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New species of genus *Dinogamasus* Kramer (Mesostigmata, Laelapidae) associated with large carpenter bees (Hymenoptera: Apidae) in Egypt, with new concepts of the genus

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Original research

ABSTRACT

The Laelapid family of cosmopolitan mites includes both free-living predators and associated species to arthropods, mammals, or birds. A new species of laelapid mite, *Dinogamasus pubescensae* **n. sp.** Abo-Shnaf & Kamel associated with *Xylocopa pubescens* Spinola (Hymenoptera: Apidae), is described and illustrated. This is a third report of the genus *Dinogamasus* from Egypt. The new species can be distinguished from its congeners by the combination of the following characters: dorsal cheliceral seta present; hypertrichous idiosoma and opisthogaster; sternum without accessory setae, *st2* longest, *st4* present, endopodal and metapodal plates present, genital shield shorter than anal shield, anal shield rectangular. The genus diagnoses are discussed in terms of new notions. Modification of Lundqvist's key (1999) is made to facilitate identification of *D. pubescensae* **n. sp.** Abo-Shnaf & Kamel from other species.

Keywords systematic; insect; Gamasida; commensalism; Suez-Canal; pollinators
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Introduction

Family Laelapidae is one of Dermanyssoidea, a superfamily that includes free-living and parasitic forms (Lindquist *et al.* 2009). Laelapidae including free-living predators that live in soil-litter habitats and arthropod, mammal and bird associates (Faraji and Halliday 2009; Moreira and Moraes 2015).

Genus *Dinogamasus* Kramer is strictly associated with Xylocopine bees (Hymenoptera: Apidae) (Lundqvist 1999), in which females have a chitinous pouch-like acarinarium inside the first metasomal tergum where the mites are live and transport (LeVeque 1930; Watmough 1974; Michener 2007; Makino *et al.* 2018). *Dinogamasus* species are symbiotic mites, they are not parasites on bee, but are harmless mites.

A comprehensive taxonomic investigation on the genus *Dinogamasus* was mad by (Lundqvist 1999), clarifying the diagnostic of the genus, examining the world species, and revising the generic concept and morphological features. Moreover, Moraes *et al.* (2022) performed the most recent revision of the genus concept.

Genus *Dinogamasus* has 44 described species so far, almost all of which are from the Africa; Middle East; East, South and Southeast Asia (Moraes *et al.* 2022).

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Most species are associated with *Xylocopa*, subgenera *Mesotrichia* or *Koptortosoma*. Only *Dinogamasus inflatus* LeVeque, 1930 associated with *Xylocopa pubescens* (Van Eyndhoven 1964; Moraes *et al.* 2022) (reported as *Mesotrichia aestuans* in LeVeque 1930: 15) was recorded from the Western Palaearctic region. The new species was collected from the same host, indicating that to have different mite species on the same host. The *Xylocopa pubescens* carrying *Dinogamasus* mites might have extended its range from Africa to the Middle East (Joharchi *et al.* 2016).

The bees have a special structure called "acarinaria" to carry the mites (Madel 1974; Eickwort 1994) whereas *Dinogamasus* mites exploited for phoresy by other smaller mite species (OConnor 1993; Okabe and Makino 2002).

The *Dinogamasus* mites are phoretic on carpenter bees, and develop in the cells with the bee larvae (Lundqvist 1999). They are not parasites, they do not seem to harm their hosts in any way, they are to be harmless feeders on only bee exudates, not any other tissues, or predators feed other small associated invertebrates (Skaife 1952). The complex association between *Dinogamasus* and *Xylocopa* species shows the actual fitness effects of a mite-bee interaction can be difficult to assess (Walter *et al.* 2002).

The *Dinogamasus* mites appear to consume pollen grains that cling to bee larvae and convert the pasty faeces to a firmer, drier state (Houston 1987). While, immature stages develop on the bee larvae or pupae, apparently feeding on secretions by the developing bees and not harming their hosts (Lundqvist 1999; Walter and Proctor 1999).

Observation of Madel (1974) indicated that *Dinogamasus* mites present around the host juvenile without harming it, where mutualism to remove microorganisms has been suggested (OConnor 1993; Eickwort 1994). *Dinogamasus* feeds on the surfaces of carpenter bee brood and may confer a benefit to the host by consuming various microbes, therefore keeping cleanness in the nest (Madel 1975; Eickwort 1994). This must mean that the mites are beneficial to the bees.

Only one species of *Dinogamasus* have so far been recorded in Egypt—*Dinogamasus inflatus* which was found phoretic on *Xylocopa pubescens* at Giza, Sharkia, Ismailia, and Beheira governorates (Zaher *et al.* 1980; El-Kawas 2011). Thus, the main goal of the present work is to describe a new species of genus *Dinogamasus* associated with *X. pubescens* bees from Suez-Canal region, Ismailia governorate.

Material and methods

Several bee insects, *Xylocopa pubescens* were collected at Suez-Canal region, Ismailia governorate using a sweep net. All of the new *Dinogamasus* specimens were obtained from 14 bee insects collected at three locations at Suez-Canal region, Ismailia governorate during 2022 as follows: 1) the Faculty of Agriculture Farm (30°13′34.46″N, 32°27′56.88″E), Suez-Canal University; 2) Abu Suwayr village (30°34′15.78″N, 32°06′55.12″E); and 3) Serapeum village (30°36′07.31″N, 32°06′55.01″E).

The location where the bee insects were collected is with a dry climate, Ismailia governorate and the collecting localities are located in North-eastern, Egypt at the north and middle terminals of the Suez-Canal. Mango, *Mangifera indica* L., Anacardiaceae is the most common fruit grown at Ismailia governorate, though a wide variety of crops and fruits are also grown there. *Brassica* spp. (Brassicaceae), *Medicago sativa* L., *Trifolium alexandrinum* L., and *Vicia faba* L. (Fabaceae) were the plants from which bees were collected.

