Acarologia 57(2): 355–363 (2017)
DOI: 10.1051/acarologia/20164160

Two new records of the genus *Kampimodromus* Nesbitt (Acari: Phytoseiidae) for Turkey with a revised key to the World species

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(Received 27 July 2016; accepted 28 September 2016; published online 20 April 2017; edited by Farid FARAJI)

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ABSTRACT — Two species of the genus *Kampimodromus* Nesbitt, *K. keae* (Papadoulis and Emmanouel) and *K. ragusai* Swirski and Amitai are reported for the first time in Turkey. The new records are re-described and illustrated. The male *K. ragusai* is described for the first time. The species status of *K. keae* and *K. ragusai* as valid species within the genus *Kampimodromus* is discussed. A revised key to all known species of *Kampimodromus* is provided.

KEYWORDS — *Kampimodromus*; re-description; movable digit dentition; peritreme length; identification key

ZOOBANK — B8125099-7FD8-4353-AECB-A31C7A03B8B0

INTRODUCTION

There are 15 nominal species in the genus *Kampimodromus* Nesbitt, 1951 (Acari: Phytoseiidae) belonging to the sub-family Amblyseiinae (Acari: Mesostigmata). They are characterized by having dorsal setal pattern 10A:8C with 18 pairs of dorsal setae (*S4* absent) including sub-laterals *r3* and *R1* (Chant and McMurtry, 2003). All *Kampimodromus* species were described from the Western Palearctic region except for *K. alettae* (Ueckermann and Loots) and *K. molle* (Ueckermann and Loots) which are known from South Africa (Ueckermann and Loots, 1985). Chant and McMurtry, (2003) postulated that the genus *Kampimodromus* evolved in the Mediterranean region and spread to other parts of the world from there. *Kampimodromus aberrans* (Oudemans, 1930) is the most widely distributed species recorded from almost all over Western Palearctic countries and the USA (Demite *et al*., 2016). However, it is doubtful if all recorded specimens are really *K. aberrans*.

In this study, *K. keae* (Papadoulis and Emmanouel, 1991) and *K. ragusai* Swirski and Amitai, (1997) are re-discovered for the first time after their original descriptions (Papadoulis and Emmanouel 1991; Swirski and Amitai 1997). The unknown male of *K. ragusai* is described and illustrated for the first time. In addition, an identification key for all known species of the genus *Kampimodromus* is given.

MATERIALS AND METHODS

Leaf samples were wrapped in paper towel and placed in plastic bags and the latter in an icebox. The samples were examined under stereobinoculer and phytoseiid mites mounted in Hoyer's medium

on microscope slides. An Olympus® U-DA drawing tube, was used for the illustrations. The taxonomic system is based on that proposed by Chant and McMurtry, (2007). The setal nomenclature used follow Lindquist and Evans, (1965) as adapted by Rowell *et al*., (1978). For the organotaxy, Athias-Henriot, (1975; 1977) was followed; for the ventral pores and leg chaetotaxy Evans, (1963) and Evans and Till, (1979); and Wainstein, (1973) for the spermatheca. The dorsal and ventral setal pattern notations follow Chant and Yoshida-Shaul, (1989; 1991; 1992). All measurements are given in micrometers (μm) and presented as the mean followed by the range in parenthesis.

RESULTS

Kampimodromus keae (Papadoulis and Emmanouel) (Figure 1)

Amblyseius keae Papadoulis and Emmanouel, 1991: 265.
Kampimodromus keae (Papadoulis and Emmanouel), Chant and McMurtry, 2003: 196; Tixier *et al*., 2003: 356; 2008: 133; Ragusa Di Chiara and Tsolakis, 1994: 312; Papadoulis *et al*. 2009: 45.

