



A complementary description of *Kampimodromus corylosus* Kolodochka (Acari: Phytoseiidae) and a revised key for the genus *Kampimodromus* Nesbitt

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ABSTRACT: *Kampimodromus corylosus* Kolodochka (Acari: Phytoseiidae), which is reported for the first time from Türkiye, is re-described and illustrated, based on female specimens collected from hazelnut (*Corylus avellana* L., Betulaceae). In addition, the reinstatement of *K. adrianae* Ferragut and Peña-Estévez as a valid species is proposed. A revised identification key for the world's *Kampimodromus* Nesbitt species is also provided.

Keywords: Identification key, Kampimodromini, new record, Phytoseiidae, predatory mites, redescription

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INTRODUCTION

Kampimodromus Nesbitt (Acari: Phytoseiidae) species are generalist predators predominantly living on pubescent leaves and exhibiting "Type IIIa" feeding behavior (McMurtry et al., 2013). *Kampimodromus aberrans* (Oudemans, 1930), which was the first species described, is widely distributed, having been documented across various areas of the Western Palearctic Region and the USA (Demite et al., 2014). In Europe, this species is naturally found on a broad range of cultivated plants, including grapes, hazelnuts and apples, and is considered an efficient predator of phytophagous mites (Kasap, 2005; Ozman-Sullivan, 2006; Duso et al., 2014).

In Türkiye, five species of the genus — *K. aberrans*, *K. ericinus* Ragusa Di Chiara and Tsolakis, 1994, *K. keae* (Papadoulis and Emmanouel, 1991), *K. langei* Wainstein and Arutunjan, 1973 and *K. ragusai* Swirski and Amitai, 1997 — have been reported, based on specimens collected from various host plants, especially from *Quercus* spp. (Fagaceae) (Kasap, 2005, 2010; Ozman-Sullivan, 2006; Döker et al., 2017, 2018; Sağlam et al., 2022).

In this study, we collected *K. corylosus* Kolodochka, 2003 from hazelnut [*Corylus avellana* L. (Betulaceae)] in Samsun Province on the Black Sea coast of Türkiye. It is re-described and illustrated, based on female specimens, to further improve diagnosis. We also propose the reinstatement of *K. adrianae* Ferragut and Peña-Estévez, 2003 as a valid species. Moreover, we provide a revised identification key for the *Kampimodromus* species of the world.

MATERIALS AND METHODS

Leaves were collected from hazelnut plants in the Gürgenyatak/Canik district of Samsun Province on the north coast of Türkiye. The collected samples were wrapped in paper, placed in labelled plastic bags, and stored in an icebox until they were transferred to the laboratory. The

leaves were then examined for mites under a stereomicroscope and all collected mites were stored in 70% alcohol until they were cleared in 60% lactic acid and mounted on slides in Hoyer's medium. The slides were then incubated at 50 °C for a week. Permanent slides were examined with an Olympus® CX-41 microscope. Illustrations were prepared with a U-Da drawing attachment (Camera Lucida). The taxonomic system used followed that of Chant and McMurtry (2007), with setal nomenclature according to Lindquist and Evans (1965), as adapted by Rowell et al. (1978). The dorsal and ventral setal pattern references were from Chant and Yoshida-Shaul (1989, 1991, 1992), the nomenclature for solenostomes on the dorsal idiosoma followed that of Athias-Henriot (1975), and the leg chaetotaxy followed that of Evans (1963). Measurements are provided in micrometers, presented as the mean, followed by the range in parentheses. The examined specimens are deposited in the mite collection of the Acarology Laboratory, Cukurova University, Adana, Türkiye.

RESULTS AND DISCUSSION

Firstly, *Kampimodromus corylosus*, which is reported from Türkiye for the first time, is re-described from female specimens collected in Samsun Province. Secondly, a justification for the reinstatement of *K. adrianae* as a valid species is provided. Thirdly, a revised key for *Kampimodromus* species is included to reflect that change.

