *J3–5*, *Z3–5* and *S3–5* elongated, finely barbed with hyaline endings. Setae *J5* are in an almost horizontal position, and apical parts of theirs extend towards each other. Although seta *S4* reaching to margin of opisthonotum, seta *S5* reaching to beyond of opisthonotum. Pores *gdS2* located between setae *Z3* and *S3*, *gdZ3* located between setae *J5* and *Z4*. Dorsal cavities distinct, large and strongly developed. Anterior margin of ventrianal shield with two pairs of setae (*JV1* and *ZV1*), glands *gv2* present. Posterolateral tips of peritrematal shield reach to level of setae *S1* (Urhan, 2001; Bilki, 2021).

Turkish distribution: Denizli, Kütahya, Muğla, Uşak (Bilki, 2021).

Known distribution: Turkey (Urhan, 2001).

Zercon turcicus Urhan & Ayyıldız, 1994

Materials examined: Five females: soil and litter samples under kermes oak (*Q. coccifera*) and pink rock-rose (*Cistus creticus*), 36°51.773' N, 28°33.919' E, 348 m a.s.l., vicinity of Sultaniye and Ekincik neighorboods, 28 April 2021.

Short desription: On podonotum, all setae short, smooth and needle-like, excluding seta *j1* and marginal setae *s3*, *s6*, *r4–5* which are finely barbed. On opisthonotum, setae *J1–2* and *Z1–2* short, smooth and needle-like. Setae *S1–2* and marginal setae *R1–6* finely barbed. Setae *J3–5*, *Z3–5* and *S3–5* elongated, finely barbed with hyaline endings. Although seta *S4* reaching to margin of opisthonotum, seta *S5* reaching to beyond of opisthonotum. Pores *gdS2* located between setae *S3* and *S4*, *gdZ3* located between setae *J5* and *Z4*, closer to *Z4*. Dorsal cavities distinct and strongly developed. Anterior margin of ventrianal shield with two pairs of setae (*JV1* and *ZV1*), glands *gv2* present. Posterolateral tips of peritrematal shield reach to level of setae *S1* (Urhan and Ayyıldız, 1994; Karaca et al., 2017; Kavianpour et al., 2018; Bilki, 2021).

Turkish distribution: Afyonkarahisar, Aydın, Erzurum, Kırklareli (Bilki, 2021), Muğla (present study).

Known distribution: Turkey (Urhan and Ayyıldız, 1994), Iran (Karaca et al., 2017; Kavianpour et al., 2018).

Descriptions of new species

Zercon dogani sp. nov. (Figures 1-6)

Zoobank: https://zoobank.org/A1076749-388B-4640-9D5A-69858E921E38

Type material. Holotype (female), soil and litter samples under pink rock-rose (*Cistus creticus*) under Turkish pine (*Pinus brutia*), 36°47.459' N, 28°11.515' E, 140 m a.s.l., vicinity of Marmaris-İçmeler road (Marmaris County, Muğla Province), 17 May 2020. Paratypes: 41 females, 15 males, three DN and one PN, same data as holotype.

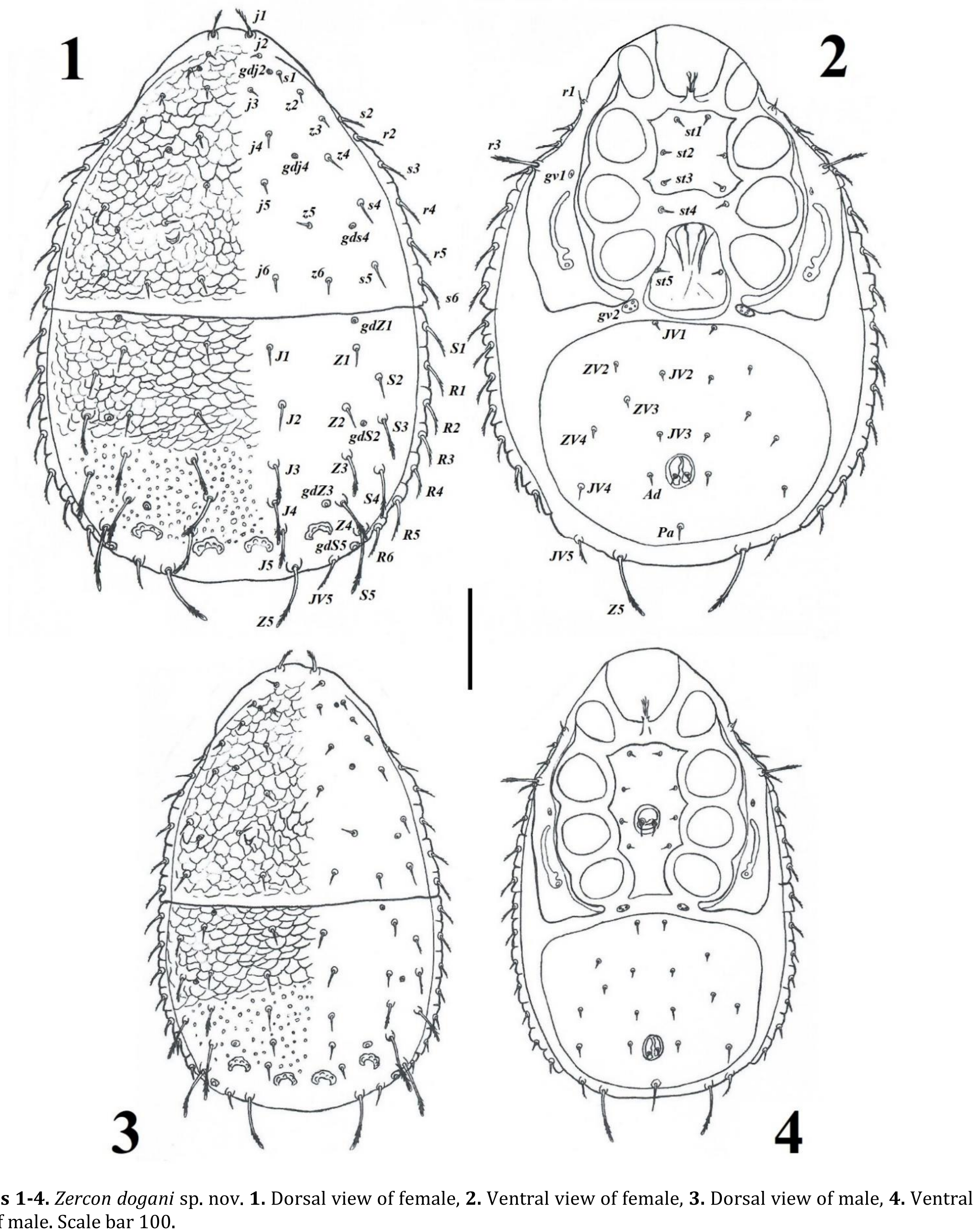
Diagnosis. Anterior margin of ventrianal shield with one pair of setae (*JV1*). All podonotal setae short, smooth and needle-like (except seta *j1* and marginal setae). Seta *j1* slightly elongated and finely barbed. Great majority of opisthonotal setae elongated, finely barbed with hyaline endings. Setae *Z5* and *S5* longer than other opisthonotal setae. Pores *gdS2* located between setae *Z2* and *S3*, *gdZ3* located between setae *J4* and *Z4*. Dorsal cavities distinct and strongly developed. Podonotum and anterior margin of opisthonotum covered with tile-like pattern, mid-area to posterior margin of opisthonotum covered by irregular punctate pattern.

Female (Figs 1-2) (n=10). Lengths (without gnathosoma) 395–419 and widths 269–284.

Dorsal side. (Fig. 1). Twenty pairs of setae present on podonotum: setae in *j* series with six pairs, *z* series with five pairs, *s* series with six pairs and *r* series with three pairs. Setae *j1*, *s2–3*, *s6*, *r2* and *r4–5* slightly elongated and finely barbed. Remaining podonotal setae short, equal in size, smooth and needle-like. Twenty one pairs of setae present on opisthonotum: setae in *J* series with five pairs, *Z* series with five pairs, *S* series with five pairs and *R* series with six pairs. Most of opisthonotal setae elongated, finely barbed with hyaline endings (except setae *J1–2*, *Z1–2*, *S2* and marginal setae). Setae *J1–2*, *Z1–2* and *S2* smooth and needle-like. Setae *J3–5*, *Z3–5* and *S2–5* elongated, finely barbed (two or three barbs apically) with hyaline endings. Setae *Z5* and *S5* longer than others, and reaching to beyond of opisthonotum. Setae *Z4* and *S4* reaching to margin of opisthonotum. Setae *J3–4* and *Z3* reaching the bases of the following seta. Seta *JV5* similar in length and shape to marginal *R* setae. All marginal setae (*S1* + *R1–6*) finely barbed without hyaline endings. The intervals between setae *Z5* and *Z5* 99–113, setae *Z5* and *JV5* 29–35, respectively. Average lengths of the opisthonotal setae and distances between setal bases within longitudinal *J*, *Z* and *S* rows are given in Table 1 for female, male, DN and PN specimens.