Female (Fig. 1) (n=1)

Dorsum (Fig. 1A) — Dorsal setal pattern 10A:8C (*r3* and *R1* off shield). Dorsal shield oval with waist, sclerotized, with a few striations posterolaterally and reticulated area between setae *j6* and *Z4*. Bearing four pairs of solenostomes (*gd1*, *gd2*, *gd6* and *gd9*); *gd1* and *gd9* rounded, *gd2* prominent, *gd6* crescentic; muscle-marks (sigilla) visible on podosoma, length of dorsal shield (*j1-J5*) 280, width (distance between bases of *s4*) 118 (distance between bases of *S2*) 133. Setae, *j4*, *j5*, *j6*, *J2*, *J5*, *z5*, and *Z1* are smooth, others are serrated. Measurements of dorsal setae as follows: *j1* 15, *j3* 28, *j4* 15, *j5* 15, *j6* 18, *J2* 20, *J5* 5, *z2* 28, *z4* 28, *z5* 15, *Z1* 20, *Z4* 30, *Z5* 40, *s4* 33, *S2* 33, *S5* 23, *r3* 30 and *R1* 23.

Peritreme — Extending to level of setae *z4*.

Venter (Fig. 1B) — Ventral setal pattern 14:JV-3:ZV. Sternal shield smooth, lightly sclerotized, with three pairs of setae (*ST1*, *ST2* and *ST2*) and two pairs of pores (*pst1* and *pst2*); length (*ST1-ST3*) 49, width (distance between bases of *ST2*) 46; metasternal setae *ST4* and a pair of pores (*pst3*) on metasternal shields. Genital shield smooth; width at level of genital setae (*ST5*) 43. Ventrianal shield elongate with waist at level of *JV2*; with a few striations; bearing three pairs of pre-anal setae (*JV1*, *JV2* and *ZV2*), a pair of para-anal (*Pa*) and a post-anal seta (*Pst*); a pair of small pores (*gv3*) posterior to *JV2* (distance between the *gv3* pores 20) and muscle-marks posterolaterally. Length of ventrianal shield 88, width 48. Setae *JV4*, *JV5*, *ZV1*, *ZV3*, and eight pairs of pores on integument surrounding ventrianal shield. Setae *JV5* serrated, much longer than other ventral setae, 25 in length.

Chelicera (Fig. 1C) — Fixed digit 25 long with two apical teeth and *pilus dentilis*; movable digit 25 long with one tooth.

Spermatheca (Fig. 1D) — Calyx cup-shaped 5 in length; with atrium small nodular, major duct long, minor duct not visible.

Legs (Fig. 1E) — Length of legs (base of coxae to base of claws) as follows: leg I 230, leg II 195, leg III 185, leg IV 245. Genu II, III, and IV with eight, seven and eight setae, respectively. Leg IV with one pointed macrosetae, *StIV* 15.

Material examined — One female, 16 June 2016, Kadincik Valley National Park, Mersin Province on *Quercus* sp. (Fagaceae).

World Distribution — Greece (Papadoulis and Emmanouel 1991; Papadoulis *et al*., 2009) and Turkey (this study).

Remarks — *Kampimodromus keae* is a new record for Turkish fauna. Turkish specimen well fit original description and re-descriptions of *K. keae* (Papadoulis and Emmanouel, 1991; Ragusa Di Chiara and Tsolakis, 1994; Papadoulis *et al*., 2009). However, the length of setae *Z5* and *r3* in the type material are, 34 and 36 oppose to 40 and 30 in Turkish specimen, respectively. According to Tixier *et al*., (2003), *K. keae* is suspected to be junior synonym of *K. aberrans* as they only differ, in the presence and absence of a tooth on movable digit (MD) of the chelicera, respectively (Tixier *et al*., 2003; Chant and McMurtry, 2003). *Kampimodromus ragusai* and

