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

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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

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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 stereobinocular 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 JV2), 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. Sternum 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 (pstr3) on metasternal shields. Genital shield smooth; width at level of genital setae (ST5) 46 (45–48). Ventrianal shield elongate with waist at level of JV; 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 setae (Pst); a pair of small pores (gv3) posterior to JV (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, SIV (19–20).

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 (Pα) and a post-anal setae (Pσ); 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, SIV 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. hmininai 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 ventri-
anal shield .................................................. 3

2. Preanal solenostomes present .......... \textit{K. florinensis}
Papadoulis, Emmanouel and Kapaxidi
— Preanal solenostomes absent .......... \textit{K. hmiminai}
McMurtry and Bounfour

3. Three pairs of solenostomes on dorsal
shield........ ............................................. \textit{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 \textit{R1} inserted on dorsal
shield...................... ................................ \textit{K. elongatus}
(Oudemans)
— Sub-lateral setae \textit{R1} on interscutal membrane . 7

7. Preanal solenostomes present; Macroseta on ba-
sitarsus IV short about 20 \(\mu\)m in length; dorsal setae
\textit{Z1} almost half-length of setae \textit{S2} ...... \textit{K. aberrans}
(Oudemans)
— Preanal solenostomes absent; Macroseta on ba-
sitarsus IV longer, about 30 \(\mu\)m in length; dorsal se-
tae \textit{Z1} longer than half-length of setae \textit{S2} (\textit{Z1}=\textit{almost}
\(2/3\ \text{length of } \textit{S2}) ................................ \textit{K. molle}
(Ueckermann and Loots)

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

9. Ventrianal shield with two pairs of preanal se-
tae.......................................................... \textit{K. alettae}
(Ueckermann and Loots)
— Ventrianal shield with three pairs of preanal se-
tae.......................................................... 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 \textit{r3}.................................................. \textit{K. echii}
Ferragut and Peña-Estévez
— Peritreme longer, at least extending to level
\textit{z2}.................................................. 12

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

13. Dorsal setae \textit{j2} shorter than 25 \(\mu\)m .... \textit{K. corylosus}
Kolodochka
— Dorsal setae \textit{j2} longer than 30 \(\mu\)m ........ 14

14. Both dorsal setae \textit{S5} and macrosetae on basitar-
sus IV smooth ................................ \textit{K. karadaghensis}
Kolodochka
— Both dorsal setae \textit{S5} and macrosetae on basitar-
sus IV slightly serrate .................. \textit{K. ericinus}
Ragusa Di Chiara and Tsolakis

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