All mite specimens were isolated from inside the acarinarium of *X. pubscens* bees. For examination, mite specimens were examined using a phase contrast (Olympus, BHA©) microscope after mounted in Hoyer's medium on microscope slides. The new mite species' taxonomically significant structures were illustrated with the help of Adobe Illustrator Software (2020). Mite structure measurements are provided in micrometers using a graded ocular micrometer and an eyepiece attached to a phase contrast microscope. Structure measurements

demonstrate the average for the total number of individuals followed by the corresponding ranges in parentheses. The length and width of the dorsal shield were taken from the anterior margin anteriad the bases of *j1* to the caudal margin posteriad the bases of *J5*, and at levels indicated as their widest point. Length and width of the sternal and genital shields were measured as the maximum length, and broadest points. The length and width of the anal shield were taken from the anterior margin to the posterior edge of the cribrum, and at levels indicated as their widest point. The length of legs was taken from the base of the coxa to the tip of the tarsus, including the pre-tarsus. The length of fixed and movable cheliceral digits were taken from the bases of the digits to apex of the digits. Leg nomenclature for setal follows Evans (1963a). Nomenclature for the dorsal idiosoma and opisthogastric region is based on Evans and Till (1965) and Lindquist (1994), respectively. Palp setae follows Evans (1963b); proidataxy is based on Athias-Henriot (1975), as interpreted by Kazemi et al. (2014).

Many leg setae variously modified in shape as follows: "macro" for long setae, "micro" for minute setae, "conical form" for thick and distally pointed setae, "truncated" for thick and distally blunt setae, "hooked" for distally bent and hook shaped setae.

Systematics

Dinogamasus Kramer

Dinogamasus Kramer, 1898: 417.

Type species: *Dinogamasus crassipes* Kramer, 1898, by monotypy.

Dinogamasus – Joharchi *et al.* 2016: 792; Moraes *et al.* 2022: 226.

Genus *Dinogamasus* has a complex nomenclatural history reviewed by LeVeque 1930, Van Eyndhoven 1941, and Lundqvist 1999.

Diagnosis — The complete diagnosis of genus *Dinogamasus* was given in Lundqvist (1999).

Short diagnosis was recently done by Moraes *et al.* (2022).

Dinogamasus pubescensae n. sp. Abo-Shnaf & Kamel

Zoobank: B92BB367-42BC-42AF-9700-BAA63D5942DE

Figures (1–5)

Diagnosis

Fixed cheliceral digit less than half the length of movable digit with three teeth and *pilus dentilis* in subapical tip; dorsal cheliceral seta present; palp-coxal seta (*pc*) and palp-trochanter seta (*pv*) with base inflated; several setae thickened and modified on palp-tibia; one long ventral seta on palp-femur not reach tip of palp. Idiosoma strongly reticulate, hypertrichy laterally, opisthonotal median region with some unpaired and asymmetrical setae, dorsal setae overlapping. Sternal with two pairs of long setae (*st1-st2*), without accessory setae; *st1* long enough to reach base of *st3*; *st2* longest, long enough to reach *st4*; metasternal *st4* present; distance *st3-st3* shorter than *st1-st1*; endopodal and metapodal plates present; genital shield shorter than anal shield; more than ten long setae between genital and anal shields; anal shield rectangular, opisthogaster hypertrichy, para-anal setae long enough to reach the base of post-anal seta. Setae *ad1-ad3* on femur I, *ad1* on femur II, *pd1-pd2* on femora I-II macrosetae; seta *Pl2* on femur I missing. Setae *ad3*, *pd3* on genu I, *av* on genu II, all setae on genu III, *ad2*, *pd3* on genu IV conical form. Seta *pv* on genu and tibia II, *ad* on tibia and trochanter IV hooked. Setae *ad2*, *pd2* on tibia I, *al1* on tibia IV, *pl1-pl2* on genua I-II and tibiae I-III conical form. Setae *ad3*, *pd3* on tibia I, *av* and *pv1* on trochanter I truncated; seta *pv2* on trochanters I-II with base inflated; setae *av* and *pv1* on trochanter II, *al* on trochanter III conical form. Setae on coxae I-III truncated, except *av* of coxa III, conical form.

Female (14 specimens measured, Figs. 1–5)