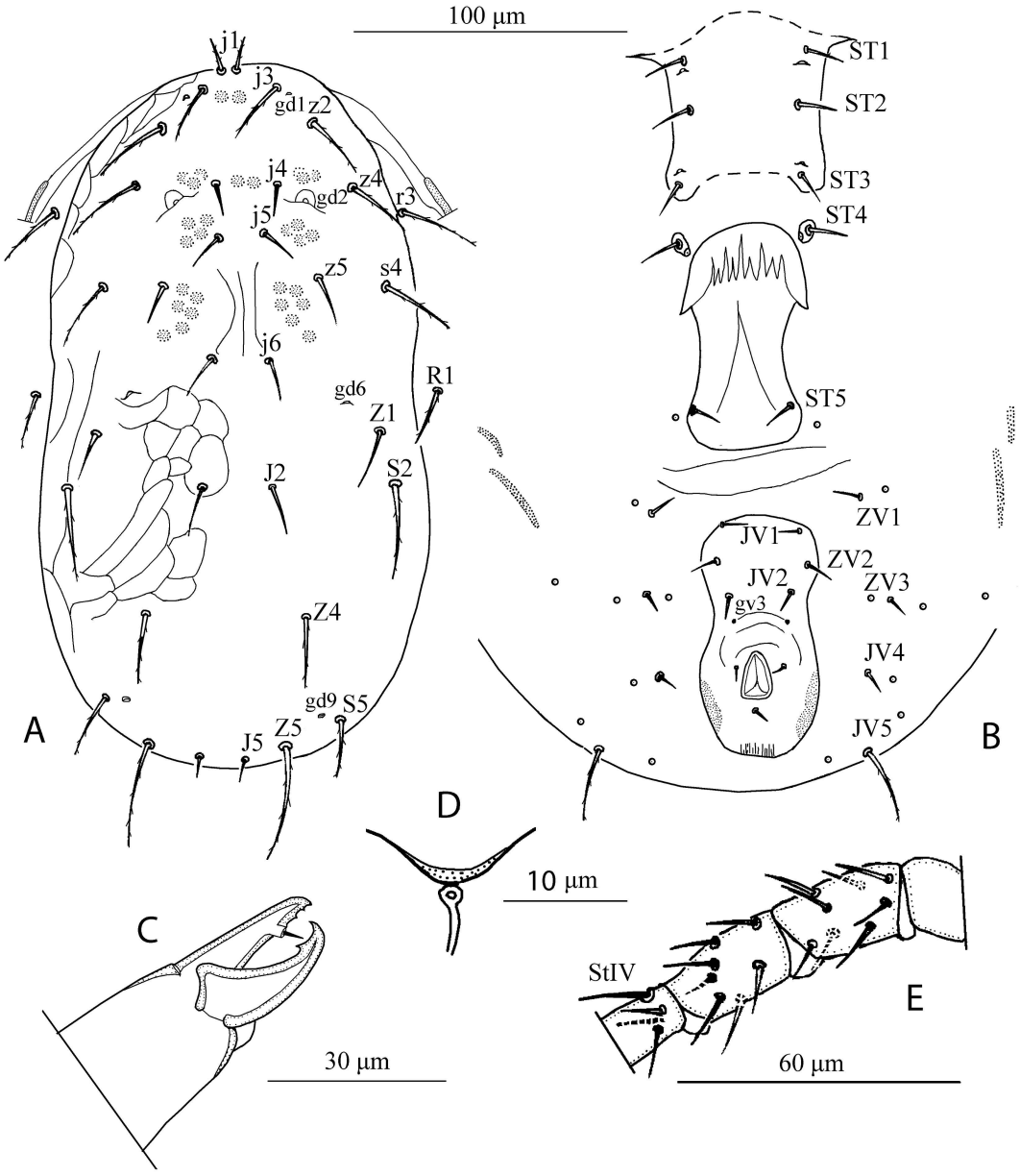


FIGURE 1: *Kampimodromus keae* (Papadoulis and Emmanouel) (Female): A – Dorsal shield; B – Ventral idiosoma; C – Chelicera; D – Spermathecae; E – Leg IV.

K. keae are also grouped together in an identification key provided by Tixier *et al*., (2008). However, it should be noted that *K. keae* has shorter peritremes compared to both *K. aberrans* and *K. ragusai* (Papadoulis and Emmanouel, 1991; Ragusa Di Chiara and Tsolakis, 1994). According to our three years collection, *K. ragusai* was never found together with neither *K. keae* nor any other phytoseiid species (see collection details of *K. ragusai*). But, *K. keae* was found together with a large population of *Typhloseiulus peculiaris* (Kolodochka, 1980) on *Quercus* sp. As the peritreme length did not vary in the examined specimens of *K. ragusai*, we consider them as two distinct species. But, nothing is known whether peritreme length is a reliable character for separation of species in the genus *Kampimodromus*. Therefore, it should be validated by molecular studies.