Diagnosis and redescription of *Kampimodromus corylosus* Kolodochka

Kampimodromus corylosus Kolodochka, 2003: 51.

Kampimodromus corylosus Kolodochka: in Cargnus et al., 2012: 590; Döker et al., 2022: 1073.

Diagnosis. Idiosomal setal pattern 10A:8C/JV-3: ZV (*r*3 and *R*1 off shield). Dorsal shield sclerotized, mostly striated; with slight waist at level of *R*1; with five pairs of so-

lenostomes (*gd1*, *gd2*, *gd6*, *gd8*, and *gd9*); dorsal setae serrated except *j4*, *j5*, *j6*, *J2*, *z5* and *Z1* smooth. Peritremes extending between setae *j3*-*z2*. All ventral shields smooth, except ventrianal shield with a few posterior striations; sternal shield with three pairs of setae; ventrianal shield elongated, with three pairs of preanal setae and a pair of minute preanal solenostomes located posteromesad to setae *JV2*; seta *JV5* serrated. Spermatheca with short, cup-shaped calyx and nodular atrium, attached to calyx without neck. Fixed digit of chelicera with three subapical teeth and movable digit without tooth. Leg IV with one serrated macroseta. Genu II and IV each with eight (2 2/1 2/0 1) setae and tibia IV with seven setae (1 1/1 2/0 2).

Re-description

Female (n=4).

Dorsal idiosoma (Fig. 1A). Dorsal setal pattern 10A: 8C (*r3* and *R1* off shield). Dorsal shield mostly striated, with slight waist at level of seta *R1*, with five pairs of solenostomes (*gd1*, *gd2*, *gd6*, *gd8* and *gd9*). Muscle-marks (sigillae) visible mostly on podosoma; length of dorsal shield 282 (280–284), width at level of *s4* 160 (156–163), width at level of *S2* 164 (163–165). Dorsal setae serrated, except *j4*, *j5*, *j6*, *J2*, *z5* and *Z1* smooth. Measurements of dorsal setae as follows: *j1* 20 (18–21), *j3* 27 (25–30), *j4* 15 (13–17), *j5* 14 (12–15), *j6* 16 (14–18), *J2* 20 (17–23), *J5* 8 (6–9), *z2* 25 (24–26), *z4* 34 (32–37), *z5* 16 (14–18), *Z1* 21 (18–24), *Z4* 40 (37–43), *Z5* 52 (49–55), *s4* 43 (38–47), *S2* 44 (40–48), *S5* 18 (17–20), *r3* 40 (38–42), and *R1* 25 (23–27). Peritremes extending between setae *j3*-*z2*.

Ventral idiosoma (Fig. 1B). Ventral setal pattern 14: *JV*-3: *ZV*. Sternal shield smooth, with three pairs of setae (*ST1*-*ST3*) and two pairs of poroids (*iv1*, *iv2*); distance between bases of setae *ST1*-*ST3* 59 (56–61), distance between bases of setae *ST2* 56 (55–58); metasternal setae *ST4* and poroids *iv3* on metasternal shields. Genital shield smooth with one pair of setae *ST5*; width at level of *ST5* 49 (48–50); one pair of para-genital poroids *iv5* on soft cuticle. Ventrianal shield elongate, mostly smooth except for some posterior striations, with three pairs of pre-anal setae (*JV1*, *JV2*, and *ZV2*), one pair of para-anal setae *PA*, unpaired post-anal seta *PST*, and a pair of minute solenostomes (*gv3*) posteromedian to *JV2*. Length of ventrianal shield 92 (89–94), width at level of *ZV2* 54 (50–58). Four pairs of caudoventral setae (*ZV1*, *ZV3*, *JV4* and *JV5*) and six pairs of poroids (five *ivo* and *ivp*) on soft cuticle surrounding ventrianal shield. Setae *JV5* serrated, 35 (34–35) in length.