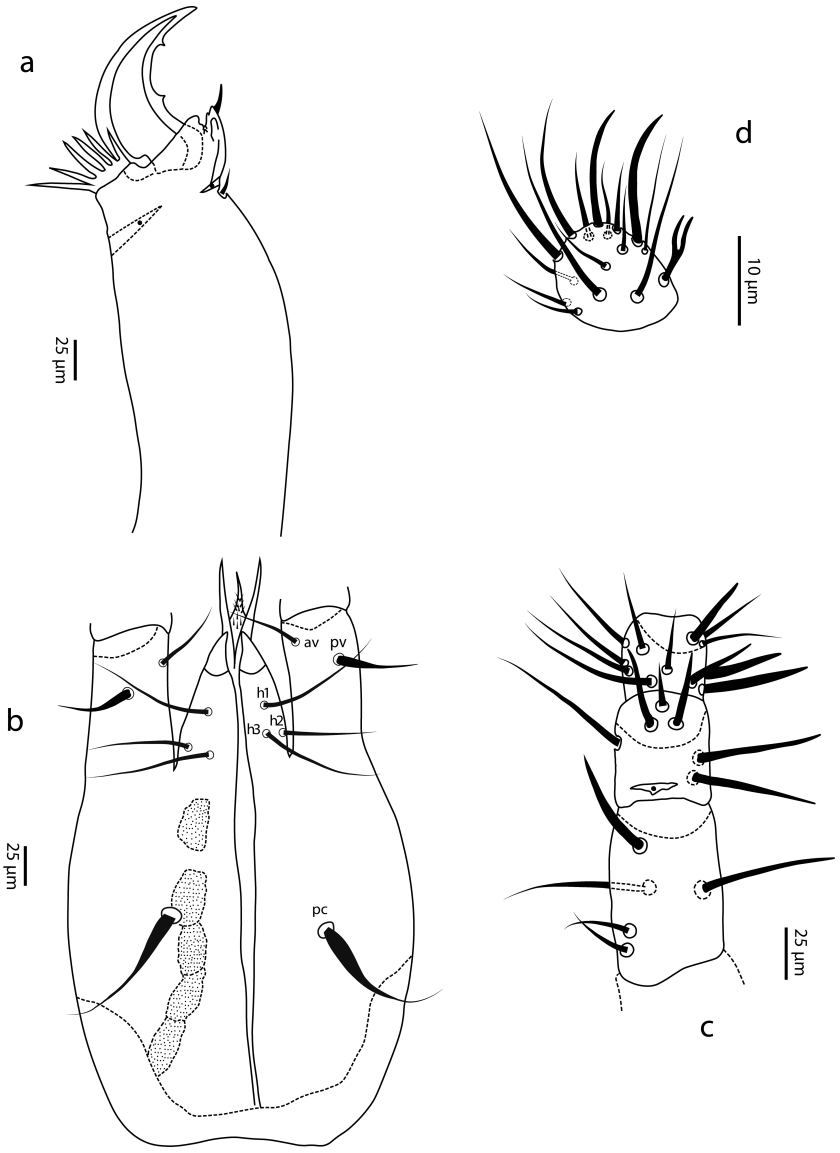

Figure 1 *Dinogamasus pubescensae* **n. sp.** Abo-Shnaf & Kamel, holotype female. a – Chelicera, b – Hypostome, c – Femur-tibia of palp, d – Tarsus of palp.

Gnathosoma (Figs. 1a-d) – Fixed cheliceral digit about less than half the length of movable digit 53 (45–59) long, with three teeth and *pilus dentilis* in subapical tip; movable digit 118 (106–126) long, with two tiny teeth in addition to apical hook; antiaxial and dorsal lyrifissures and dorsal seta as well distinct (Fig. 1a). Deutosternal groove with no rows. Corniculi parallel to each other, 55 (41–68) long and 28 (18–36) wide basally, distance between tips 22 (16–45); hypostomal setae *h2* laterad *h3*, setae *h3* short not reaching palp-coxal setae (Fig. 1b). Palp 294 (275–320) long; palp chaetotaxy (Figs. 1c-d): trochanter 2 (*pv* with base inflated), femur 5 (one long ventral seta not reach tip of palp), genu 6, tibia 12 (several setae thickened and modified), tarsus 15; palp apotele two-tined. Setal lengths: *h1* 96 (81–104), *h2* 63 (50–74), *h3* 99 (81–122), *pc* 97 (90–113), *av* 60 (50–68), *pv* 73 (63–83); all setae aciculate and smooth, except *pc* and *pv* with base inflated.

Dorsum (Figs. 2a-b) – Dorsal idiosoma 1541 (1406–1656) long and 892 (788–981) wide at widest level. Idiosoma with holodorsal shield, covering most of the entire idiosoma (Fig. 2a), strongly reticulate, 1470 (1116–1625) long and 821 (747–882) wide at widest level,

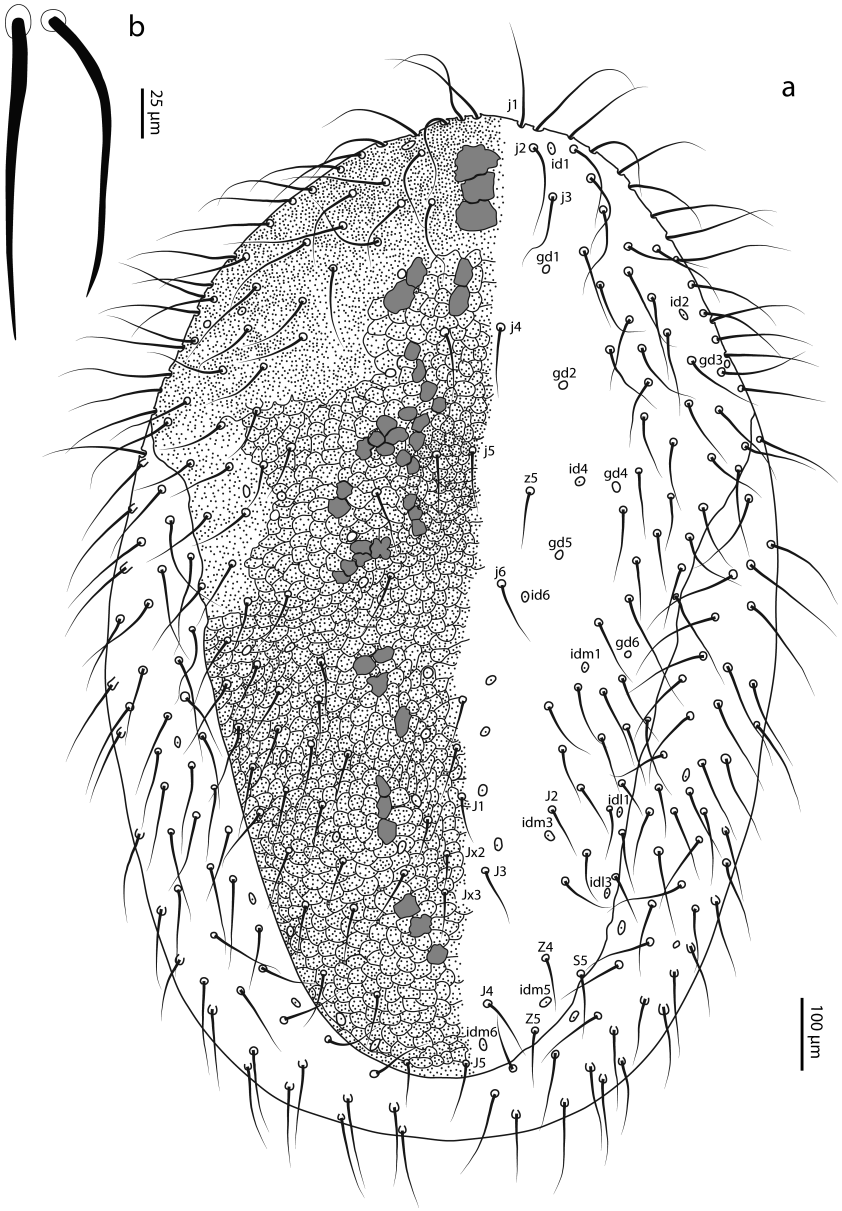

Figure 2 *Dinogamasus pubescensae* **n. sp.** Abo-Shnaf & Kamel, holotype female. a – Dorsal idiosoma, b – Different dorsal setae.