Kampimodromus ragusai Swirski and Amitai (Figure 2)

Kampimodromus ragusai Swirski and Amitai, 1997: 3; Swirski *et al*., 1998: 108; Chant and McMurtry, 2003: 196; Tixier *et al*., 2003: 356; 2008: 133.

Female (Fig. 2) (n=10)

Dorsum (Fig. 2A) — Dorsal setal pattern 10A:8C (*r3* and *R1* off shield). Dorsal shield oval with waist, sclerotized, with a few striations, bearing four pairs of solenostomes (*gd1*, *gd2*, *gd6* and *gd9*); first three are crescentic and *gd9* is rounded; muscle-marks (sigilla) visible, mostly on podosoma, length of dorsal shield (*j1-J5*) 290 (288 – 293), width (distance between bases of *s4*) 119 (118 – 120) (distance between bases of *S2*) 129 (128 – 130). Setae, *j4*, *j5*, *j6*, *J2*, *J5*, *z5*, and *Z1* are smooth, others are serrated. Measurements of dorsal setae as follows: *j1* 19 (18 – 20), *j3* 29 (28 – 30), *j4* 14 (13 – 15), *j5* 14 (13 – 15), *j6* 14 (13 – 15), *J2* 21 (20 – 23), *J5* 5, *z2* 31 (30 – 33), *z4* 30 (28 – 33), *z5* 14 (14 – 15), *Z1* 19 (18 – 20), *Z4* 41 (40 – 43), *Z5* 49 (48 – 50), *s4* 34 (33 – 35), *S2* 39 (38 – 40), *S5* 21 (20 – 23), *r3* 36 (35 – 38) and *R1* 26 (25 – 28).

Peritreme — Extending to level of setae *z2*.

Venter (Fig. 2B) — Ventral setal pattern 14:JV – 3:ZV. Sternal shield smooth, lightly sclerotized, with three pairs of setae (*ST1*, *ST2* and *ST2*) and two pairs of pores (*pst1* and *pst2*); length (*ST1-ST3*) 51 (50 – 53), width (distance between bases of *ST2*) 54 (53 – 55); metasternal setae *ST4* and a pair of pores (*pst3*) on metasternal shields. Genital shield smooth; width at level of genital setae (*ST5*) 46 (45 – 48). Ventrianal shield elongate with waist at level of *JV2*; with a few striations; bearing three pairs of pre-anal setae (*JV1*, *JV2* and *ZV2*), a pair of paraanal (*Pa*) and a post-anal setae (*Pst*); a pair of small pores (*gv3*) posterior to *JV2* (distance between the *gv3* pores 29) and muscle-marks posterolaterally. Length of ventrianal shield 91 (90 – 93), width 51 (50 – 53). Setae *JV4*, *JV5*, *ZV1*, *ZV3*, and eight pairs of pores on integument surrounding ventrianal shield. Setae *JV5* serrated, much longer than other ventral setae, 31 (30 – 33) in length.

Chelicera (Fig. 2C) — Fixed digit 23 (22 – 25) long with two apical teeth and *pilus dentilis*; movable digit 24 (24 – 25) long with one tooth.

Spermatheca (Fig. 2D) — Calyx cup-shaped 6 (5 – 8) in length; with atrium small nodular, major duct long, minor duct not visible.

Legs (Fig. 2E) — Length of legs (base of coxae to base of claws) as follows: leg I 236 (235 – 238), leg II 191 (190 – 193), leg III 184 (183 – 185), leg IV 244 (243 – 245). Genu II, III, and IV with eight, seven and eight setae, respectively. Leg IV with one pointed macrosetae, *StIV* 19 (18 – 20).

Male (Fig. 2) (n=5) Similar to female. But, dorsal shield is slightly reticulated.