Pores. (Fig. 1). On podonotum, pores *gdj2* located on the line connecting setae *j2–s1*, closer to *s1*. Pores *gdj4* located on the line connecting setae *j4–z4*. Pores *gds4* located on the line connecting setae *z6–s4*, closer to *s4*. On opisthonotum, pores *gdZ1* located above the insertions of setae *Z1*. Pores *gdS2* located on the line connecting setae *Z2–S3*. Pores *gdZ3* located on the line connecting setae *J4–Z4*, closer to *Z4*. Pores *gdS5* located below to the insertions of setae *S5*.

Ventral side. (Fig. 2). Chaetotaxy and shape of the peritrematal shields normal for the genus *Zercon*. Posterolateral tips of peritrematal shield reaching the level of setae *S1*. Peritrematal shield with two pairs of setae (*r1* and *r3*), seta *r1* short, smooth and needle-like, seta *r3* elongated and finely barbed apically. Peritremes similar to reverse comma. Sternal shield with three pairs of setae (*st1–st3*), epigynal shield with one pair of setae (*st5*), and one seta (*st4*) located between sternal and epigynal shields; all of them (*st1–st5*) short, smooth and needle-like. Glands *gv2* present between posterior section of epigynal shield and anterior section of ventrianal shield. Ventrianal shield with nine pairs of setae (*JV1–JV5*, *ZV2–ZV4* and *Ad*) and one single postanal seta (*Pa*); all of them short, smooth and needle-like (except seta *JV5*). Seta *ZV1* absent. Anterior margin of ventrianal shield with one pair of setae (*JV1*).



Figures 1-4. *Zercon dogani* sp. nov. **1.** Dorsal view of female, **2.** Ventral view of female, **3.** Dorsal view of male, **4.** Ventral view of male. Scale bar 100.

Male (Figs 3-4) (n=10). Lengths (without gnathosoma) 352–387 and widths 235–255. Chaetotaxy of idiosoma, location of pores on idiosoma and ornamentation of dorsal shields similar to the females (except setae *s2*, *r2*, *J3–J5*, *S2*, *R4–6* and *JV5*). Setae *s2*, *r2*, *R4–6* and *JV5* are finely barbed without hyaline endings in female specimens, they are smooth and needle-like in male specimens. In addition, setae *J3–J5* are finely barbed with hyaline endings in female specimens, they are smooth and needle-like in male specimens. Lastly, seta *S2* is smooth and needle-like in female specimens, this is finely barbed without hyaline endings in male specimens. The intervals between setae *Z5* and *Z5* 84–93, setae *Z5* and *JV5* 14–19, respectively. Deutonymph (Fig. 5) (n=3). Lengths 342–374, widths 233–254. On podonotum, setae *j1*, *s3* and *s6* slightly elongated and finely barbed. Remaining podonotal setae short, smooth and needle-like.

Table 1. Average lengths of opisthonotal setae and the distances between their insertions in *J*, *Z*, and *S* rows of *Zercon dogani* sp. nov.

Setae	♀	♂	DN	PN	Setae	♀	♂	DN	PN	Setae	♀	♂	DN	PN
J1	23	16	16	7	***Z1***	22	13	15	10	***S1***	28	16	20	6
J1–J2	61	38	38	26	***Z1–Z2***	58	38	41	32	***S1–S2***	58	17	45	15
J2	25	16	15	8	***Z2***	24	14	17	12	***S2***	25	21	20	20
J2–J3	45	39	36	24	***Z2–Z3***	30	30	22	18	***S2–S3***	40	32	23	24
J3	36	12	9	7	***Z3***	43	29	29	30	***S3***	33	24	26	24
J3–J4	35	30	23	18	***Z3–Z4***	39	29	29	21	***S3–S4***	48	35	36	28
J4	36	10	8	6	***Z4***	37	46	49	57	***S4***	40	32	39	36
J4–J5	32	18	16	18	***Z4–Z5***	67	53	74	40	***S4–S5***	49	42	42	34
J5	42	12	9	7	***Z5***	52	47	51	55	***S5***	45	51	48	43

On opisthonotum, setae *J1–5*, *Z1–2* and *R2–6* short, smooth and needle-like. Setae *S1–2*, *R1* and *JV5* finely barbed without hyaline ending. Setae *Z3–5* and *S3–5* finely barbed with hyaline ending. Although seta *Z4* reaching to margin of opisthonotum, setae *Z5* and *S4–5* reaching to beyond of opisthonotum. Location of idiosomal pores as in adults. The intervals between setae Z5 and Z5 89–94, setae *Z5* and *JV5* 18–21, respectively.

Protonymph (Fig. 6) (n=1). Length 292, width 181. On podonotum, setae *j1* and *s3* slightly elongated and finely barbed. Remaining podonotal setae short, smooth and needle-like. On opisthonotum, setae *J1–5*, *Z1–2 R1* and *JV5* short, smooth and needle-like. Setae *S2–3* finely barbed without hyaline ending. Setae *Z3–5* and *S4–5* finely barbed with hyaline ending. Although seta *S3* reaching to margin of opisthonotum, setae *Z4–5* and *S4–5* reaching to beyond of opisthonotum. All idiosomal pores are invisible. The intervals between setae Z5 and Z5 70, setae *Z5* and *JV5* 15, respectively.

Etymology. The name of the new species is dedicated in honour of the acarologist Prof. Dr. Salih Doğan (Erzincan Binali Yıldırım University, Turkey) for his valuable contributions to the Turkish acarofauna.

Remarks. *Zercon dogani* sp. nov. is quite similar to *Z. colligans* Berlese, 1920, *Z. cretensis* Ujvári, 2008 and *Z. turcicus* Urhan & Ayyıldız, 1994. The morphological distinguishing characters of these four species were given in Table 2.

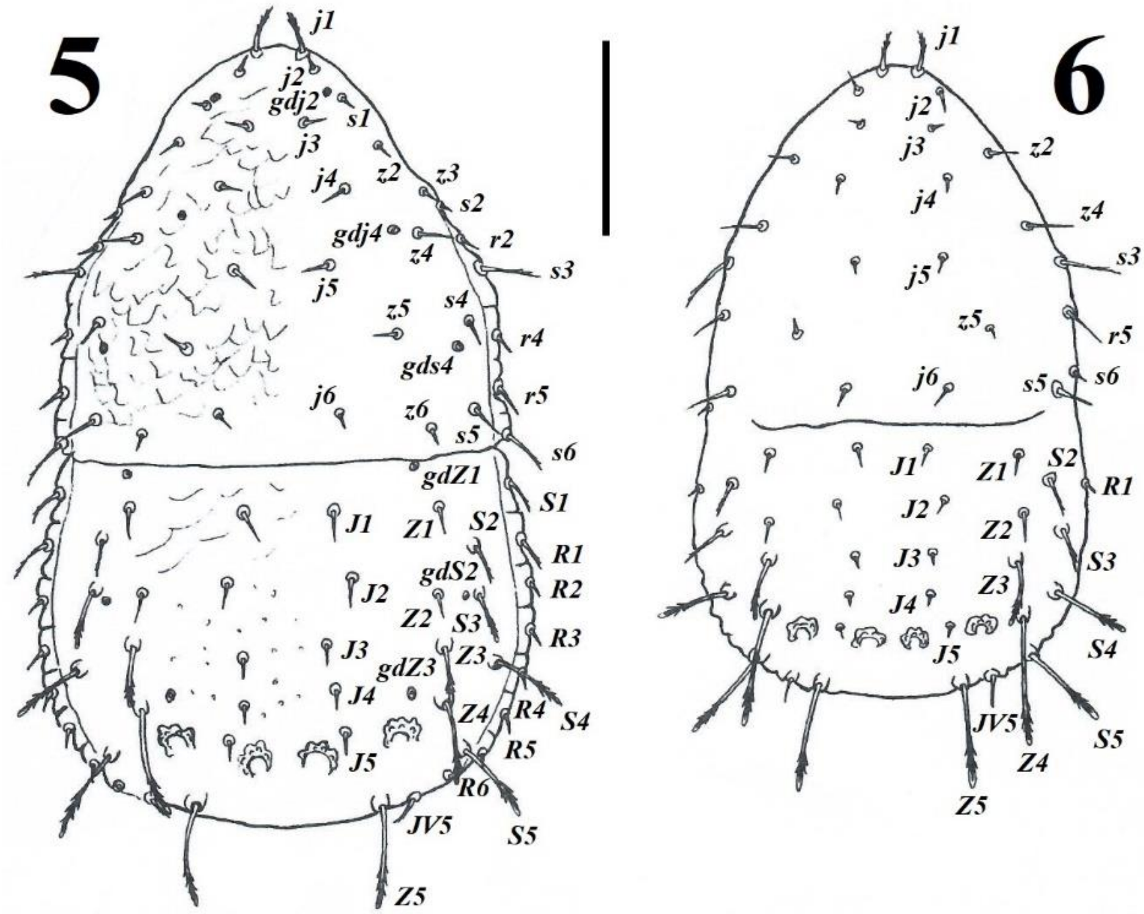
Zercon marmarisensis sp. nov. (Figures 7-10)

