

## ON NEWLY DISCOVERED DEUTONYMPHAL STAGE OF *Stigmaeus kumalariensis* Akyol & Koç (ACARI: STIGMAEIDAE) FROM TURKEY, WITH NUMERICAL AND STRUCTURAL VARIATIONS IN ADULTS

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**Abstract:** Deutonymph of *Stigmaeus kumalariensis* Akyol & Koç (Acari: Stigmaeidae) is herein described and illustrated based on specimens collected from litter and soil from Ekşisu marsh, Erzincan (Turkey). This is the first record of deutonymphal stage of *S. kumalariensis*. In addition, variations in the number of aggenital setae and structure of the median zonal shields in some adult specimens of the species are reported.

**Key words:** Ekşisu, immature, mite, *Stigmaeus*, variation, Turkey.

**Özet:** *Stigmaeus kumalariensis* Akyol & Koç (Acari: Stigmaeidae)'in deutonimf evresi, Erzincan'ın Ekşisu sazlığından toplanan döküntü ve toprak örnekleri içindeki bireyler üzerinden tanımlandı ve şekilleri çizildi. Bu, *S. kumalariensis*'in deutonimf evresinin ilk kayıdır. Buna ilaveten, türün bazı ergin bireylerinde gözlenen, median zonal plağın yapısı ve aggenital kilların sayısındaki varyasyonlara da değinildi.

### Introduction

Stigmaeidae is one of the most diverse mite families in Raphignathoidea with 33 genera one of which is *Stigmaeus* Koch (Fan *et al.* 2019, Khaustov 2019). The genus *Stigmaeus* is a large group with 147 described species (Fan *et al.* 2016, Bingül *et al.* 2017a, Khaustov *et al.* 2017, Doğan 2019a,b) of which 46 species have been recorded so far from Turkey (Erman *et al.* 2007, Doğan 2007, 2019a,b, Doğan *et al.* 2015a, 2016, 2017, Dilkaraoğlu *et al.* 2016a, Bingül *et al.* 2017a, Akyol 2019) and 24 of these species, including *Stigmaeus kumalariensis* Akyol & Koç, are known only from Turkey (Doğan & Ayyıldız 2003, Koç 2005, Akyol & Koç 2007, Dönel & Doğan 2011, Özçelik & Doğan 2011, Dönel *et al.* 2012, Doğan *et al.* 2015a, 2017, Uluçay 2015a-c, Bingül *et al.* 2017a, Doğan 2019a,b).

It is important to know morphological features of immature stages of mites as in many organisms for understanding history of developmental morphology. Most mite species are known only with adults, although immature instars show a diversity of characters and possess remarkable features potentially useful for understanding mite taxonomy, phylogeny and biology (Zhang 2018), making descriptions of immature stages

important to know morphological diversity in all life stages. There are five different life stages - egg, larva, protonymph, deutonymph and adult - in members of Stigmaeidae (Fan & Zhang 2005, Fan & Flechtmann 2015). Recently, Doğan *et al.* (2019) reported presence of the third nymphal stage in Stigmaeidae. The deutonymphal stage can be distinguished from adults by absence of genital setae and fewer setae on some leg segments. *Stigmaeus kumalariensis* has been known so far with only females and males and no data have been published on its immature stages. In the present study, the deutonymphal stage of *S. kumalariensis* specimens collected from litter and soil has been revealed for the first time. We also reported variations in *S. kumalariensis* for the first time. Variations in the genus *Stigmaeus* have been observed so far in *S. elongatus* Berlese, *S. longiclipeatus* Doğan, Doğan & Erman, *S. longipilis* (Canestrini), *S. erzincanus* Doğan, Bingül, Dilkaraoğlu & Fan, *S. solidus* Kuznetsov, *S. bifurcus* Bingül, Doğan & Dilkaraoğlu and *S. miandoabiensis* Bagheri & Zarei (Dilkaraoğlu *et al.* 2016b, Doğan *et al.* 2016, 2017, 2019, Bingül *et al.* 2017a,b). Our results also contributed to the knowledge about variations in the genus *Stigmaeus*.