Dorsum — Dorsal setal pattern 10A:8C (*r3* off shield, *R1* on shield). Dorsal shield oval, sclerotized, reticulated, bearing four pairs of solenostomes (*gd1*, *gd2*, *gd6* and *gd9*); all pores prominent; *gd2* is the largest. Length of dorsal shield (*j1-J5*) 209 (208 – 210), width (distance between bases of *s4*) 99 (98 – 100) and (distance between bases of *S2*) 101 (100 – 103). Serrations of the setae as in female. Measurements of dorsal setae as follows: *j1* 16 (15 – 18), *j3* 37 (36 – 39), *j4* 20 (19 – 21), *j5* 22 (21 – 24), *j6* 24 (23 – 25), *J2* 32(30 – 33), *J5* 7 (5 – 8), *z2* 35 (34 – 36), *z4* 40 (39 – 42), *z5* 22 (21 – 23), *Z1* 32 (31 – 33), *Z4* 37 (36 – 38), *Z5* 39 (38 – 40), *s4* 44 (43 – 45), *S2* 42 (40 – 43), *S5* 16 (15 – 18), *r3* 36 (35 – 38) and *R1* 26 (25 – 28).

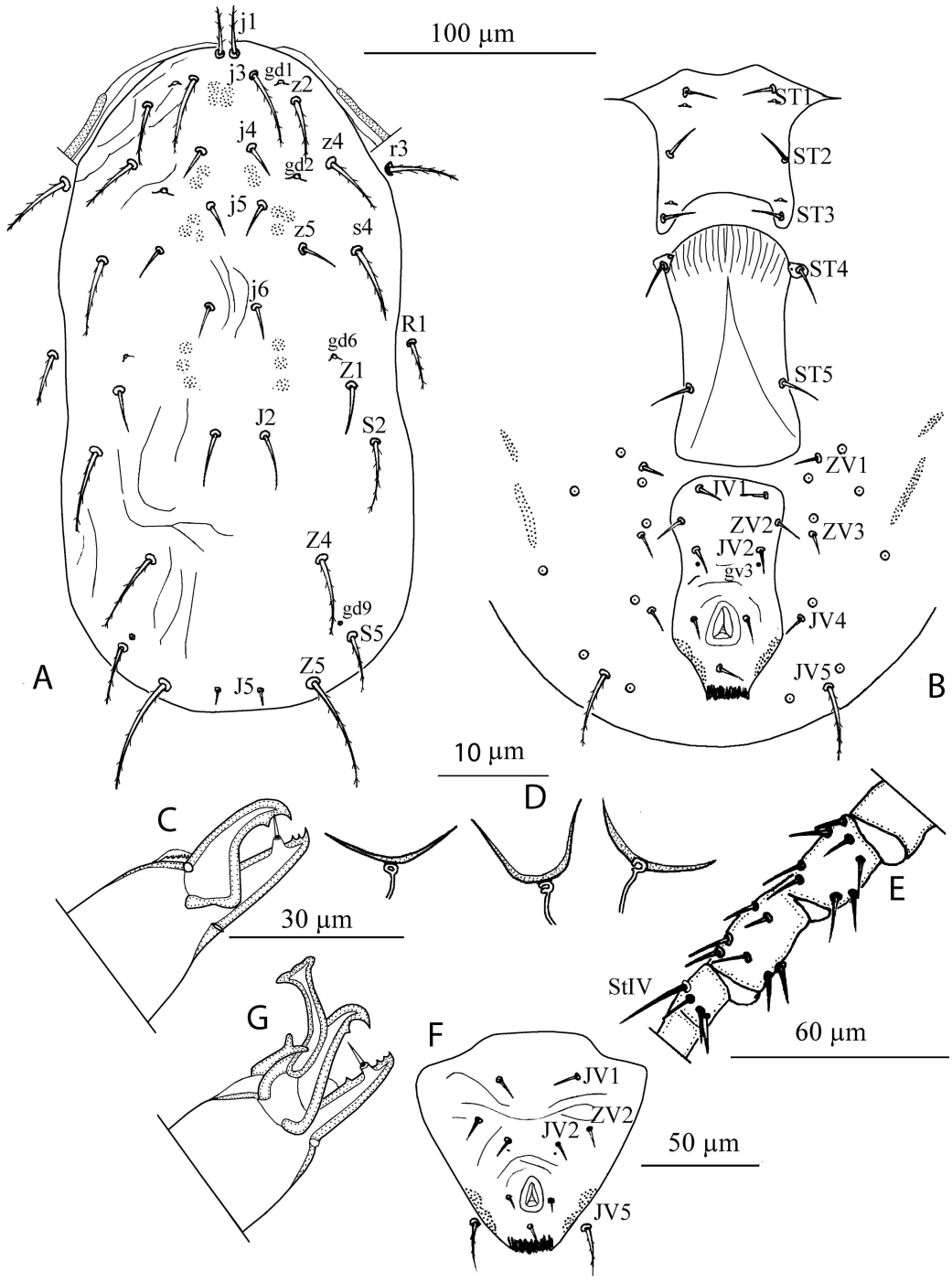


FIGURE 2: *Kampimodromus ragusai* Swirski and Amitai, (Female): A – Dorsal shield; B – Ventral idiosoma; C – Chelicera; D – Spermathecae; E – Leg IV. (Male); F – Ventrianal shield; G – Chelicera.

Peritreme — Extending to level of setae *z2*.

Venter (Fig. 2F) — Ventral setal pattern 11:JV – 3,4: ZV – 1,3. Sternogenital shield smooth, lightly sclerotized, with five pairs of setae (*ST1*, *ST2*, *ST3*, *ST4* and *ST5*) and three pairs of crescentic pores. Ventrianal shield triangular, with striations, bearing three pairs of pre-anal setae (*JV1*, *JV2* and *ZV2*), a pair of para-anal (*Pa*) and a post-anal setae (*Pst*); a pair of small pores (*gv3*) is present posterior to JV2; muscle-marks, posterolaterally. Length of ventrianal shield 89 (86 – 90), width 100 (99 – 103). Setae *JV5* serrated, much longer than other ventral setae, 19 (20 – 21) in length.

Chelicera (Fig. 2G) — Fixed digit with three teeth and *pilus dentilis*; two apically and the other behind *pilus dentilis*; movable digit with one tooth, spermatodactyl with a strong toe and an opposing heel. Foot 15 (14 – 16) long, (from basal attachment point to tip of toe).

Legs — Genu II, III, and IV with eight, seven and eight setae, respectively. Leg IV with one pointed macroseta, *StIV* 19 (18 – 20).