Zoobank: https://zoobank.org/FBA0E854-EA89-4BE0-AB5D-EC2339DA7C91

Type material. Holotype (female), soil and litter samples under Aleppo oak (*Quercus infectoria*), evergreen oak (*Q. ilex*) and pink rock-rose (*Cistus creticus*), 36°53.571' N, 28°18.312' E, 550 m a.s.l., vicinity of Beldibi neighborhood (Marmaris County, Muğla Province), 12 January 2021. Paratypes: Seven females and 15 males, same data as holotype. Six females: soil and litter samples under *Sarcopoterium spinosum* (thorny burnet), 36°47.459' N, 28°11.515' E, 140 m a.s.l., vicinity of Marmaris-İçmeler road, 17 May 2020. 20 females and one male: soil, litter and moss samples under Turkish pine (*Pinus brutia*), pink rock-rose (*Cistus creticus*) and kermes oak (*Q. coccifera*), 36°47.437' N, 28°12.885' E, 27 m a.s.l., vicinity of İçmeler neighborhood, 17 May 2020. 11 females: soil and litter samples under Turkish pine (*Pinus brutia*), carob (*Ceratonia siliqua*) and kermes oak (*Q. coccifera*), 36°48.933' N, 28°17.661' E, 84 m a.s.l., vicinity of Nimara cave (Cennet island), 24 October 2020. One female and two males: soil and litter samples under pink rock-rose (*Cistus creticus*) and oriental sweetgum (*Liquidambar orientalis*), 36°50.245' N, 28°20.292' E, 137 m a.s.l., vicinity of Aksaz military zone, 12 January 2021. One female and four males: soil and litter samples under evergreen oak (*Q. ilex*) and laurel (*Laurus nobilis*), 36°51.002' N, 28°17.208' E, 15 m a.s.l., vicinity of Aksaz military zone, 12 January 2021.

Diagnosis. Anterior margin of ventrianal shield with one pair of setae (*JV1*). All podonotal setae short, smooth and needle-like (except seta *j1* and marginal setae). Seta *j1* slightly elongated and finely barbed. Great majority of opisthonotal setae elongated, finely barbed with hyaline endings. Setae *Z5* and *S5* longer than other opisthonotal setae. Pores *gdS2* located between setae *Z2* and *S3*, *gdZ3* located between setae *J5* and *Z4*. Dorsal cavities distinct and strongly developed. Podonotum and anterior margin of opisthonotum covered with tile-like pattern, mid-area to posterior margin of opisthonotum covered by irregular punctate pattern.

Female (Figs 7-8) (n=10). Lengths (without gnathosoma) 453–486 and widths 338–378.



Figures 5-6. *Zercon dogani* sp. nov. **5.** Dorsal view of deutonymph, **6.** Dorsal view of protonymph. Scale bar 100.

Dorsal side. (Fig. 7). Twenty pairs of setae present on podonotum: setae in *j* series with six pairs, *z* series with five pairs, *s* series with six pairs and *r* series with three pairs. Setae *j1*, *s2–3*, *s6*, *r2* and *r4–5* slightly elongated and finely barbed. Remaining podonotal setae short, equal in size, smooth and needle-like. Twenty one pairs of setae present on opisthonotum: setae in *J* series with five pairs, *Z* series with five pairs, *S* series with five pairs and *R* series with six pairs. Most of opisthonotal setae elongated, finely barbed with hyaline endings (except setae *J1*, *Z1*, *S1–2* and marginal setae). Setae *J1* and *Z1* short, smooth and needle-like. Setae *S1–2* and *R1–6* finely barbed without hyaline endings. Setae *J2–5*, *Z2–5* and *S3–5* elongated, finely barbed (two or three barbs apically) with hyaline endings. Setae *Z5* and *S5* longer than others, and reaching to beyond of opisthonotum. Setae *Z4* and *S4* reaching to margin of opisthonotum. Setae *J3–4* and *Z3* reaching the bases of the following seta. Seta *JV5* similar in length and shape to marginal *R* setae. All marginal setae (*S1* + *R1–6*) finely barbed without hyaline endings. The intervals between setae *Z5* and *Z5* 103–114, setae *Z5* and *JV5* 29–36, respectively. Average lengths of the opisthonotal setae and distances between setal bases within longitudinal *J*, *Z* and *S* rows are given in Table 3 for female and male specimens.

Pores. (Fig. 7). On podonotum, pores *gdj2* located on the line connecting setae *j3–s1*, closer to *s1*. Pores *gdj4* located on the line connecting setae *j4–z4,* closer to *z4*. Pores *gds4* located on the line connecting setae *z6–s4*, closer to *s4*. On opisthonotum, pores *gdZ1* located above the insertions of setae *Z1*. Pores *gdS2* located on the line connecting setae *Z2–S3*. Pores *gdZ3* located on the line connecting setae *J4–Z4*, closer to *Z4*. Pores *gdS5* located between setae *S5* and *JV5*.

Ventral side. (Fig. 8). Posterolateral tips of peritrematal shield reaching the level of setae *S1–R1*. Postanal seta as the longest on the ventrianal shield. Remaining all ventral characters as in female specimens of ***Zercon dogani*** sp. nov.

Male (Figs 9-10) (n=10). Lengths (without gnathosoma) 355–373 and widths 233–251. Chaetotaxy of idiosoma, location of pores on idiosoma and ornamentation of dorsal shields similar to the females (except setae *s2*, *r2* and *R4–6*). Although all of these setae are finely barbed without hyaline endings in female specimens, they are smooth and needle-like in male specimens. The intervals between setae Z5 and Z5 86–94, setae *Z5* and *JV5* 18–23, respectively.

Immature stages. Not found.

Etymology. The specific epithet '*marmarisensis*' refers to the Marmaris County (Muğla Province) where the new species was collected.

Remarks. *Zercon marmarisensis* sp. nov. is quite similar to *Z. colligans* Berlese, 1920, *Z. denizliensis* Urhan, 2011 and *Z. marinae* Ivan & Călugăr, 2004. The morphological distinguishing characters of these four species were given in Table 4.

Table 2. Morphological distinctive characters among *Z. dogani* sp. nov., *Z. colligans*, *Z. cretensis* and *Z. turcicus*.

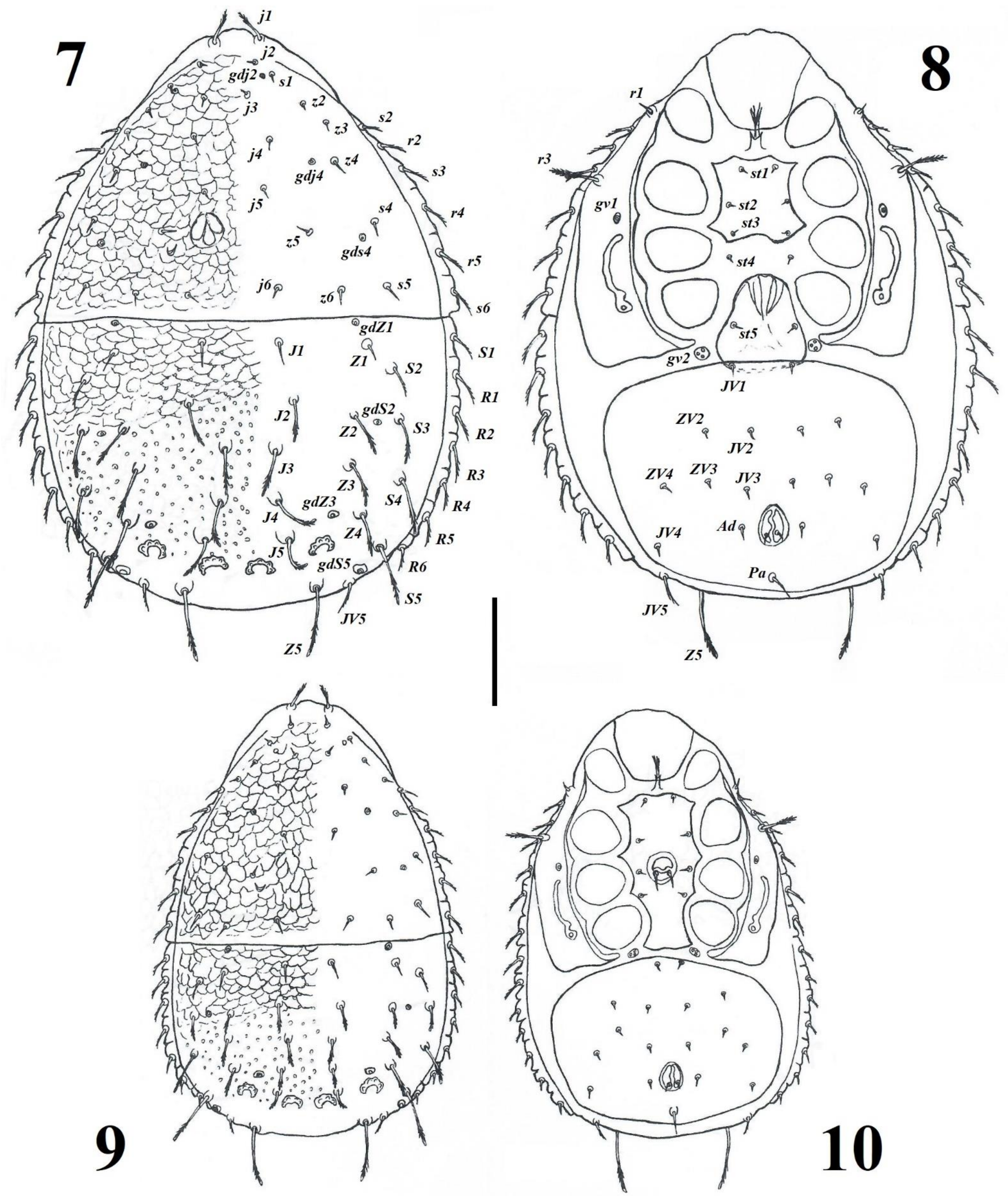
Characters	***Z. dogani*** sp. nov.	***Z. colligans*** Berlese, 1920	***Z. cretensis*** Ujvári, 2008	***Z. turcicus*** Urhan & Ayyıldız, 1994
Seta *j2*	short and smooth	short and smooth	short and smooth	finely barbed
Setae *J3–J5, Z3–Z5* and *S3–S5*	elongated, finely barbed with hyaline ending	short, finely barbed with hyaline ending	elongated, finely barbed, broadened apically	elongated, finely barbed with hyaline ending
Seta *S2*	short and smooth	short and smooth	elongated and smooth	short and finely barbed
Seta *S4*	reaching the margin of opisthonotum	not reaching the margin of opis-thonotum	reaching the margin of opisthonotum	reaching the margin of opisthonotum
Marginal setae on opisthonotum (*S1* and *R* setae)	finely barbed	*S1* and *R1–R2* finely barbed, *R3–R6* smooth	broadened apically	finely barbed
Anterior margin of ventrianal shield	with 2 setae	with 2 setae	with 2 setae	with 4 setae