Chelicera (Fig. 1C). Fixed digit 24 (23–25) long, with three teeth clustered sub-apically and pilus dentilis; movable digit 24 (23–25) long, without tooth.

Spermatheca (Fig. 1D). Calyx short, cup-shaped, 8 (6–10) long, atrium nodular, connected to calyx without neck, major duct long, narrow, minor duct visible.

Legs (Figs 2A-D). Leg I 262 (260–264), II 209 (205–213), III 195 (190–200), IV 279 (265–286) in length. Chaetotaxy of legs as follows: Leg I: coxa 0 0/1 0/1 0, trochanter 1 0/1 0/2 1, femur 2 3/1 2/2 2, genu 2 2/1 2/1 2, tibia 2

2/1 2/1 2. Leg II: coxa 0 0/1 0/1 0, trochanter 1 0/1 0/2 1, femur 2 3/1 2/1 1, genu 2 2/1 2/0 1, tibia 1 1/1 2/1 1. Leg III: coxa 0 0/1 0/1 0, trochanter 1 1/1 0/2 0, femur 1 2/1 1/0 1, genu 1 2/1 2/0 1, tibia 1 1/1 2/1 1. Leg IV: coxa 0 0/1 0/0 0, trochanter 1 1/1 0/2 0, femur 1 2/1 1/0 1, genu 2 2/1 2/0 1, tibia 1 1/1 2/0 2. Leg IV with one macroseta *StIV* (*pd3*) 22 (21–23), usually with two barbs, smooth in one specimen. Other legs without macrosetae.

Male. Not collected in this study.

Material examined. Four females from hazelnut, *C. avellana* in Gürgenyatak village, Canik, Samsun, Türkiye (41° 13' 32 "N, 36° 21' 50" E, 513 meters above sea level); collected by S.K. Ozman-Sullivan and G.T. Sullivan on 01 October 2021.

Discussion. *Kampimodromus corylosus* was described from specimens mostly collected from hazelnut, *C. avellana*, in Ukraine and Moldova. The current study reports *K. corylosus* for the first time from Türkiye. The morphological characters and measurements of the newly collected specimens are almost identical to the original description and redescrptions (Cargnus et al., 2012; Döker et al., 2022). We re-examined the Belgian specimens reported by Döker et al. (2022) and confirm that the measurements of dorsal seta *j3* are not 21 (21–22) but 31 (31–32). Also, the preanal solenostomes in the Belgian specimens are small and circular, not crescentic, as in the original description and the redescription provided here.

Notes on the identification key for the genus *Kampimodromus*

The identification key provided in this study for 16 species of *Kampimodromus* is based on the previous key by Döker et al. (2017). However, in the present study, we resurrected *K. adrianae* to valid species status and included it in the key due to the distinct differences in its dorsal setal length especially for dorsocentral setae and serrations on *j4*, *j5*, *j6*, *J2*, *Z5*, *Z1* and *S5*. Tixier et al. (2006) suspected that *K. adrianae* is a junior synonym of *K. hmiminai* McMurtry and Bounfour, 1989 based on COI sequences from populations collected from *Salix canariensis* Chr. Sm. ex Link (Salicaceae) in the Canary Islands and *Ficus carica* L. (Moraceae) in Meknes, Morocco. The same authors stated that the genetic distance between these two species was similar to the distance between two populations of *K. aberrans* which were collected from *Celtis australis* L. (Ulmaceae) and *Quercus pubescens* Willd. (Fagaceae) in Montpellier, France. However, Döker et al. (2018) used four species of *Kampimodromus* to construct a phylogenetic tree based on their ITS sequences and the sequences available in the GenBank database. The phylogenetic tree of Döker et al. (2018) showed that the sequence, HQ404798, deposited as *K. aberrans*, originating from a population collected from *C. australis* in Montpellier, France is identical to *K. corylosus*. Therefore, at least one of the two *K. aberrans* populations identified by Tixier et al. (2006) is likely to be *K. corylosus*. This situation appears to negate the argument of Tixier et al. (2006) that the genetic difference between *K. hmiminai* and *K. adrianae* is the same as that between two populations of *K.*

aberrans. In that light, we propose the reinstatement of *K. adrianae* as a valid species due to the distinct differences in its dorsal setal lengths, until more accurate morphological and molecular studies, and possibly cross-breeding experiments, are conducted.