Material examined — 35 females and one male, 2 November 2014; 18 females and one male, 10 October 2015 associated with tydeid mites (Acari: Tydeidae); 21 females and two males, 17 March 2016; 10 females and one male 7 June 2016, associated with tydeid and tetranychid mites *Tetranychus* sp. (Acari: Tetranychidae), near Sunturas waterfall, Hangedigi town, Mersin Province on *Quercus cerris* (Fagaceae).

World Distribution — Israel (Swirski and Amitai, 1997) and Turkey (this study).

Remarks — *Kampimodromus ragusai* is a new record for Turkish fauna. The male *K. ragusai* is described for the first time in this study. Based on female, Turkish specimens well fit original description of *K. ragusai* given by Swirski and Amitai, (1997). However, the length of setae *Z4*, *Z5* and *S5* in the type material are 30, 38 and 13 oppose to 41, 49 and 21 in Turkish specimens, respectively. As in *K. keae* the only difference between *K. ragusai* and *K. aberrans* is also the presence and absence of a tooth on MD of the chelicera, respectively, therefore former was suspected to be junior synonym of the latter (Tixier *et al*., 2003; Chant and McMurtry, 2003). However, as suggested by Tixier *et al*., (2008), MD dentition is a reliable character for discrimination between *Kampimodromus* species that have similar numbers of solenostomes on the dorsal shield. In addition, all 84 females of the Turkish specimens of *K. ragusai* have one tooth on MD. These two species further differ in that the fixed digit (FD) of the male of *K. aberrans* bears two apical teeth (Ragusa Di Chiara and Tsolakis, 1994; Arutunjan, 1977) while that of the male of *K. ragusai* bears three teeth (two apically and the other behind the *pilus dentilis*). Therefore, we consider the presence of a tooth on MD of the female and presence of an additional tooth behind *pilus dentilis* on FD of the male *K. ragusai* as reliable characters to separate it from *K. aberrans*. Swirski and Amitai, (1997) reported that Genu II and IV each have eight setae, rarely seven setae. All the female Turkish specimens have eight setae on genu II and IV.