Table 3. Average lengths of opisthonotal setae and the distances between their insertions in *J*, *Z*, and *S* rows of *Zercon marmarisensis* sp. nov.

Setae	♀	♂	**Setae**	♀	♂	**Setae**	♀	♂
J1	22	15	***Z1***	24	16	***S1***	31	24
J1–J2	55	33	***Z1–Z2***	57	36	***S1–S2***	71	42
J2	35	19	***Z2***	38	18	***S2***	28	19
J2–J3	43	30	***Z2–Z3***	37	23	***S2–S3***	41	28
J3	41	19	***Z3***	39	26	***S3***	40	21
J3–J4	41	24	***Z3–Z4***	39	25	***S3–S4***	52	31
J4	42	21	***Z4***	42	34	***S4***	43	34
J4–J5	35	18	***Z4–Z5***	84	62	***S4–S5***	56	36
J5	34	18	***Z5***	52	47	***S5***	48	49

Table 4. Morphological distinctive characters among *Z. marmarisensis* sp. nov., *Z. colligans*, *Z. denizliensis* and *Z. marinae*.

Characters	***Z. marmarisensis*** sp. nov.	***Z. colligans*** Berlese, 1920	***Z. denizliensis*** Urhan, 2011	***Z. marinae*** Ivan & Călugăr, 2004
Marginal setae on podonotum (*s2–s3*, *s6*, *r2* and *r4–r5*)	finely barbed	*s2–s3* and *r2* short, *r4–r5* and *s6* finely barbed	finely barbed	with hyaline ending
Setae *J2* and *Z2*	finely barbed with hy-aline ending	short and smooth	short and smooth	short and smooth
Seta *S2*	finely barbed	short and smooth	finely barbed	short and smooth
Seta *JV5*	finely barbed	finely barbed	finely barbed	with hyaline ending
Marginal setae on opisthonotum (*S1* and *R* setae)	finely barbed	*S1* and *R1–R3* finely barbed, *R4–R6* smooth	finely barbed	with hyaline ending
Anterior margin of ventrianal shield	with 2 setae	with 2 setae	with 4 setae	with 2 setae



Figures 7-10. *Zercon marmarisensis* sp. nov. **7.** Dorsal view of female, **8.** Ventral view of female, **9.** Dorsal view of male, **10.** Ventral view of male. Scale bar 100.

Zercon muglaensis sp. nov. (Figures 11-14)

Zoobank: https://zoobank.org/3B901AE6-8AAF-4CD9-8BD0-0DC80F8243C0

Type material. Holotype (female), soil, litter and moss samples under kermes oak (*Q. coccifera*), oriental sweetgum (*Liquidambar orientalis*) and olive (*Olea europaea*), 36°51.603' N, 28°13.259' E, 123 m a.s.l., vicinity of Yeşilbelde neighborhood (Marmaris County, Muğla Province), 13 March 2021. Paratypes: 16 females and five males, same data as holotype. Five females and two males: soil and litter samples under kermes oak (*Quercus coccifera*), Aleppo oak (*Q. infectoria*) and Turkish pine (*Pinus brutia*), 36°44.877' N, 28°14.700' E, 408 m a.s.l., vicinity of Kumlubük road, 13 March 2021. 11 females and one male: soil and litter samples under kermes oak (*Quercus coccifera*) and Turkish pine (*Pinus brutia*), 36°45.289' N, 28°15.735' E, 41 m a.s.l., vicinity of Kumlubük road, 13 March 2021. Five females and seven males: soil and litter samples under Turkish pine (*Pinus brutia*), 36°53.068' N, 28°18.912' E, 715 m a.s.l., vicinity of sawmill, 13 March 2021.

Diagnosis. Anterior margin of ventrianal shield with one pair of setae (*JV1*). All podonotal setae short, smooth and needle-like (except seta *j1* and marginal setae). Seta *j1*, s3, s6 and *r4–5* slightly elongated and finely barbed. Great majority of opisthonotal setae elongated, finely barbed without hyaline endings. Setae *Z5* and *S5* with hyaline endings, longer than other opisthonotal setae. Pores *gdS2* located between setae *Z2* and *S3*, *gdZ3* located between setae *J4* and *Z4*. Dorsal cavities distinct and strongly developed. Podonotum and anterior margin of opisthonotum covered with tile-like pattern, mid-area to posterior margin of opisthonotum covered by irregular punctate pattern.

Female (Figs 11-12) (n=10). Lengths (without gnathosoma) 441–454 and widths 322–346.

Dorsal side. (Fig. 11). Twenty pairs of setae present on podonotum: setae in *j* series with six pairs, *z* series with five pairs, *s* series with six pairs and *r* series with three pairs. Setae *j1*, *s3*, *s6* and *r4–5* slightly elongated and finely barbed. Remaining podonotal setae short, equal in size, smooth and needle-like. Twenty one pairs of setae present on opisthonotum: setae in *J* series with five pairs, *Z* series with five pairs, *S* series with five pairs and *R* series with six pairs. Most of opisthonotal setae elongated, finely barbed without hyaline endings (except setae *J1*, *Z5* and *S5*). Setae *J1* short, smooth and needle-like. Setae *Z1*, *S1–2* and *R1–6* shorter than other opisthonotal setae, finely barbed without hyaline endings. Setae *J2–5*, *Z2–4* and *S3–4* elongated, finely barbed (two or three barbs apically) without hyaline endings. Setae *Z5* and *S5* longer than others, elongated, finely barbed (two barbs apically) with hyaline endings, and reaching to beyond of opisthonotum. Setae *J5*, *Z4* and *S4* reaching to margin of opisthonotum. Setae *J2–4*, *Z2–3* and *S2–3* reaching the bases of the following seta (Setae *J3–4* and *Z3* reaching beyond the bases of the following seta). Seta *JV5* similar in length and shape to marginal *R* setae. All marginal setae (*S1* + *R1–6*) finely barbed without hyaline endings. The intervals between setae *Z5* and *Z5* 101–112, setae *Z5* and *JV5* 28–34, respectively. Average lengths of the opisthonotal setae and distances between setal bases within longitudinal *J*, *Z* and *S* rows are given in Table 5 for female and male specimens.

Pores. (Fig. 11). On podonotum, pores *gdj2* located on the line connecting setae *j2–s1*, closer to *s1*. Pores *gdj4* located on the line connecting setae *j5–z3*. Pores *gds4* located on the line connecting setae *z6–s4*, closer to *s4*. On opisthonotum, pores *gdZ1* located above the insertions of setae *Z1*. Pores *gdS2* located on the line connecting setae *Z2–S3*. Pores *gdZ3* located on the line connecting setae *J4–Z4*, closer to *Z4*. Pores *gdS5* located below to the insertions of setae *S5*.

Ventral side. (Fig. 12). Posterolateral tips of peritrematal shield reaching the level of setae *S1*. Postanal seta as the longest on the ventrianal shield. Remaining all ventral characters as in female specimens of ***Zercon dogani*** sp. nov. and ***Z. marmarisensis*** sp. nov.