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## Materials and Methods

Specimens of *S. kumalariensis* were collected from litter and soil in Ekşisu, Erzincan located 11 km to the east of Erzincan Province. The specimens were extracted by using Berlese-Tullgren funnels, cleared in 60% lactic acid and mounted on microscopic slides in Hoyer's medium. The specimens were examined by using a Leica DM 4000B phase-contrast microscope. The photographs of the specimens were taken by an Olympus BX63-CBH DIC microscope. Measurements of the deutonymphs (four specimens) identified within the sampled material were taken in micrometers ( $\mu\text{m}$ ) with the aid of the Leica Application Suite (LAS) Software Version 3.8. The mean values followed by the range values in paranthesis were given. Dorsal idiosomal and leg setal designations follow Kethley (1990) and Grandjean (1944), respectively. Specimens examined are deposited in Acarology Laboratory of Erzincan Binali Yıldırım University, Erzincan, Turkey.

## Results

Superfamily: Raphignathoidea

Family: Stigmaeidae

Genus: *Stigmaeus* Koch

*Stigmaeus kumalariensis* Akyol & Koç

### Description

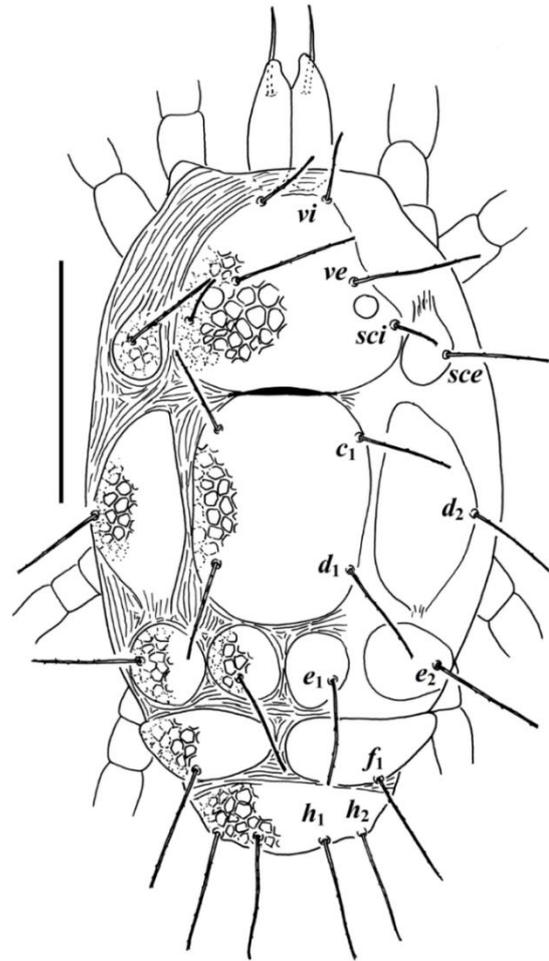
Deutonymph (Figs 1-5)

Length of body 269 (231-292), width 191 (179-199).