holotrichy laterally with approximately 79 pairs of setae, opisthonotal median region with some unpaired and asymmetrical setae. With 14 pairs of distinguishable poroids and six pairs of distinguishable solenostomes. Unsclerotized cuticle laterad dorsal shield hypertrichy, straight. Most dorsal setae overlapping reach the nearest posterior neighbour setae, acute and smooth (Fig. 2b). Length of recognized setae: *j1* 176 (140–214), *j2* 151 (122–189), *j3* 125 (113–149), *j4* 91 (65–117), *j5* 82 (70–104), *j6* 83 (63–199), *z5* 81 (77–90), *J1* 63 (45–86), *J2* 77 (59–95), *J3* 80 (63–95), *J4* 83 (70–104), *J5* 81 (72–90), *Jx2* 59 (41–72), *Jx3* 58 (45–63), *Z4* 77 (54–95), *Z5* 85 (68–108), *S5* 84 (72–99).

Venter (Figs. 3a-c) – Tritosternum long, with base about 80 (72–86) long and 41 (38–43) wide basally, with a pair of long pilose laciniae, 75 (68–79) long, separated for about 75% (Fig. 3a). Pre-sternal region with a few transverse striae. Sternal shield punctate, wider than long, 130 (122–135) long and 234 (185–254) wide at *st2* level, with slightly concave anterior

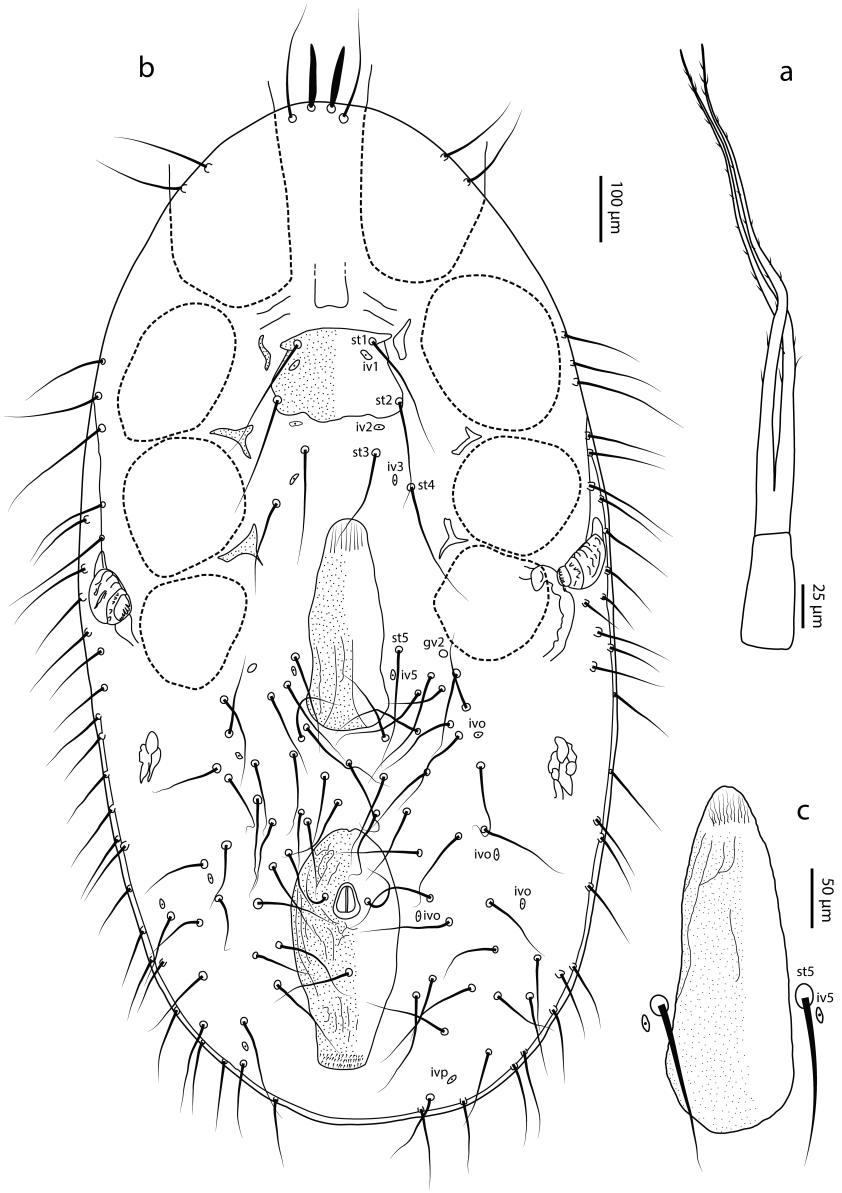

Figure 3 *Dinogamasus pubescensae* **n. sp.** Abo-Shnaf & Kamel, holotype female. a – Tritosternum, b – Ventral idiosoma, c – Genital shield.