Male (Figs 13-14) (n=10). Lengths (without gnathosoma) 347–363 and widths 242–251. Chaetotaxy of idiosoma, location of pores on idiosoma and ornamentation of dorsal shields similar to the females (except setae *s2*, *Z1*, *S2* and *R4–6*). Although all of these setae are finely barbed without hyaline endings in female specimens, they are smooth and needle-like in male specimens. Additionally, seta *J5* reaching to margin of opisthonotum in female specimens, it is not reaching to margin of opisthonotum in male specimens.

The intervals between setae Z5 and Z5 89–96, setae *Z5* and *JV5* 14–20, respectively.

Immature stages. Not found.

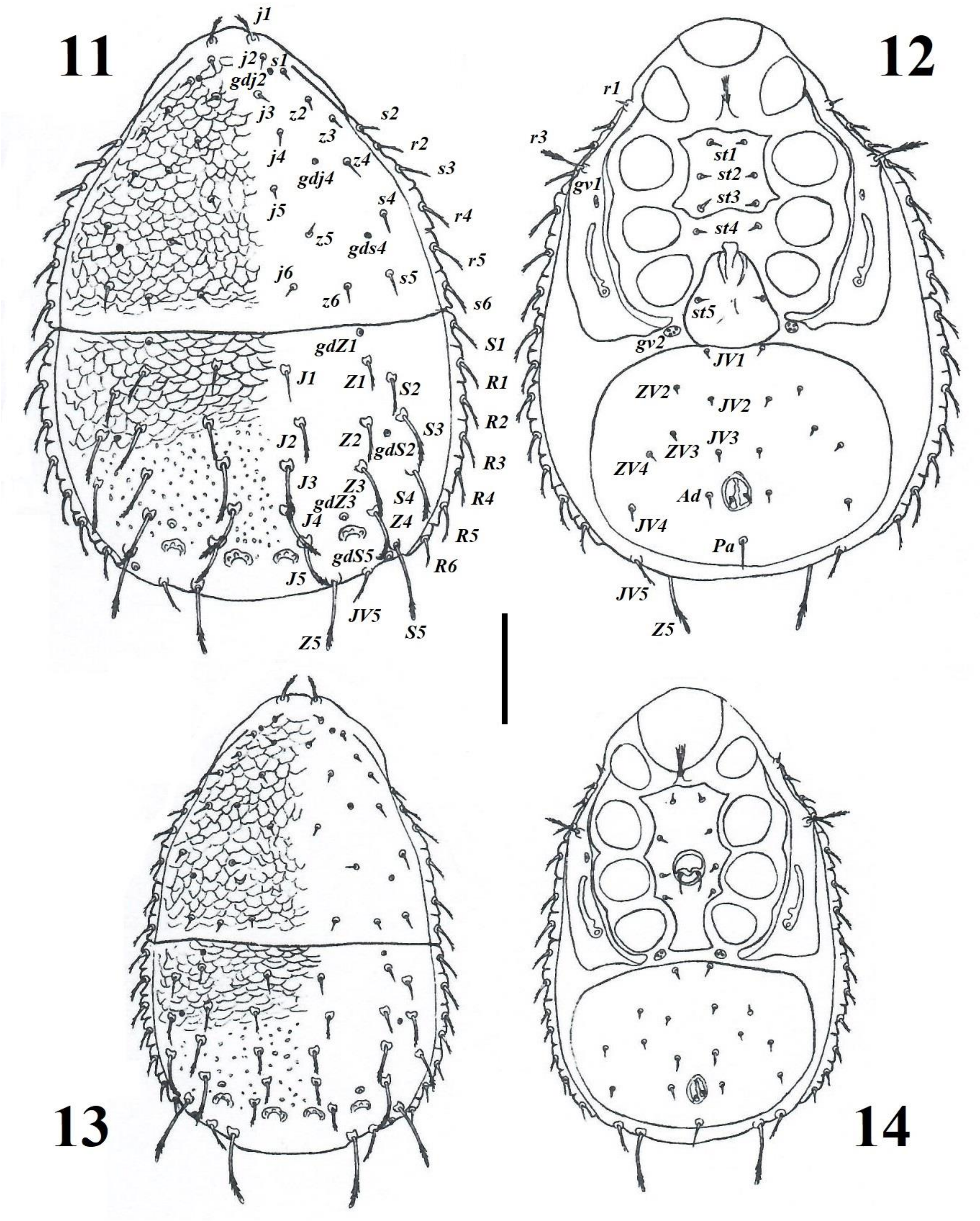
Etymology. The specific epithet '*muglaensis*' refers to the Muğla Province where the new species was collected.

Remarks. *Zercon muglaensis* sp. nov. is quite similar to *Z. denizliensis* Urhan, 2011, *Z. marinae* Ivan & Călugăr, 2004 and *Z. plumatopilus* Athias-Henriot, 1961. The morphological distinguishing characters of these four species were given in Table 6.

Altitude preferences of Zerconidae specimens in the study area

All materials of zerconid mites were collected from suitable forestland areas at the altitude from 4 to 973 m a.s.l. All sampling areas were divided according to 100 meters elevation ranges. After identification processes in the laboratory, the altitudinal distribution results of the *Prozercon* and *Zercon* species were marked in Table 3.

According to Table 7, *P. yavuzi* was only found at 0–100 m a.s.l., *Z. dogani* sp. nov. was only found at 100–200 m a.s.l. and *Z. turcicus* sp. nov. was only found at 300–400 m a.s.l. *P. bulgariensis* and *Z. quadricavum* were almost found at all altitudinal zones, from 0 to 1000 m a.s.l. Remaining species have no clear preference in terms of altitudinal ranges.



Figures 11-14. *Zercon muglaensis* sp. nov. **11.** Dorsal view of female, **12.** Ventral view of female, **13.** Dorsal view of male, **14.** Ventral view of male. Scale bar 100.

Table 5. Average lengths of opisthonotal setae and the distances between their insertions in *J*, *Z*, and *S* rows of *Zercon muglaensis* sp. nov.

Setae	♀	♂	Setae	♀	♂	Setae	♀	♂
J1	26	16	***Z1***	27	14	***S1***	21	20
J1–J2	46	33	***Z1–Z2***	43	34	***S1–S2***	73	31
J2	38	20	***Z2***	36	20	***S2***	28	24
J2–J3	37	30	***Z2–Z3***	33	20	***S2–S3***	39	32
J3	45	25	***Z3***	42	26	***S3***	42	28
J3–J4	38	25	***Z3–Z4***	38	31	***S3–S4***	37	28
J4	45	20	***Z4***	42	37	***S4***	44	39
J4–J5	28	24	***Z4–Z5***	69	49	***S4–S5***	54	45
J5	37	21	***Z5***	55	53	***S5***	53	50

Table 6. Morphological distinctive characters among *Zercon muglaensis* sp. nov., *Z. denizliensis*, *Z. marinae* and *Z. plumatopilus.*

Characters	***Z. muglaensis*** sp. nov.	***Z. denizliensis*** Urhan, 2011	***Z. marinae*** Ivan & Călugăr, 2004	***Z. plumatopilus*** Athias-Henriot, 1961
Seta *j2*	short and smooth	short and smooth	short and smooth	finely barbed
Seta *J2*	elongated with hyaline ending	short and smooth	short and smooth	with hyaline ending
Setae *J3–J5*	elongated, finely barbed	elongated, finely barbed with hyaline ending	elongated, finely barbed with hyaline ending	elongated, finely barbed with hyaline ending
Setae *Z2–Z4*	elongated, finely barbed	Z2 short and smooth, *Z3–Z4* elongated, finely barbed with hyaline ending	Z2 short and smooth, *Z3–Z4* elongated, finely barbed with hyaline ending	elongated, finely barbed with hyaline ending
Seta *JV5*	finely barbed	finely barbed	with hyaline ending	finely barbed
Setae *S2–S4*	elongated, finely barbed	*S2–S3* finely barbed, *S4* with hyaline ending	*S2* short and smooth, *S3–S4* with hyaline ending	with hyaline ending
Anterior margin of ventrianal shield	with 2 setae	with 4 setae	with 2 setae	with 2 setae

Table 7. Altitude preferences of zerconid mites in the Marmaris National Park (Muğla).

	0–100[1]	100–200	200–300	300–400	400–500	500–600	600–700	700–800	800–900	900–1000
P. bulgariensis	+	+	+	+	+	+	+	+		+
P. tragardhi	+	+				+				
P. yavuzi	+									
Z. colligans	+	+	+	+			+	+		
Z. dogani sp. nov.		+								
Z. inonuensis						+			+	
Z. marmarisensis sp. nov.	+	+	+		+			+		
Z. muglaensis sp. nov.	+	+	+		+			+		
Z. quadricavum	+	+	+	+	+	+	+	+		+
Z. turcicus				+						

[1] Altitudes in m a.s.l.