**Dorsum** (Fig. 1). Dorsal integument striated except for the shields. Dorsal shields reticulated. Propodosomal shield bearing a pair of eyes and setae *vi*, *ve* and *sci*. Eyes 9 (8-9) in diameter. A pair of auxiliary shields bearing setae *sce*. Setae *c*<sub>1</sub> and *d*<sub>1</sub> on central hysterosomal shield. Setae *d*<sub>2</sub> located on marginal shields. Setae *e*<sub>2</sub> located on lateral zonal shields. Median zonal and intercalary shields paired, bearing setae *e*<sub>1</sub> and *f*<sub>1</sub>. Suranal shield entire, bearing two pairs of setae (*h*<sub>1</sub> and *h*<sub>2</sub>). All dorsal setae long and faintly barbed. Lengths and distances of dorsal setae as follows: *vi* 30 (28-31), *ve* 48 (46-50), *sci* 18 (17-19), *sce* 40 (37-43), *c*<sub>1</sub> 38 (35-41), *c*<sub>2</sub> 37 (35-41), *d*<sub>1</sub> 38 (37-40), *d*<sub>2</sub> 40 (37-44), *e*<sub>1</sub> 40 (38-42), *e*<sub>2</sub> 44 (42-46), *f*<sub>1</sub> 49 (48-50), *h*<sub>1</sub> 48 (47-49), *h*<sub>2</sub> 45 (45-46), *vi-vi* 17 (17-18), *ve-ve* 44 (42-46), *vi-ve* 28 (25-30), *sci-sci* 78 (74-82), *ve-sci* 20 (19-21), *sce-sce* 125 (117-136), *sci-sce* 25 (22-28), *c*<sub>1</sub>-*c*<sub>1</sub> 55 (52-58), *c*<sub>2</sub>-*c*<sub>2</sub> 182 (175-194), *d*<sub>2</sub>-*d*<sub>2</sub> 157 (145-170), *c*<sub>1</sub>-*d*<sub>1</sub> 53 (52-54), *c*<sub>1</sub>-*d*<sub>2</sub> 57 (54-63), *d*<sub>1</sub>-*d*<sub>1</sub> 53 (49-57), *d*<sub>2</sub>-*d*<sub>1</sub> 53 (50-56), *e*<sub>2</sub>-*e*<sub>2</sub> 125 (111-147), *d*<sub>2</sub>-*e*<sub>2</sub> 60 (58-62), *d*<sub>1</sub>-*e*<sub>1</sub> 49 (43-54), *d*<sub>1</sub>-*e*<sub>2</sub> 53 (49-57), *e*<sub>1</sub>-*e*<sub>1</sub> 44 (41-48), *e*<sub>2</sub>-*e*<sub>1</sub> 42 (32-48), *f*<sub>1</sub>-*f*<sub>1</sub> 68 (62-74), *e*<sub>1</sub>-*f*<sub>1</sub> 37 (35-40), *f*<sub>1</sub>-*h*<sub>1</sub> 39 (35-44), *f*<sub>1</sub>-*h*<sub>2</sub> 30 (28-34), *h*<sub>1</sub>-*h*<sub>1</sub> 22 (20-23), *h*<sub>2</sub>-*h*<sub>2</sub> 49 (45-53), *h*<sub>1</sub>-*h*<sub>2</sub> 12 (11-13).

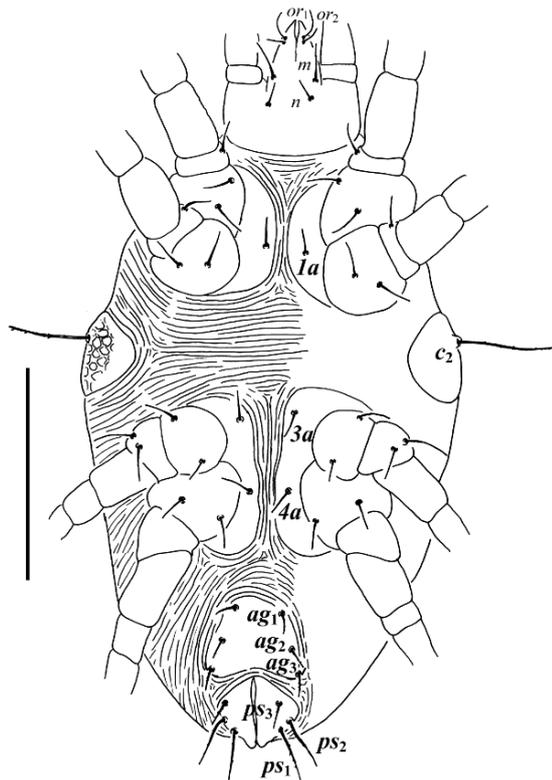
**Venter** (Fig. 2). Humeral shields situated ventrolaterally between coxae II and III, bearing setae *c*<sub>2</sub>. Setae *c*<sub>2</sub> faintly barbed as those of dorsal setae. Coxisternal shields divided in midline, bearing three pairs of

intercoxal setae (*1a*, *3a* and *4a*). Lengths and distance of these setae: *1a* 10 (9-11), *3a* 12 (11-12), *4a* 11 (10-11), *1a-1a* 20 (17-23), *3a-3a* 32 (30-33), *4a-4a* 20 (18-21). Three pairs of aggenital setae (*ag*<sub>1-3</sub>) present on the aggenital shield. Genital shield and setae (*g*) absent. Anal shields subterminal, bearing three pairs of pseudanal setae (*ps*<sub>1-3</sub>). Lengths of aggenital and pseudanal setae: *ag*<sub>1</sub> 9 (8-9), *ag*<sub>2</sub> 8 (7-8), *ag*<sub>3</sub> 10 (10-11), *ps*<sub>1</sub> 25 (24-26), *ps*<sub>2</sub> 23 (22-24), *ps*<sub>3</sub> 11 (11-12).