margin, with two pairs of long setae (*st1-st2*) and a pair of distinguishable solenostomes (*iv1*), without accessory setae, *st2* longest reach base of *st4*, *st1* long enough to reach the base of *st3*, distance *st3-st3* shorter than *st1-st1*; with irregularly posterior margin. Setae *st3* and solenostomes *iv2-iv3* on unsclerotized cuticle, metasternal setae *st4* present, on unsclerotized cuticle. Distance between *st1* and posterior margin of sternal shield 116 (106–122), *st1-st1* 140 (126–149), *st2-st2* 218 (176–234), *st3-st3* 99 (83–124), *st4-st4* 188 (162–236). Metasternal plates absent. Endopodal plates represented by three pairs of tri-radiate fragments at level of coxae II, between coxae II-III and III-IV. Genital shield short and tongue-shaped, punctate with a few longitudinal lines posteriorly, 334 (302–378) long and 140 (122–164) wide at posterior corner (Fig. 3c), posterior margin convex; genital setae *st5* off the shield, distance *st5-st5* 164 (146–187). Paragenital solenostomes (*iv5*) on unsclerotized cuticle posterolaterad *st5*; with a pair of gland pores (*gv2*) posterolaterad coxa IV. More than ten pairs of setae between

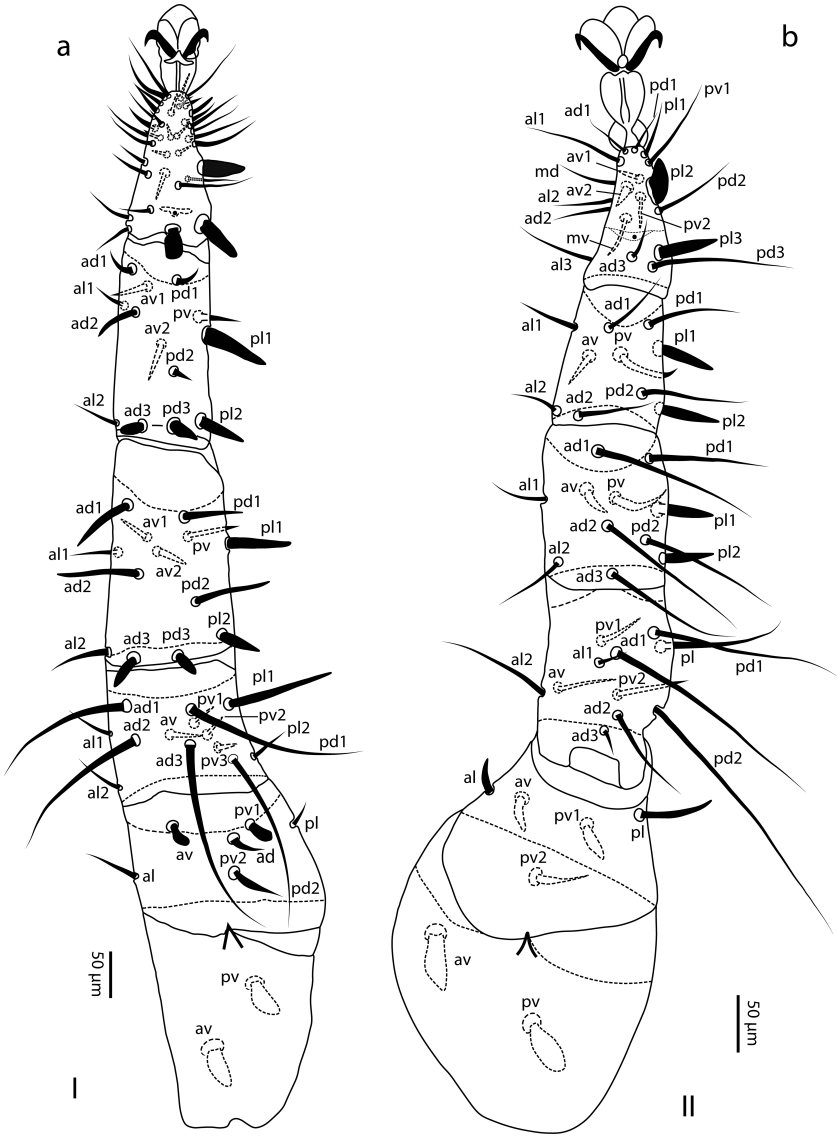

Figure 4 *Dinogamasus pubescensae* **n. sp.** Abo-Shnaf & Kamel, holotype female. a – Leg I, b – Leg II.

genital and anal shields. Anal shield elongate, much longer than wide, rectangular, punctate with a few striae, longer than the genital shield, 363 (338–383) long and 197 (176–230) wide; with circumanal setae, post-anal seta longer than para-anal setae, para-anal setae reach base of post-anal seta; anal pores indistinct, anus not large, 59 (54–65) long. Opisthogaster hypertrichy. Length of setae: *st1* 191 (126–225), *st2* 210 (189–239), *st3* 185 (167–198), *st4* 187 (171–200), *st5* 188 (169–203), para-anal 88 (77–104), post-anal 119 (81–207). All ventral setae aciculate and smooth (Fig. 3b).

Peritreme (Fig. 3b) – Stigmata between coxae III-IV surrounded by peritrematic atrium. Peritreme, poroids and solenostomes near stigmata and post-stigmatal plate indistinct.