Habitat preferences of Zerconidae specimens in the study area

All materials of zerconid species were collected from 156 sites in the study area and the following 24 habitat types, mostly tree species, were noted: Aleppo oak (*Quercus infectoria*), broom (*Genista sandrasica*), carob (*Ceratonia siliqua*), common juniper (*Juniperus communis*), common myrtle (*Myrtus communis*), evergreen oak (*Q. ilex*), Greek strawberry tree (*Arbutus andrachne*), holy bramble (*Rubus sanctus*), kermes oak (*Q. coccifera*), laurel (*Laurus nobilis*), mastic (*Pistacia lentiscus*), moss (unspecified), oleaster-leafed pear (*Pyrus elaeagrifolia*), oriental sweetgum (*Liquidambar orientalis*), olive (*Olea europaea*), pink rock-rose (*Cistus creticus*), shrub (*Sytrax officinalis*), strawberry tree (*Arbutus unedo*), terebinth (*Pistacia terebinthus*), thorn (*Paliurus spina-christi*), thorny burnet (*Sarcopoterium spinosum*), tree heather (*Erica arborea*), Turkish pine (*Pinus brutia*) and wattles (*Acacia* sp.). Habitat preferences of the *Prozercon* and *Zercon* species were marked in Table 8.

According to Table 8, *P. bulgariensis* and *Z. quadricavum* were found in samples taken from 21 and 20 different habitat types, respectively. On the other hand, *Z. inonuensis* was found only in Turkish pine (*Pinus brutia*) habitat, *Z. dogani* sp. nov. was found only in pink rock-rose (*Cistus creticus*) and Turkish pine (*Pinus brutia*) habitats, *Z. turcicus* was found only in pink rock-rose (*Cistus creticus*) and kermes oak (*Q. coccifera*) habitats. Specimens of *Z. marmarisensis* sp. nov. and *Z. muglaensis* sp. nov. were exactly found in the same habitats. In addition, the most richness habitats in terms of species diversity of zerconids are follow: Turkisk pine, moss, pink rock-rose and Aleppo oak. In contrary of these richness habitats, only one specimens of zerconid mites were found in the following habitats: strawberry tree, broom, laurel and thorn.

Key to Zerconidae species in the study area (based on adult females)

1 Peritrematal seta *r3* short and smooth; there is no gap between peritremal shield and the edge of the podonotum; adgenital shield and pore *gv2* absent; the anterior margin of ventrianal shield always with two setae (seta *ZV1* absent) ……….. genus ***Prozercon*** Sellnick, 1943……………... **2**

1′ Peritrematal seta *r3* elongated, feathered, or spiny; there is a clear gap between peritremal shield and the edge of the podonotum; adgenital shield and pore *gv2* present; the anterior margin of ventrianal shield with two or four setae .... genus ***Zercon*** C. L. Koch, 1836 ……………… **4**

2 Setae *S1* and *R1–6* short and smooth .... ***P. tragardhi*** (Halbert, 1923)

2′ Seta *S1* finely barbed, setae *R2–6* short and smooth..... **3**

3 Seta *S4* present…….................. ***P. bulgariensis*** Ujvári, 2013

3′ Seta *S4* absent ………………………. ***P. yavuzi*** Urhan, 1998

4 Anterior margin of ventrianal shield with two setae **5**

4′ Anterior margin of ventrianal shield with four setae ... **9**

5 Setae *J3–5* finely barbed without hyaline ending .... ***Z. muglaensis*** sp. nov.

5′ Setae *J3–5* smooth or finely barbed with hyaline endings **6**

6 Setae *J3–5* smooth .... ***Z. inonuensis*** Urhan, 2007

6′ Setae *J3–5* finely barbed with hyaline endings **7**

7 Seta *J2* with hyaline ending ... ***Z. marmarisensis*** sp. nov.

7′ Seta *J2* short and smooth **8**

8 Setae *Z4* and *S4* not reaching to margin of opisthonotum ……………………………….............. ***Z. colligans*** Berlese, 1920

8′ Setae *Z4* and *S4* reaching to margin of opisthonotum .... ***Z. dogani*** sp. nov.

9 Seta *J5* lies parallel to horizontal axis of idiosoma, dorsal cavities strongly developed..***Z. quadricavum*** Urhan, 2001

9′ Seta *J5* lies parallel to vertical axis of idiosoma, dorsal cavities weakly developed …………………………………………. ……………..……………….. ***Z. turcicus*** Urhan & Ayyıldız, 1994

Authors' contributions

Kamil Bilki: Investigation, collection of specimens (lead), methodology (equal), writing-original draft (supporting), preservation. **Raşit Urhan:** Funding acquisition, methodology (equal), project administration, supervision (lead), collection of specimens (supporting), identification, illustration. **Mehmet Karaca:** Data curation, formal analysis, methodology (equal), supervision (supporting), writing-original draft (lead), writing-review & editing, collection of specimens (supporting).

Statement of ethics approval

Not applicable.

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Conflict of interest

No potential conflict of interest was reported by the authors.

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Table 8. Habitat preferences of zerconid mites in the Marmaris National Park (Muğla).

	P. bulgariensis	*P. tragardhi*	*P. yavuzi*	*Z. colligans*	*Z. dogani* sp. nov.	*Z. inonuensis*	*Z. marmarisensis* sp. nov.	*Z. muglaensis* sp. nov.	*Z. quadricavum*	*Z. turcicus*
Acacia sp.				+					+	
Arbutus andrachne	+			+					+	
Arbutus unedo	+									
Ceratonia siliqua	+			+						
Cistus creticus	+	+		+	+				+	+
Erica arborea	+			+					+	
Genista sandrasica	+									
Juniperus communis	+								+	
Laurus nobilis	+									
Liquidambar orientalis	+			+			+	+	+	
Moss (unspecified)	+	+	+	+			+	+	+	
Myrtus communis		+							+	
Olea europaea	+						+	+	+	
Paliurus spina-christi									+	
Pinus brutia	+	+		+	+	+	+	+	+	
Pistacia lentiscus	+		+						+	
Pistacia terebinthus	+								+	
Pyrus elaeagrifolia	+								+	
Quercus coccifera	+						+	+	+	+
Q. ilex	+			+					+	
Q. infectoria	+		+	+			+	+	+	
Rubus sanctus	+								+	
Sarcopoterium spinosum	+			+					+	
Sytrax officinalis	+								+	

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RESEARCH NOTE

Ali Dağı'nın (Kayseri) oppiid akarları (Acari: Oppiidae) üzerine taksonomik araştırmalar

Hamide ALİDAĞI[1], **Nusret AYYILDIZ**[2,3]

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ÖZET: Ali Dağı'ndan toplanan döküntü ve toprakta yaşayan oppiid akarlar taksonomik bakımdan değerlendirilmiş ve iki alt familyaya ait toplam beş takson tespit edilmiştir. Bunlar; *Discoppia* (*Cylindroppia*) *cylindrica cylindrica* (Pérez-Íñigo, 1965), *Rhinoppia* (*R.*) *obsoleta obsoleta* (Paoli, 1908), *Microppia minus minus* (Paoli, 1908), *Berniniella* (*B.*) *bicarinata* (Paoli, 1908) ve *Oppiella* (*O.*) *nova nova* (Oudemans, 1902)'dır. Tespit edilen taksonlar ışık mikroskobunda incelenmiş, çeşitli vücut yapılarına ait ölçümleri yapılmış, yaşama alanları ile dünyadaki yayılışları verilmiş ve çeşitli taksonomik sorunları tartışılmıştır.

Anahtar Kelimeler: Oribatid akarlar, taksonomi, Ali Dağı, Kayseri, Türkiye.
Zoobank: https://zoobank.org/4864D7A1-39C7-44B7-8580-44A5C2396626

Taxonomic investigations on the oppiid mites (Acari: Oppiidae) of Ali Mountain (Kayseri)

ASBTRACT: The oppiid mites dwelling in litter and soil collected from Ali Mountain have been evaluated from taxonomical viewpoint; totally five taxa belonging to two subfamilies have been identified. These are *Discoppia* (*Cylindroppia*) *cylindrica* (Pérez-Íñigo, 1965), *Rhinoppia* (*R.*) *obsoleta obsoleta* (Paoli, 1908), *Microppia minus minus* (Paoli, 1908), *Berniniella* (*B.*) *bicarinata* (Paoli, 1908) and *Oppiella* (*O.*) *nova nova* (Oudemans, 1902). The identified taxa were examined by a light microscopy, the measurements belonging to their various body structures were done, their habitats and distributions on the world were given and systematical problems discussed.

Keywords: Oribatid mites, taxonomy, Ali Mountain, Kayseri, Turkey.