Revised key to the genus *Kampimodromus* Nesbitt, 1951 (Modified from Döker et al., 2017)

1. Six pairs of solenostomes on dorsal shield (*gd1*, *gd2*, *gd4*, *gd6*, *gd8* and *gd9*).....2
 - Less than six pairs of solenostomes on dorsal shield (at least *gd4* absent, *gd1* and *gd8* present/absent).....4
2. Setae *Z1* and *S5* smooth; ratio setae *s4:Z1* > 4:1.....3
 - Setae *Z1* and *S5* serrated; ratio setae *s4:Z1* < 3:1.....*K. adrianae* Ferragut and Peña-Estévez
3. Preanal solenostomes absent.....*K. hmiminai* McMurtry and Bounfour
 - Preanal solenostomes present.....*K. florinensis* Papadoulis, Emmanouel and Kapaxidi
4. Three pairs of solenostomes on dorsal shield (*gd2*, *gd6* and *gd9*).....*K. judaicus* (Swirski and Amitai)
 - Four or five pairs of solenostomes on dorsal shield (*gd8* absent or present).....5
5. Four pairs of solenostomes on dorsal shield (*gd8* absent)6
 - Five pairs of solenostomes on dorsal shield (*gd8* present).....10
6. Movable digit of chelicera smooth.....7
 - Movable digit of chelicera with one tooth.....9
7. Sub-lateral setae *R1* of females inserted on dorsal shield..... *K. elongatus* (Oudemans)
 - Sub-lateral setae *R1* of females on soft cuticle.....8
8. Macroseta on basitarsus IV short about 20 µm in length; dorsal setae *Z1* almost half-length of setae *S2*.....*K. aberrans* (Oudemans)
 - Macroseta on basitarsus IV longer, about 30 µm in length; dorsal setae *Z1* longer, about 2/3 length of *S2*)..... *K. molle* (Ueckermann and Loots)
9. 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
10. Ventrianal shield with two pairs of preanal setae.....*K. alettae* (Ueckermann and Loots)

- Ventrianal shield with three pairs of preanal setae..... 11
- 11. Movable digit of chelicera smooth.....12
 - Movable digit of chelicera with one tooth.....14
- 12. Dorsal setae *J2* shorter than 25 µm.....*K. corylosus* Kolodochka
 - Dorsal setae *J2* longer than 30 µm.....13
- 13. Both dorsal seta *S5* and macroseta on basitarsus IV smooth.....*K. karadaghensis* Kolodochka
 - Both dorsal seta *S5* and macroseta on basitarsus IV slightly serrate.....*K. ericinus* Ragusa Di Chiara and Tsolakis
- 14. Peritreme short extending to level of sub-lateral setae *r3*.....*K. echii* Ferragut and Peña-Estévez
 - Peritreme longer, at least extending to level *z2*.....15
- 15. 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 level setae level of *z2*.....*K. langei* Wainstein and Arutunjan

Authors' contributions

Ismail Döker: Identification of mite species, visualization, writing original draft, review-editing. **Sebahat K. Ozman-Sullivan:** Material collection, review-editing, funding. **Gregory T. Sullivan:** Material collection, review-editing, resources.

Statement of ethics approval

Not applicable.

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Conflict of interest

The authors declare that they have no conflicts of interest with respect to this study.