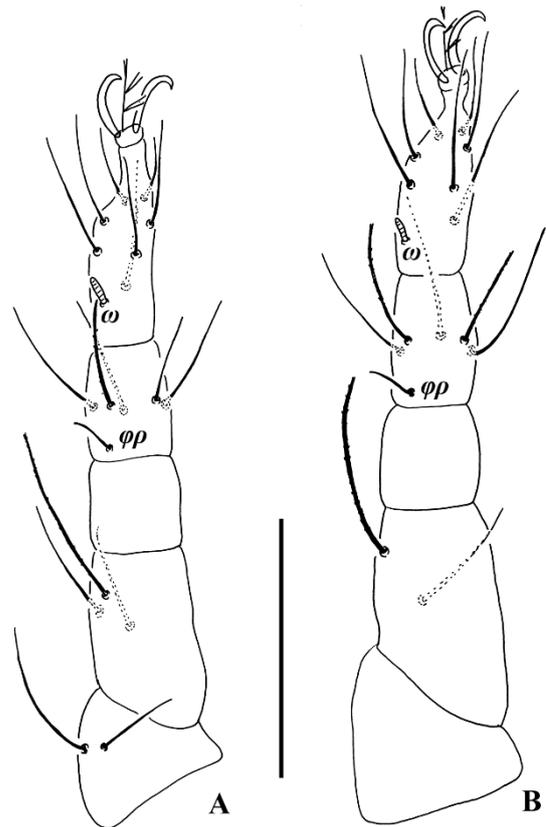


**Fig. 1.** Dorsal view of idiosoma of *Stigmaeus kumalariensis* deutonymph. Scale 100  $\mu\text{m}$ . (*vi* = internal pair of vertical setae; *ve* = external pair of vertical setae; *sci* = internal pair of scapular setae; *sce* = external pair of scapular setae; *c*<sub>1</sub> = internal pair of humeral setae; *d*<sub>1</sub> = internal pair of dorsal setae; *d*<sub>2</sub> = external pair of dorsal setae; *e*<sub>1</sub> = internal pair of lumbral setae; *e*<sub>2</sub> = external pair of lumbral setae; *f*<sub>1</sub> = internal pair of sacral setae; *h*<sub>1</sub> = 1<sup>st</sup> pair of clunal setae; *h*<sub>2</sub> = 2<sup>nd</sup> pair of suranal setae)

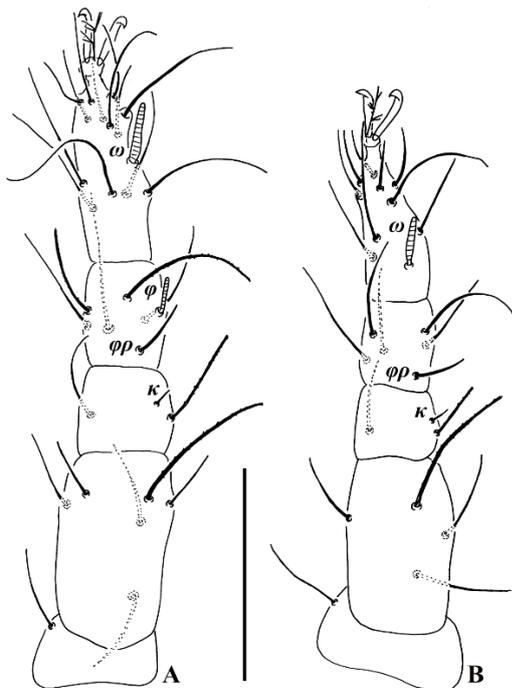
**Legs** (Figs 3, 4). Leg I 138 (133-141), leg II 118 (115-121), leg III 120 (116-124), leg IV 132 (128-135) long. Numbers of setae on legs I-IV: coxae 2-2-2-2, trochanters 1-1-2-0, femora 6-4-3-2, genua 2(+1 $\kappa$ )-2(+1 $\kappa$ )-0-0, tibiae 5(+1 $\phi$ )+1 $\phi$ -5(+1 $\phi$ )-5(+1 $\phi$ )-5(+1 $\phi$ ), tarsi 13(+1 $\omega$ )-9(+1 $\omega$ )-7(+1 $\omega$ )-7(+1 $\omega$ ).