Akarlar; Arachnida sınıfında yer alan keliserli eklembacaklıların üyeleridir. Şimdiye kadar tanımlanmış yaklaşık 45000 türü bilinmektedir. Oysa gerçek sayılarının bir milyondan fazla olduğu tahmin edilmektedir (Proctor ve Owens, 2000). Bunlar içerisinde oribatid akarlar; şimdiye kadar tanımlanmış yaklaşık 11000 civarında türü ve çok sayıda bireyi ile akarların zengin gruplarından birini oluşturmaktadır (Subías, 2004). Ayrıca, bilinen tür sayısının, bu grubun gerçek sayısının %10 ile %30'u arasında olduğu tahmin edilmektedir (Solhoy, 2001). Oribatid akarlar; çoğunlukla ergin ve ergin olmayan evrelerindeki bireylerinin birbirlerine benzememeleri, uzun yaşam süresine sahip olmaları ve diğer eklembacaklıların aksine nispeten yavaş üremeleri nedeniyle toprak faunası içerisinde eşsiz özelliklere sahip olup ağaç kabukları, kaya çatlakları, toprak, döküntü, yosun, liken ve nadiren sucul ortamlarda yaşarlar; fakat en yaygın olarak toprakta bulunurlar. Besinlerini yüksek bitkilerin dokuları, çeşitli bitki kalıntıları, canlı hayvan dokuları, ölü hayvanlar ve dışkı oluşturur (Evans, 1992). Oribatidlerin çeşitliliğinde, beslenme ve yaşam ortamları çeşitliliğinin etken olduğu bildirilmektedir (Karasawa ve Hijii, 2004). Bunlardan dolayı, taksonomik çalışmaların yoğun olarak yürütüldüğü bir grup özelliği taşımaktadır. Ülkemizde oribatid akarlar üzerine yapılmış çok sayıda çalışma bulunmaktadır (Ör: Ayyıldız, 1989; Özkan vd., 1988, 1994; Dik vd., 1995; Erman vd., 2007; Baran vd., 2018).

Araştırma alanı olarak seçilen Ali Dağı, dağ niteliği ile özel bir ekosistem oluşturmaktadır. Ali Dağı; Kayseri'nin Talas ilçesinde, 38°40.56'-38°39.06'K enlemleri ile 35°33.56'-35°32.10'D boylamları arasında yer alan yaklaşık 3,00-3,25 km kaide çapında ve en yüksek tepesi 1870 m yüksekliğinde bir dağdır. Bitki örtüsü olarak etekleri 0,5-1,0 m boyunda genç meşe ve çam ormanı, diğer kısımları ise çayır, mera ve otlaklarla örtülüdür. Araştırma alanından alınan toplam on altı toprak örneğinin, Kayseri Köy Hizmetleri 4. Bölge Müdürlüğü Toprak Analiz Laboratuarında yapılan analizler sonucu; toprağın killi-tınlı yapıda olduğu, tuzsuz, hafif asit, kireçsiz, bitki besin maddeleri yönünden fosfor ve azotça zengin olduğu tespit edilmiştir. Araştırma bölgesinde bu çalışma dışında ilkel oribatidlerin taksonomik bakımdan incelendiği iki çalışma ve "Ali Dağı`nda (Kayseri) bir eğim boyunca oribatid akarların düşey dağılımı" başlıklı bir tez çalışması yürütülmüştür (Toluk ve Ayyıldız, 2006, 2008a; Taşkıran, 2010). Ayrıca, Toluk (2016) tarafından oppiid akarların yeni bir türü de tanımlanmıştır. Oribatid akarlar içerisinde tür ve birey sayısı bakımından zengin olan oppiid akarların çalışma konusu olarak seçilmesi ile ülkemizin biyolojik çeşitliliğinin ortaya çıkarılmasına ve dünya hayvan varlığına katkı sağlanması amaçlanmaktadır.

Ali Dağı'nda, 2003 yılının Mayıs ayından 2004 yılının Ağustos ayına kadar kış ayları hariç peryodik olmayan şekilde farklı zamanlarda çeşitli yaşama alanlarından toprak ve döküntü örnekleri alındı. Bu işlem esnasında yaşama alanı ile ilgili özellikler kaydedildi. Alınan örnekler naylon torbalara konularak etiketlenip laboratuara getirildi ve Berlese hunilerinden oluşan ayıklama düzeneğine yerleştirildi. Örnekler, önemlilik durumuna göre 3-5 gün süreyle ayıklama işlemine tabi tutuldu. Bu işlemin sonunda, huninin alt tarafına yerleştirilmiş ve içinde % 70'lik etil alkol bulunan toplama şişelerinde biriken akarlar, petri kaplarına boşaltılıp stereo mikroskop altında pipet ve iğneler yardımı ile ayıklandı. Ayıklanan örnekler daha sonra incelenmek üzere, içinde %70'lik etil alkol ve 1-2 damla gliserin bulunan saklama şişelerine konuldu. Örneklerin mikroskobik incelenmesi, ışık mikroskobunda 1:2 oranındaki su-laktik asit ortamında yapıldı. Ancak, farklı konumlarda incelenmesi gerektiğinde Faure ortamında geçici preparatları hazırlandı. Örneklerin ağartılmasında %50'lik laktik asit kullanıldı. Ölçümleri yapılıp, şekilleri çizilen örnekler teşhis edilerek, tekrar saklama şişelerine konulup etiketlendi. Türlerin tanımında verilen ölçümler, incelenen örnek sayısının birden fazla olduğu durumlarda ortalamayı ifade etmektedir.

Oppiidae Sellnick, 1937

Medioppiinae Subías ve Minguez, 1985

Discoppia (*Cylindroppia*) Subías ve Rodriguez, 1986

Discoppia (*C.*) *cylindrica cylindrica* (Pérez-Iñigo, 1965)

İncelenen Örnekler: 38°40.385'K, 35°33.130'D; 1361 m; döküntü ve toprak; 20.09.2003; 2 ergin. 38°40.302'K, E 35°33.079'D; 1435 m; döküntü ve toprak; 01.11.2003; 1 ergin.

İlk defa Pérez-Iñigo tarafından 1965 yılında *Oppia minus cylindrica* olarak tanımlanan bu alt tür, daha sonra Subías ve Rodriguez tarafından 1986 yılında tanımlanan *Discoppia* (*Cylindroppia*) alt cinsinin tip türü olarak değerlendirilmiştir (Subías ve Balogh, 1989). Şimdiye kadar yayılışı ile ilgili sınırlı sayıda veri bulunmasına karşın (Pérez-Íñigo, 1965; Golosova, 1975; Vasiliu vd., 1993; Olszanowski vd., 1996), bu alt türün Palearktik ve Tropikal (Vietnam ve Panama) bölgede yayılış gösterdiği anlaşılmaktadır (Subías, 2004). Bu alt tür Türkiye'de Amanos Dağları'ndan kaydedilmiştir (Ay, 2018). Taksonun özgün tanımı dışında morfolojik tanımına ilişkin ek bir bilgiye rastlanılmamıştır. Pérez-Iñigo (1965), özgün tanımı verirken tartışmada Willmann (1931)'ın anladığı anlamdaki *Oppia minus* (Paoli)'un özellikleri ile bu alt türün özelliklerinin uyuştuğunu bildirmiştir. Buna göre; alt türün vücut boyutu (uzunluk/genişlik) tip örneği için Pérez-Iñigo (1965), tarafından 225/75 µm, Willmann (1931) tarafından 225/93 µm ve Golosova (1975) tarafından ise vücut uzunluğu 225 µm olarak verilmiştir. Ay (2018), Amanos Dağları'ndan kaydettiği örnekler için vücut uzunluğunu 209 (198-220) µm, genişliğini ise 84 (75-90) µm olarak vermiştir. Örneklerimizde vücut boyutunun (uzunluk/genişlik) ortalama 196/74 µm, vücut uzunluğunun genişliğine oranı ise ortalama 2,64 olarak tespit edilmiştir. Bu oran; tip örneğinde 3,00 (Pérez-Iñigo, 1965), Almanya örneğinde 2, 42 (Willmann, 1931), Türkiye'den kaydedilen örnekler için bu oran 2,48'dir (Ay, 2018). Bu verilerden; örneğimizin vücut boyutları bakımından şimdiye kadar bilinenler içerisinde en küçüğü olmasına karşın, genel görünüm bakımından tip örneğine benzediği anlaşılmaktadır. Pérez-Iñigo (1965), tip örneğinde genital plak ile anal plak arasındaki mesafenin anal plağın uzunluğuna eşit olduğunu bildirmiştir. İncelediğimiz örnekte de bu mesafe ve uzunluk 32 µm olarak ölçülmüş olup, tip örneği ile uyuşmaktadır. Örneklerimizin, diğer yapısal özellikleri bakımından daha önceki verilerle uyum içinde olduğu tespit edilmiştir.

Microppia Balogh, 1983

Microppia minus minus (Paoli, 1908)

İncelenen Örnek: 38°40.302'K, 35°33.079'D; 1435 m; döküntü ve toprak; 18.10.2003; 1 ergin.

Kozmopolit yayılışa sahip olan bu taksona Palearktik bölgede sıklıkla rastlanmaktadır (Subías, 2004). Daha önceki verilerden, bu alt türün vücut boyutlarının (uzunluk/genişlik) 170-225/75-96 µm arasında değiştiği anlaşılmaktadır (Paoli, 1908; Willmann, 1931; Sellnick, 1960; Pérez-Iñigo, 1971; Baran, 2003; Miko, 2006; Toluk ve Ayyıldız, 2008b). Örneğimizde vücut boyutu (uzunluk/genişlik) 160/84 µm olarak ölçülmüş olup, tip örneğinin ölçülerine biraz daha yakın tespit edilmiştir (Paoli, 1908). Örneklerimizin, yapısal özellikleri bakımından daha önceki verilerle uyum içinde olduğu tespit edilmiştir.