Legs (Figs. 4–5) – All pre-tarsi with a pair of claws and a membranous ambulacrum. Leg length: I 1250 (1143–1296), II 1064 (1017–1134), III 1087 (1031–1134), IV 1223 (1197–1278) long. Leg chaetotaxy: coxae: I—0 0/1 0/1 0 (all setae truncated) (Fig. 4a); II—0 0/1 0/1 0 (all setae truncated) (Fig. 4b); III—0 0/1 0/1 0 (*av* conical form, *pv* truncated) (Fig. 5a); IV—0 0/1 0/0 0 (*av* with base inflated) (Fig. 5b); trochanters: I—1 1/1 0/2 1 (*av* and *pv1* truncated; *pv2*

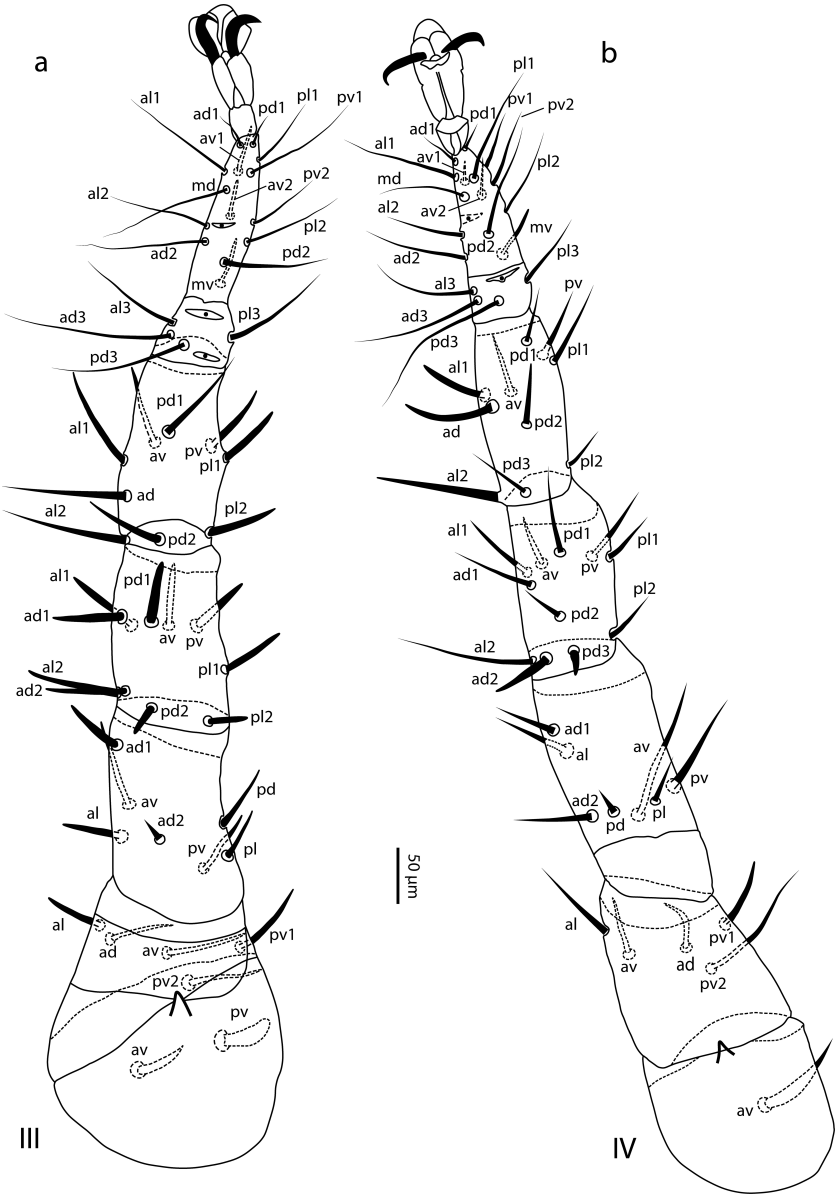

Figure 5 *Dinogamasus pubescensae* **n. sp.** Abo-Shnaf & Kamel, holotype female. a – Leg III, b – Leg IV.

with base inflated) (Fig. 4a); II—1 0/1 0/2 1 (*av*, *pv1* conical form; *pv2* with base inflated) (Fig. 4b); III—1 1/1 0/2 0 (*al*, *pv1* conical form) (Fig. 5a); IV—1 1/1 0/2 0 (*ad* hooked, *pv1* conical form) (Fig. 5b); femora: I—2 3/1 2/3 2 (*ad1-ad3*, *pd1-pd2* macrosetae; *av*, *pv1-pv3* falciform, *pl1* conical form) (Fig. 4a); II—2 3/1 2/2 1 (*ad1*, *pd1-pd2* macrosetae; *ad3* microseta) (Fig. 4b); III—1 2/1 1/1 1 (*ad1*, *al* conical form, *pd*, *pl* thick) (Fig 5a); IV—1 2/1 1/1 1; genua: I—2 3/2 3/1 2 (*ad3*, *pd3*, *pl1-pl2* conical form, *ad1-ad2*, *pd1-pd2* thick) (Fig. 4a); II—2 3/1 2/1 2 (*pl1-pl2*, *av* conical form, *pv* hooked) (Fig. 4b); III—2 2/1 2/1 2 (all setae conical form) (Fig. 5a); IV—2 2/1 3/1 2 (*ad2*, *pd3* conical form) (Fig. 5b); tibiae: I—2 3/2 3/1 2 (*ad3*, *pd3* truncated, *ad2*, *pd2*, *pl1-pl2* conical form) (Fig. 4a); II—2 2/1 2/1 2 (*pl1-pl2* conical form; *pv* hooked) (Fig. 4b); III—2 1/1 2/1 2 (*al1*, *pd2*, *pv* thick; *pl1-pl2* conical form) (Fig. 5a); IV—2 1/1 3/1 2 (*ad* hooked, *al1* conical form, *al2*, *pd2* thick) (Fig. 5b). Tarsi I not counted, tarsi II-IV with 18 setae each. Apical seta of tarsus II modified (large claw-like) (Fig. 4b).

Type material

One holotype female and six paratype females collected from first metasomal tergite of *Xylocopa pubescens*, at Serapeum village (30°36′07.31″N, 32°06′55.01″E), Suez-Canal, Ismailia governorate, at Apr. 2022; four paratype females collected from the same previous host and location, at 29 Feb. 2022; three paratype females collected from the same previous host, at Abu Suwayr village (30°34′15.78″N, 32°06′55.12″E), Suez-Canal, Ismailia governorate, at 28 Feb. 2022; collected by M.S. Kamel; all mite specimens are deposited in the mite reference collection of the Egyptian Society of Acarology Museum (ESAM), Zoology and Agricultural Nematology Department, the Faculty of Agriculture, Cairo University, Giza governorate, Egypt.