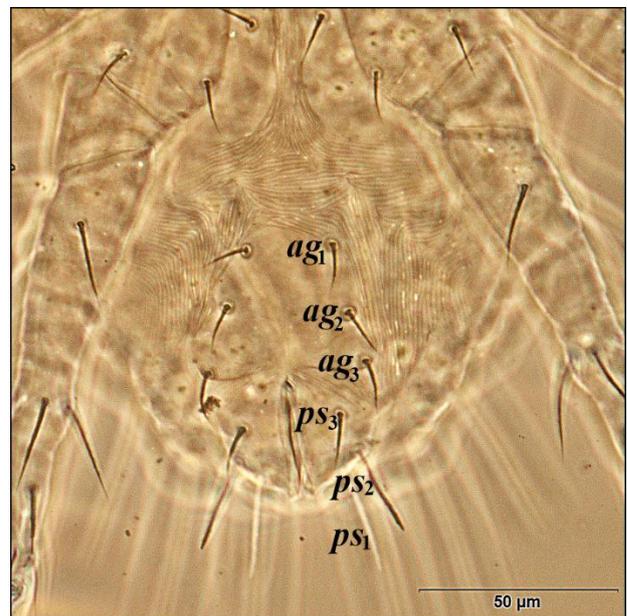
**Fig. 2.** Ventral view of idiosoma of *S. kumalariensis* deutonymph. Scale 100  $\mu$ m. (*or*<sub>1</sub> = 1<sup>st</sup> pair of adoral setae; *or*<sub>2</sub> = 2<sup>nd</sup> pair of adoral setae; *m* = anterior pair of subcapitular setae; *n* = posterior pair of subcapitular setae; *c*<sub>2</sub> = external pair of humeral setae; *1a* = 1<sup>st</sup> pair of intercoxal setae; *3a* = 2<sup>nd</sup> pair of intercoxal setae; *4a* = 3<sup>rd</sup> pair of intercoxal setae; *ag*<sub>1</sub> = 1<sup>st</sup> pair of aggenital setae; *ag*<sub>2</sub> = 2<sup>nd</sup> pair of aggenital setae; *ag*<sub>3</sub> = 3<sup>rd</sup> pair of aggenital setae; *ps*<sub>1</sub> = 1<sup>st</sup> pair of pseudanal setae; *ps*<sub>2</sub> = 2<sup>nd</sup> pair of pseudanal setae; *ps*<sub>3</sub> = 3<sup>rd</sup> pair of pseudanal setae).



**Fig. 4.** Legs in *S. kumalariensis* deutonymph. A) Leg III, B) Leg IV. Scale 40  $\mu$ m.



**Fig. 3.** Legs in *S. kumalariensis* deutonymph. A) Leg I, B) Leg II. Scale 40  $\mu$ m. ( $\omega$  = solenidion on tarsi;  $\phi$  = solenidion on tibia I;  $\phi\rho$  = proximal solenidion on tibiae;  $\kappa$  = famulus on genua).