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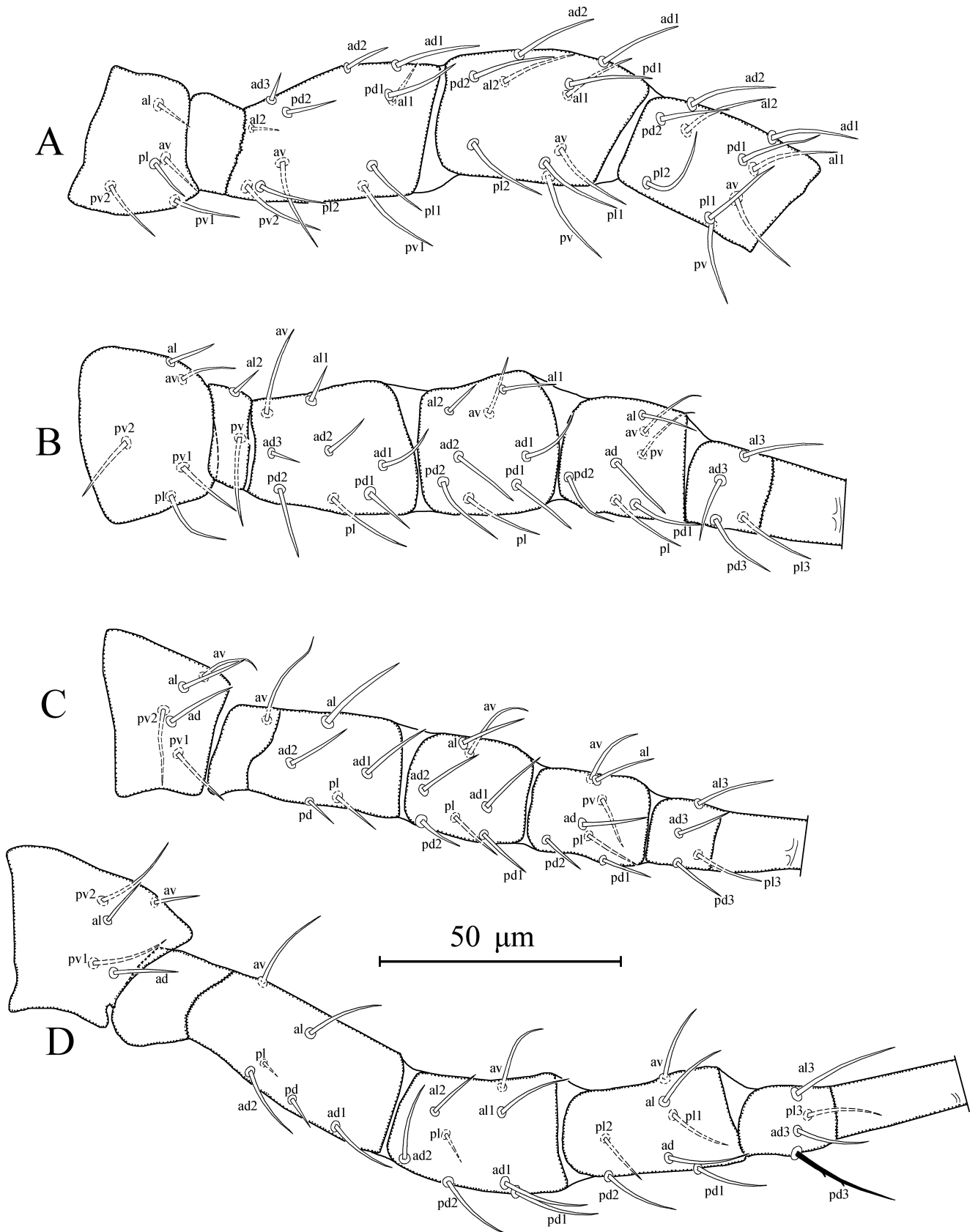


Figure 2. *Kampimodromus corylosus* Kolodochka, 2003 female right legs: A. Leg I (coxa and tarsus omitted), B. Leg II (coxa and tarsus omitted), C. Leg III (coxa and tarsus omitted), D. Leg IV (coxa and telotarsus omitted). Macroseta drawn in solid black for clarity.

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