Notes on Identification Key

Ragusa Di Chiara and Tsolakis, (1994) provided first identification key for the genus *Kampimodromus* with eight species that were known at that time. Tixier *et al*. (2008) provided second key after confirming that movable digit dentition is a useful character. In addition to the number of solenostomes and movable digit dentition, the peritreme length should also be used for species diagnosis, as discussed earlier. *Kampimodromus elongatus* (Oudemans, 1930) was synonymized with *K. aberrans* by Chant, (1955) and Ragusa Di Chiara and Tsolakis, (1994). As suggested by Chant and McMurtry (2003), we treated *K. elongatus* as a valid species due to the presence of sublateral setae *R1* on dorsal shield. *Kampimodromus adrianae* Ferragut & Peña-Estévez 2003, and *K. vitis* (Oudemans, 1930) are also considered junior synonyms of *K. hmiminai* McMurtry Bounfour and *K. aberrans*, respectively (Chant, 1955; Tixier *et al*. 2006).

Key to known species of the genus *Kampimodromus* Nesbitt

1. Six pairs of solenostomes on dorsal shield; one pair of preanal setae on ventrianal shield 2
— Less than six pairs of solenostomes on dorsal

shield; two or three pairs of preanal setae on ventrianal shield 3

2. Preanal solenostomes present . . . . . *K. florinensis* Papadoulis, Emmanouel and Kapaxidi
— Preanal solenostomes absent . . . . . *K. hmiminai* McMurtry and Bounfour

3. Three pairs of solenostomes on dorsal shield. . . . . *K. judaicus* (Swirski and Amitai)
— Five or four pairs of solenostomes on dorsal shield 4

4. Four pairs solenostomes on dorsal shield 5
— Five pairs of solenostomes on dorsal shield 9

5. Movable digit of chelicera smooth 6
— Movable digit of chelicera with one tooth 8

6. Sub-lateral setae *R1* inserted on dorsal shield. . . . . *K. elongatus* (Oudemans)
— Sub-lateral setae *R1* on interscutal membrane . . 7

7. Preanal solenostomes present; Macroseta on basitarsus IV short about 20 μm in length; dorsal setae *Z1* almost half-length of setae *S2* . . . . . *K. aberrans* (Oudemans)
— Preanal solenostomes absent; Macroseta on basitarsus IV longer, about 30 μm in length; dorsal setae *Z1* longer than half-length of setae *S2 (Z1=almost 2/3 length of S2)* . . . . . *K. molle* (Ueckermann and Loots)

8. Peritreme short, extending to level of setae *z4*. . . . . *K. keae* (Papadoulis and Emmanouel)
— Peritreme longer, extending to level of setae *z2*. . . . . *K. ragusai* Swirski and Amitai

9. Ventrianal shield with two pairs of preanal setae. . . . . *K. alettae* (Ueckermann and Loots)
— Ventrianal shield with three pairs of preanal setae 10

10. Movable digit of chelicera with one tooth 11
— Movable digit of chelicera smooth 13

11. Peritreme short extending to level of sub-lateral setae *r3* . . . . . *K. echii* Ferragut and Peña-Estévez
— Peritreme longer, at least extending to level *z2*. 12

12. Macroseta on basitarsus IV pointed apically; peritreme extending to level between setae *j3-z2*. . . . . *K. coryli* Meshkov
— Macroseta on basitarsus IV knobbed apically; peritreme extending to setae level of *z2*. . . . . *K. langei* Wainstein and Arutunjan

13. Dorsal setae *J2* shorter than 25 μm . . *K. corylosus* Kolodochka
— Dorsal setae *J2* longer than 30 μm 14

14. Both dorsal setae *S5* and macrosetae on basitarsus IV smooth . . . . . *K. karadaghensis* Kolodochka
— Both dorsal setae *S5* and macrosetae on basitarsus IV slightly serrate . . . . . *K. ericinus* Ragusa Di Chiara and Tsolakis

ACKNOWLEDGEMENTS

This study was funded by Scientific Research Foundation of Çukurova University, Project Number: FBA-2015-4939. The authors would like to thank anonymous reviewers for their valuable suggestions on an early version of the manuscript. A part of this paper was presented at 8th Symposium of the European Association of Acarologists and appears in the abstract book of that meeting.

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