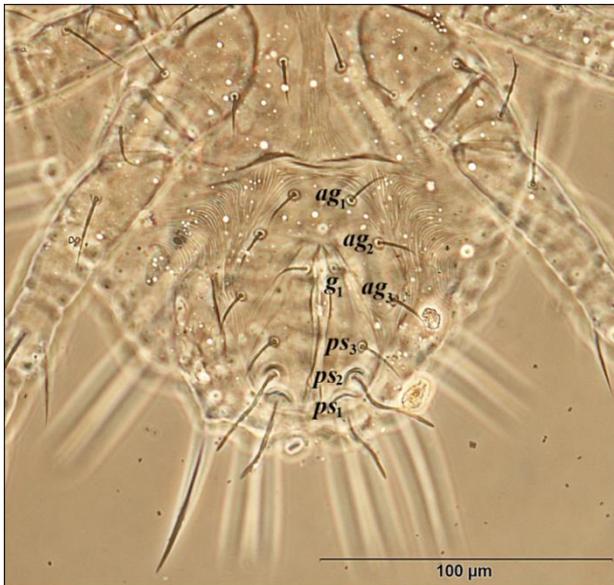


**Fig. 5.** Anogenital region and setae in *S. kumalariensis* deutonymph.

*Gnathosoma.* 53 (51-55) long. Subcapitulum with two pairs of setae. Dimensions and distances between subcapitular setae, *m* 14 (13-14), *n* 9 (8-9), *m-m* 17 (16-18), *n-n* 14 (13-15), *m-n* 7 (5-8). Chelicerae 71 (69-72) long. Palp 69 (68-71).

Female (n = 5) (Figs 6-9)

Length of body 320 (309-338), width 206 (191-226). Integument striated except for the shields. Dorsal shields reticulated. Propodosomal shield bearing a pair of eyes and setae *vi*, *ve* and *sci*. A pair of auxiliary shields bearing setae *sce*. Setae *c*<sub>1</sub> and *d*<sub>1</sub> on central shield. Setae *d*<sub>2</sub> located on marginal shields. Setae *e*<sub>2</sub> located on lateral zonal shields. Median zonal and intercalary shields paired, bearing setae *e*<sub>1</sub> and *f*<sub>1</sub>. Suranal shield entire, bearing two pairs of setae (*h*<sub>1</sub> and *h*<sub>2</sub>). All dorsal setae faintly barbed (Fig. 8). Humeral shields reticulated, bearing setae *c*<sub>2</sub>. Coxisternal shields divided in midline, bearing three pairs of intercoxal setae (*1a*, *3a* and *4a*). Three pairs of aggenital setae (*ag*<sub>1-3</sub>) on the aggenital shield. Genital shield bearing a pair of genital setae (*g*<sub>1</sub>). Anal shields bearing three pairs of pseudanal setae (*ps*<sub>1-3</sub>) (Fig. 6). Numbers of setae on legs I-IV: coxae 2-2-2-2, trochanters 1-1-2-1, femora 6-5-3-2, genua 2(+1κ)-2(+1κ)-0-0, tibiae 5(+1φρ)+1φ-5(+1φρ)-5(+1φρ)-5(+1φρ), tarsi 13(+1ω)-9(+1ω)-7(+1ω)-7(+1ω).



**Fig. 6.** Anogenital region and the setae in *S. kumalariensis* female. (*g*<sub>1</sub> = 1<sup>st</sup> pair of genital setae).

Male (n = 5) (Fig. 10)

Length of body 294 (288-305), width 173 (167-178). Resembles female in general appearance, but posterior of body narrower, genital setae absent, tarsus I-IV bearing two solenidia ( $\omega$  and  $\omega^{\text{♂}}$ ).

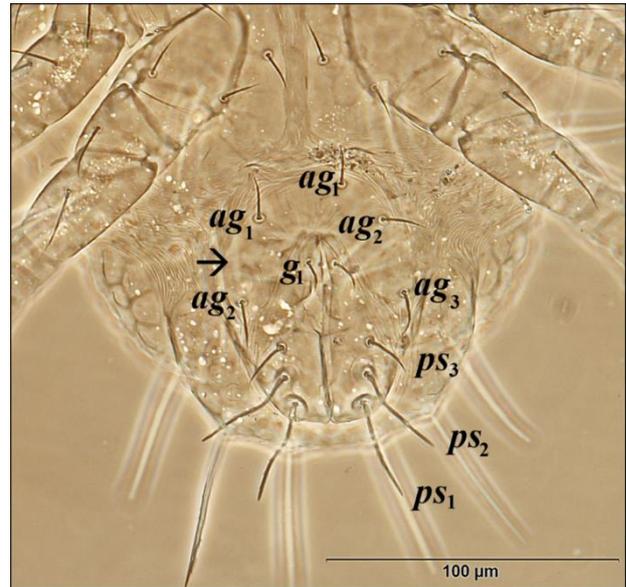
Other immature stages: Unknown.