Etymology

The epithet *pubescensae* delivered from "*pubescens*" the species name of the host insect (*Xylocopa pubescens*), from which type specimens were isolated.

Remarks

According to the phylogenetic analysis of the genus by Lundqvist (1999), the 36 characteristics for *Dinogamasus pubescensae* **n. sp.** as follows: 1) length of dorsal shield (1300–1800 long); 2) dorsum hypertrichy; 3) dorsal setae reach the nearest posterior neighbors (overlapping); 4) all dorsal setae straight; 5) with holodorsal shield; 6) internal posterior hypostomal setae (*h3*) short, not reach the insertion of the palp-coxal setae (*pc*); 7) one long ventral seta on palp-femur, not reach tip of palp; 8) several setae thickened and modified on palp-tibia; 9) fixed cheliceral digit less than half the length of movable digit; 10) sternal shield with two pairs of long setae; 11) with no accessory setae on sternal shield; 12) *st2* longest pair of sternal setae; 13) *st1* reach the insertion of *st3*; 14) distance between insertion of *st3* shorter than distance between *st1*; 15) setae *st4* present; 16) more than ten pairs of long setae between genital and anal shields; 17) anal shield longer than genital shield; 18) para-anal setae reach the insertion of post-anal seta; 19) anal shield rectangular; 20) chaetotaxy; no deviation in the number of setae on podomeres of legs III and IV from the formula given as typical for the genus, except for trochanter III (*ad* present, *pl* absent); 21–23) all ventral setae of trochanter I modified (*av*, *pv1* truncated; *pv2* with base inflated); 24) seta *pv* of femur I modified (setae *pv1*-*pv3* falciform); 25, 26) ventral setae of trochanter II modified (*av*, *pv1* conical form; *pv2* with base inflated); 27) setae *ad1*-*ad2*, *pd1*-*pd2* of genu I thick; 28) seta *ad3* of tibia I modified (truncated); 29) setae on coxa I-III modified (all setae truncated, except *av* of coxa III, conical form); 30, 31) seta *pl1* of genu and tibia I modified (conical form); 32) seta *pv* of genu and tibia II hooked; 33) three *pv* setae on femur I; 34) five setae on trochanter IV; 35) apical seta of tarsus II large claw-like; 36) seta *av* of femur II not modified (setiform and thick).

Based on the matrix analysis of the previous characters given by Lundqvist (1999) and Attasopa *et al.* (2021), the new species is resamples *Dinogamasus acutus* LeVeque, 1930, *D. affinis* (Berlese, 1918), *D. braunsi* (Vitzthum, 1914), *D. heteraspis* LeVeque, 1930, *D. hirtissima* (Berlese, 1910), *D. inflatus* LeVeque, 1930, *D. kazerunensis* Joharchi, Khodaparast & Moghadam, 2016, and *D. oudemansi* LeVeque, 1930.

The most important differences are: *Dinogamasus acutus* differs from the new species by having one long ventral seta on palp-femur, reach tip of palp (characters 7) (not reach tip of palp in *D. pubescensae* **n. sp.**); anal shield semicircular (character 19) (rectangular in *D. pubescensae* **n. sp.**), anal shield shorter than genital shield (character 17) (longer than genital shield in *D. pubescensae* **n. sp.**); ventral setae of trochanter I long (character 23) (setae *av* and *pv1* truncated; *pv2* with base inflated in *D. pubescensae* **n. sp.**), seta *pv3* of femur I conical form (character 24) (falciform in *D. pubescensae* **n. sp.**), setae *ad2* and *pd2* of genu and tibia I setiform (characters 27) (conical form in *D. pubescensae* **n. sp.**), seta *pl1* of genu and tibia I large setiform (characters 30, 31) (conical form in *D. pubescensae* **n. sp.**). *Dinogamasus affinis* having length of dorsal shield less than 1300 long (character 1) (1541 long in *D. pubescensae*

n. sp.); no modified setae on palp-tibia (character 8) (three modified setae in *D. pubescensae* **n. sp.**); with accessory setae on sternum (character 11) (absent in *D. pubescensae* **n. sp.**), distance *st3-st3* more than half-length of distance *st1-st1* (character 14) (shorter than distance *st1-st1* in *D. pubescensae* **n. sp.**), about 5–8 setae between genital and anal shields (character 16) (more than ten setae in *D. pubescensae* **n. sp.**), anal shield semicircular, shorter than genital shield, para-anal setae not reaching post-anal seta (character 18) (reaching post-anal seta in *D. pubescensae* **n. sp.**); seta *pv2* of trochanter I bulbiform, seta *pv3* of femur I setiform, seta *pl1* of genu and tibia I large setiform. *Dinogamasus braunsi* having length of dorsal shield less than 1300 long; with accessory setae on sternum, about 8–10 setae between genital and anal shields, anal shield semicircular, anal and genital shields equal in length, para-anal setae not reaching post-anal seta; seta *pv2* of trochanter I bulbiform, seta *av* of trochanter I conical form (character 22) (truncated in *D. pubescensae* **n. sp.**), ventral setae of trochanter I long, seta *pv3* of femur I truncated, seta *pv2* of trochanter II bulbiform (character 25) (with base inflated in *D. pubescensae* **n. sp.**), seta *pl1* of genu and tibia I large setiform. *Dinogamasus heteraspis* having two thick setae on palp-tibia; anal and genital shields almost equal in length, para-anal setae not reaching post-anal seta; seta *pv3* of femur I truncated, seta *pl1* of genu and tibia I large setiform. *Dinogamasus hirtissima* having length of dorsal shield 1700 long; with no modified setae on palp-tibia; para-anal setae not reaching post-anal seta; ventral setae of trochanter I long, seta *pv3* of femur I conical form, seta *pl1* of genu and tibia I large setiform, tarsus II with two modified setae (character 35) (with one apical seta, large claw-like in *D. pubescensae* **n. sp.**). *Dinogamasus inflatus* having length of dorsal shield less than 1300 long; with no modified setae on palp-tibia; anal and genital shields equal in length, para-anal setae not reaching post-anal seta; ventral setae of trochanter I long, seta *pv3* of femur I conical form, seta *pl1* of genu and tibia I large setiform, tarsus II with two modified setae (distally: hooked, claw-like, second: long, ensiform). *Dinogamasus kazerunensis* having anal shield shorter than genital shield, para-anal setae not reaching post-anal seta; seta *pv3* on femur I conical form, seta *ad3* on tibia I conical form (character 28) (truncated in *D. pubescensae* **n. sp.**), only seta *pv* on tibia II hooked (character 32) (seta *pv* of genu and tibia II hooked in *D. pubescensae* **n. sp.**). *Dinogamasus oudemansi* having length of dorsal shield less than 1300 long; fixed cheliceral digit about half the length of movable digit (character 9) (less than half the length of movable digit in *D. pubescensae* **n. sp.**), one long seta on palp-femur, reach tip of palp, three thick setae on palp-tibia; anal shield semicircular, shorter than genital shield; setae *av* and *pv1* of trochanter I ensiform and *pv2* bulbiform, seta *pv3* of femur I truncated, setae *ad1-ad2* and *pd1-pd2* of genu and tibia I setiform, seta *pl1* of genu and tibia I large setiform.