Rhinoppia Balogh, 1983

Rhinoppia (*R.*) *obsoleta obsoleta* (Paoli, 1908)

İncelenen Örnekler: 38°40.385'K, 35°33.130'D; 1361 m; döküntü ve toprak; 31.05.2003; 1 ergin. 38°40.385'K, E 35°33.130'D; 1361 m; döküntü ve toprak; 07.06.2003; 3 ergin. 38°40.302'K, 35°33.079'D; 1435 m; döküntü ve toprak; 20.09.2003; 3 ergin. 38°40.302'K, 35°33.079'D; 1435 m; döküntü ve toprak; 02.10.2003; 1 ergin.

Bu alt tür Mahunka (1987) tarafından *Kunoppia* cinsi içerisinde değerlendirilmiş ve yaygın bir Avrupa taksonu olarak tanımlanmıştır. Bu çalışmada Subías ve Balogh (1989) tarafından önerilen sınıflandırma sistemi kullanıldığından; bu araştırıcıların da sinonim olarak düşündüğü *Kunoppia* cinsi yerine *Medioppia* cinsi içerisinde değerlendirilmiştir. Bu alt türe ait vücut ölçülerinin (uzunluk/genişlik) daha önceki çalışmalardan 285-360/125-163 µm arasında değiştiği anlaşılmaktadır (Paoli, 1908; Willmann, 1931; Pérez-Iñigo, 1971; Woas, 1986; Beck ve Woas, 1991; Baran, 2003; Miko, 2006). Ayrıca, Beck ve Woas (1991), GB Almanya örnekleri için vücut uzunluğunu 285-330 µm, vücut uzunluğunun genişliğine oranını da 1,80-2,05 olarak tespit etmişlerdir. Toluk ve Ayyıldız (2008b) incelediği örnekler için vücut uzunluğunu ortalama 298 (280-316) µm, genişliğini ise 160 (140-180) µm olarak vermişlerdir. Örneklerimizde vücut boyutları (uzunluk/genişlik) ortalama 315 (290-343)/155 (150-162) µm olarak tespit edilmiş olup, türün bilinen vücut ölçülerine ait değişim aralığında bulunduğu anlaşılmaktadır. Örneklerimizin, yapısal özellikleri bakımından daha önceki verilerle uyum içinde olduğu tespit edilmiştir.

Oppiellinae Seniczak, 1975

Berniniella Balogh, 1983

Berniniella (*B.*) *bicarinata* (Paoli, 1908)

İncelenen Örnek: 38°40.302'K, 35°33.079'D; 1435 m; döküntü ve toprak; 18.10.2003; 1 ergin.

Palearktik, Madagaskar ve Vietnam'da yayılış göstermektedir (Subías, 2004). Palearktik bölgede sıklıkla rastlanan bu türün vücut uzunluğunun, şimdiye kadar bilinenlerden 210-315 µm arasında değişim gösterdiği anlaşılmaktadır (Paoli, 1908; Golosova, 1975; Miko, 2006; Toluk ve Ayyıldız, 2008b). Örneğimizde vücut uzunluğu 226 µm ve genişliği 100 µm olarak ölçülmüş olup, türün bilinen vücut uzunluğuna ait değişim aralığı içerisinde bulunduğu anlaşılmaktadır. Örneklerimizin, diğer yapısal özellikleri bakımından daha önceki verilerle uyum içinde olduğu tespit edilmiştir. Schatz (1996), Avusturya'da Virgental bölgesinde kurak çayırlıkların oribatid akar kommunitelerini incelediği çalışmasında bu türü öryök ve panfitofag olarak tanımlamıştır. Mahunka (1987); incelediği araştırma alanında bu türün yaygın olmadığını, fakat Palearktik bölgede yayılış gösterdiğini belirtmiştir. Araştırma alanımızda da bu türün bir örnekle temsil edilmesi, Mahunka (1987)'nın ifadesiyle uyuşmaktadır.

Oppiella Jacot, 1937

Oppiella (*O.*) *nova nova* (Oudemans, 1902)

İncelenen Örnekler: 38˚40.385'K, 35˚33.130'D; 1361 m; döküntü ve toprak; 07.06.2003; 2 ergin. 38˚40.225'K, 35˚33.030'D; 1547 m; döküntü ve toprak; 07.06.2003; 1 ergin. 38˚40.385'K, 35˚33.130'D; 1361 m; döküntü ve toprak; 13.09.2003; 1 ergin; 38˚40.302'K, 35˚33.079'D; 1435 m; döküntü ve toprak; 13.09.2003;1 ergin. 38˚40.302'K, 35˚33.079'D; 1435 m; döküntü ve toprak; 20.09.2003, 2 ergin. 38°40.302'K, 35°33.079'D; 1435 m; döküntü ve toprak; 02.10.2003; 1 ergin. 38°40.302'K, 35°33.079'D; 1435 m; döküntü ve toprak; 01.11.2003; 1 ergin. 38°40.225'K, 35°33.030'D; 1547 m; döküntü ve toprak; 01.11.2003; 1 ergin.

Kozmopolit yayılış gösteren bu alt türün vücut ölçülerinin (uzunluk/genişlik) daha önceki çalışmalardan 210-320/117-170 µm arasında değiştiği anlaşılmaktadır (Pérez-Iñigo, 1971; Woas, 1986; Beck ve Woas, 1991; Subías, 2004; Miko, 2006; Toluk ve Ayyıldız, 2008b). Ayrıca, Beck ve Woas (1991), GB Almanya örnekleri için vücut uzunluğunu 220-260 µm, vücut uzunluğunun genişliğine oranını da 1,70-2,00 olarak tespit etmişlerdir. Örneklerimizde vücut uzunluğu ortalama 280 (272-300) µm, genişliği ise ortalama 134 (120-155) µm olarak tespit edilmiş olup, türün bilinen vücut ölçülerine ait değişim aralığında bulunduğu anlaşılmaktadır. Woas (1986), birçok araştırıcı tarafından *O.nova*'nın eşadı listesinde verilen *O. uliginosa* (Willmann, 1919)'un gerçekte ayrı bir tür olduğunu belirtmektedir. Özellikle bu ayrımda vücut uzunluğu, rostrum ve sensillusun şekli kullanılmaktadır. Aynı araştırıcı *O. nova*'nın vücut uzunluğunun 231-241 µm, *O. uliginosa*'nın ise 276-320 µm arasında değiştiğini ve bu türler arasında vücut büyüklüğü bakımından farklılık olduğunu bildirmektedir. Ayrıca rostrumun *O. uliginosa*'da rostral kıllar arasında burun şeklinde çıkıntılı olduğunu, *O. nova*'da ise hafif bombeli yapıda olduğunu göstermektedir. Örneklerimiz; sensillus ve rostrumun şekli ile vücut uzunluğu bakımından Woas (1986) tarafından yeniden tanımı verilen *O. uliginosa*'ya benzerlik göstermektedir. Diğer taraftan, Van der Hammen (1952) tarafından verilen prodorsumun şekli örneklerimizdeki ile uyum içindedir. Van der Hammen (1952)'in; bu taksonu değişken olarak görmesi ve orijinal tip örneği etiketlerinin de yanlışlıkla değiştirilmiş olduğunu ifade etmesi ve ayrıca Subias ve Arillo (1991)'nun da bu taksonda birçok karakterin önemli varyasyonlar gösterdiğini belirtmiş olması gibi nedenler, şimdilik örneklerimizin *O.* (O*.) nova nova* olarak değerlendirilmesinde önemli rol oynamıştır. Araştırıcıların çoğu tarafından, kozmopolit ve ubikuyit tür olarak tanımlanması da tespit edilen farklılıkların varyasyon sınırları içerisinde değerlendirilmesini olası kılmaktadır. Schatz (1996), Avusturya'da Virgental bölgesinde kurak çayırlıkların oribatid akar kommunitelerini incelediği çalışmasında bu türü öryök ve mikrofitofag olarak tanımlamıştır. Luxton (1985), bu türün her yerde bulunan (ubikuyit) bir tür olabileceğini bildirmiştir. Önceki araştırıcıların bu türü tespit ettiği yaşama alanları ile bulgularımız dikkate alındığında geniş bir hoşgörüye sahip olduğu anlaşılmaktadır.

Sonuç olarak; Türkiye'den daha önce bilinen ancak araştırma alanı için ilk kayıtlar oldukları tespit edilen taksonlara ilişkin verilerin, gelecekte yapılacak çalışmalar için kaynak oluşturacağı kanısındayız.

Yazar Katkıları

Hamide Alidağı: Kavramsallaştırma, veri toplama, metodoloji, araştırma, görselleştirme, yazma-taslak metin. **Nusret Ayyıldız:** Kavramsallaştırma, metodoloji, araştırma, yönetim, yazma-inceleme ve düzeltme. Bu çalışma, ilk yazarın yüksek lisans tezinden üretilmiştir.

Etik Onay Beyanı

Gerekli değildir.

Çıkar İlişkisi

Yazarlar çalışma ile ilgili herhangi bir çıkar ilişkisi bildirmemiştir.

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