Material examined: 5 females from litter in *Juncus heldreichianus* T. Marssoon ex Parl. (Juncaceae), 39°43'44"N 39°37'28"E, 31 January 2014; 31 females, 6 males and 4 deutonymphs from litter and soil, 39°42'37.11"N 39°37'43.52"E, 1139 m. a.s.l., 13 March 2018, Ekşisu marsh, Erzincan, Turkey.

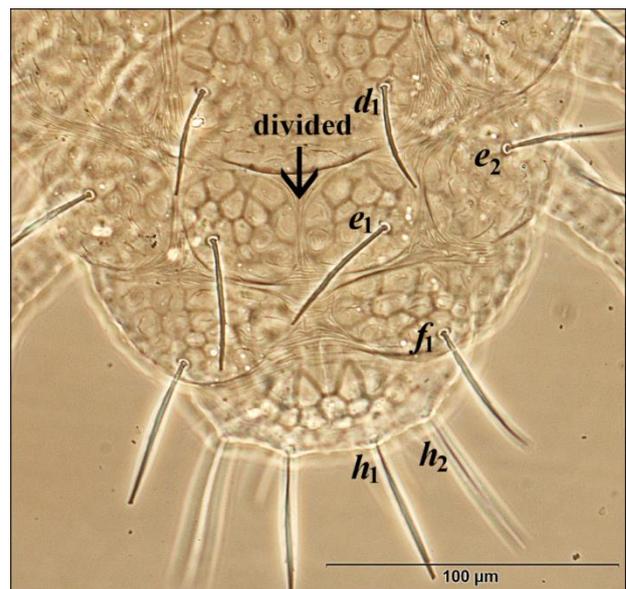
Distribution: Turkey (Afyonkarahisar, Hakkari and Erzincan) (Akyol & Koç 2007, Doğan et al. 2015b, Uluçay 2015a, Doğan 2019b).

### Variation

In the present study, a total of 46 specimens (36 females, 6 males and 4 deutonymphs) of *S. kumalariensis* were examined and variations in some adult specimens were found. The variations were determined in the structure of median zonal shields of one adult female (Fig. 9) and one adult male (Fig. 10), and in the number of aggenital setae (*ag*) of two adult females (Fig. 7). The median zonal shield in *S. kumalariensis* is normally divided (Fig. 8), and symmetrically three pairs of aggenital setae are present (Fig. 6). In the abnormal specimens examined, the median zonal shield is undivided (Figs 9, 10) and one aggenital seta on the left side of aggenital shield is absent (Fig. 7). This unilateral absence of the seta is a form of asymmetry.



**Fig. 7.** Variation in the number of aggenital setae in *S. kumalariensis* female.



**Fig. 8.** Divided median zonal shields in *S. kumalariensis* female.

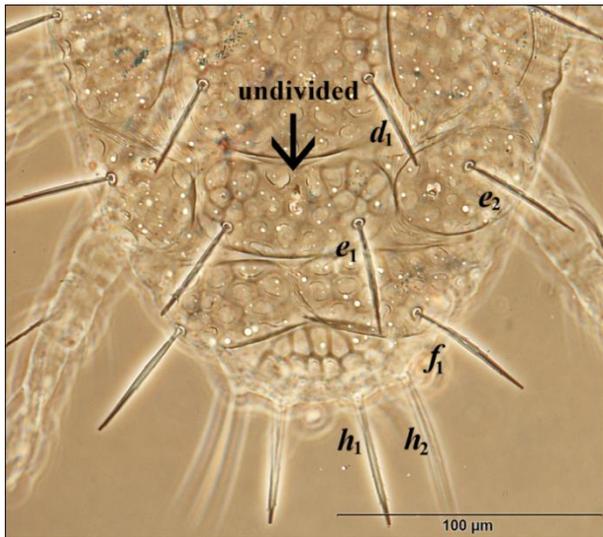


Fig. 9. Undivided median zonal shield in *S. kumalariensis* female.