Chaetotaxy formula of legs I-IV typical for the genus according to Lundqvist (1999), except for femur I of the new species has 13 setae (*pd3* absent: 2 3/1 2/3 2), trochanter III (*ad* present, *pl* absent: 1 1/1 0/2 0).

Modification of the key of Lundqvist's (1999) to allow identification of *D. pubescensae* n. sp.

The couplet 6 is modified as follows:

6A. Fixed digit of chelicera half the length of movable digit, small sized (Lundqvist 1999, p. 85) ..... *D. oudemansi*

— Fixed digit of chelicera less than half the length of movable digit; middle sized 6B

6B. One long ventral seta on palp-femur, reach tip of palp; anal shield semicircular, shorter than genital shield (Lundqvist 1999, p. 46) ..... *D. acutus*

— One long ventral seta on palp-femur, not reach tip of palp; anal shield rectangular, longer than genital shield ..... *D. pubescensae* **n. sp.**

Discussion

Differently from what was reported by Joharchi *et al.* (2016), this is the fourth study report on the genus *Dinogamasus* from the Middle East after Zaher *et al.* (1980) and El-Kawas (2011) both in Egypt and Joharchi *et al.* (2016) in Iran. All together including the new species herein described are three species.

Dinogamasus pubescensae **n. sp.** is a typical member of the *braunsi* group associated with the subgenera *Koptortosoma* of the genus *Xylocopa* for the African continent; this strongly supports the theory that *Xylocopa pubescens* originated on the African continent and migrated eastward, rather than being an Asiatic species that migrated westward.

New concept of genus *Dinogamasus*

The new species is consistent with the diagnosis of the genus *Dinogamasus*, with the exception of a dorsal seta present on the chelicera and the presence of endopodal and metapodal plates, which have never been observed before among species of this genus.

These unusual character states are specifically excluded in the diagnosis of the genus. Based on the observation of the new species herein described, changing the taxonomic concept of the genus is important. Therefore, the new concepts of the genus are: 1) chelicera with dorsal seta present; 2) endopodal and metapodal plates present.

The new species obviously belongs in *Dinogamasus*, but it lacks some character states that are usually diagnostic for the genus. If the loss of the dorsal cheliceral seta and the endopodal plates are apomorphic character states for the genus, this species could be an early derivative form that represents the sister group to all the rest of the genus. This is an important point that discussed in this paper.

These important characters should be considered and included in the diagnosis of the genus given in Moraes *et al.* (2022: 49–50); however, genus *Dinogamasus* can still be identified correctly in the key to genera in Moraes *et al.* (2022).

Relationship of *Dinogamasus* to its related genera *Raymentia* Womersley and *Stigmatolaelaps* Krant

Only *Dinogamasus* species have a nude genital shield among bee-associated laelapids; however, *Raymentia* shares none of the other striking synapomorphies of *Dinogamasus* species, such as the absence of deutosternal denticles, loss of peritreme, sternal shield with 1–2 pairs of setae, blunt corniculi, retention of the protonymphal chaetome on the palp-tibia of the adult, and extensive idiosomal hypertrichy (Lundqvist 1999).

A nude genital shield, eroded sternal shield, and the enlarged peritrematal atrium of *Raymentia* argue for a relationship to the *Dinogamasus*-*Stigmatolaelaps* clade (Krantz 1998; Lundqvist 1999). The stigma is typically about the same width as the peritreme, but distinctly enlarged in *Raymentia*, *Stigmatolaelaps* and *Dinogamasus* (Moraes *et al.* 2022).

Raymentia species, according to Walter *et al.* (2002), are primarily pollenkitt-feeders, as the tong-like chelicerae would be well suited to capturing nectar-coated pollen grains and keeping them during external digestion (Royce and Krantz 1989). This form of interaction is probably best considered kleptoparasitism or food theft, and appears to be at least marginally harmful to the developing bee larvae.

However, as the complex relationship between *Dinogamasus* and *Xylocopa* spp. demonstrates, the actual fitness implications of a mite-bee interaction can be challenging. Given the relatively large size of *Raymentia* species, the pollen resource drain on developing bees could be severe. The two large genera of laelapid bee mites, *Dinogamasus* and *Stigmatolaelaps*, are nest associates of carpenter (Xylocopinae) and leaf-cutting (Megachilidae) bees in Asia and Africa (Krantz 1998; Lundqvist 1999).

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