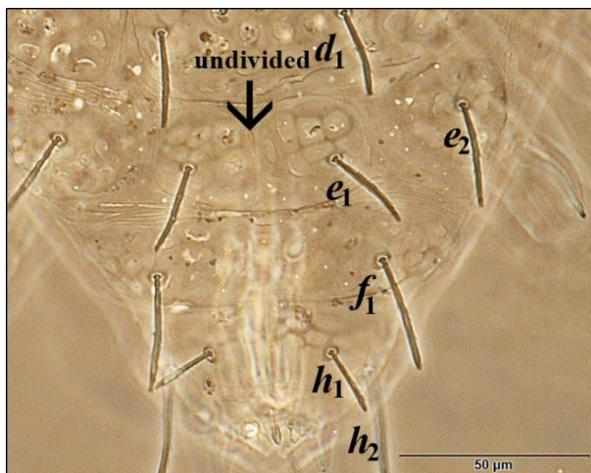


Fig. 10. Undivided median zonal shield in *S. kumalariensis* male.

#### Remarks

*Stigmaeus kumalariensis* was first discovered in Afyonkarahisar (type locality), and later reported from Hakkari and Erzincan in Turkey. Until now, female and male of this species have been known. The deutonymphal stage of the species is described for the first time in this study. Deutonymph specimens resemble adult females. Dorsal idiosoma and setae as in adult female. Ventral idiosoma similar to adult female, but genital setae absent (Figs 2, 5), with fewer setae on segments of the legs (trochanter IV and femur II) than those of adult female. Also, famulus  $\kappa$  is present on genu I and II in both adult female and male specimens as in Hakkari male specimens of the species (Uluçay 2015a), but in Afyonkarahisar specimens genu II lacks famulus  $\kappa$  (Akyol & Koç 2007).

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No variation was reported so far for *S. kumalariensis* (Akyol & Koç 2007, Uluçay 2015a). In the present study, variations in the structure of median zonal shields and in the number of aggenital setae were observed. In some studies, variations in the genus *Stigmaeus* have been reported. Variations in *S. elongatus* Berlese were recorded as lack of unilateral intercalary shield and numerical variations in form of presence or absence of intercoxal, suranal, dorsal, genital and aggenital setae (Doğan *et al.* 2019). Variations in location of aggenital setae in *S. longiclapeatus* Doğan, Doğan & Erman was mentioned by Doğan *et al.* (2017). Variations on location of central and aggenital setae and numerical variations in form of absence of intercoxal and aggenital setae have been reported in *S. longipilis* (Canestrini) by Dilkaraoğlu *et al.* (2016b). Variations in *S. erzincanus* Doğan, Bingül, Dilkaraoğlu & Fan were observed as lack of unilateral intercalary shield and as presence or absence of suranal, dorsal, genital and aggenital setae by Bingül *et al.* (2017b). Doğan *et al.* (2016) mentioned variations in structure of suranal setae of *S. solidus* Kuznetsov. Variations in the shape of some dorsal setae were reported in both *S. bifurcus* Bingül, Doğan & Dilkaraoğlu and *S. miandoabiensis* Bagheri & Zarei, as well as asymmetric variations in the number and structure of some setae in *S. bifurcus* (Bingül *et al.* 2017a). In conclusion, it is clear that most of the variations in *Stigmaeus* are in the form of unilateral or bilateral presence or absence of some body setae.

Unilateral absence of aggenital setae observed in *S. kumalariensis* is a common variation in *Stigmaeus*, but variation in structure of the median zonal shields is reported for the first time with this study. Entire or divided median zonal shields for identification of the species are considered to be an important character in the genus *Stigmaeus*. This variation was observed in only 2 adult specimens of all examined specimens. We consider that the fusion of median zonal shields in this species is a rare, but an important variation. Such variations among individuals of the same species can lead to misidentifications.

There is no certain explanation about what factors causes the variation. Observed asymmetric and structural variations may be the result of the interactions of genetic and environmental factors (Bingül *et al.* 2017b, 2018).

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