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A new genus and species of Laelapidae (Acari: Mesostigmata) from Iran

SHAHROOZ KAZEMI[1] & FRÉDÉRIC BEAULIEU[2]

[1]*Department of Biodiversity, Institute of Science and High Technology and Environmental Sciences, Graduate University of Advanced Technology, Kerman, Iran. E-mails: shahroozkazemi@yahoo.com, sh.kazemi@kgut.ac.ir*
[2]*Canadian National Collection of Insects, Arachnids and Nematodes, Agriculture and Agri-Food Canada, 960 Carling Avenue, Ottawa, ON K1A 0C6, Canada. E-mail: frederic.beaulieu@agr.gc.ca*

Abstract

A new monotypic mite genus of the family Laelapidae, *Persicolaelaps* **gen. nov.**, is described to accommodate a new species, *P. hallidayi* **sp. nov.**, on the basis of adult female specimens collected from decaying wood, soil and litter in northern Iran, Golestan and Mazandaran provinces, respectively. The new genus can be distinguished from other members of the family by a combination of morphological attributes, some of which are unique or rarely observed in laelapids, such as (1) a series of small subrectangular sclerites flanking dorsally coxae I and gnathosomal base and adjoining podal plates anterolaterally, which are extending from and fused with sternal shield between coxae I and II; (2) an epigynal shield, so broad as to reach or even overlap acetabula III–IV, posteriorly axe-shaped; (3) metasternal setae absent; (4) a typical anal shield, though capturing pair of opisthogastric setae *JV3*; (5) gnathotectum triangular and acuminate; (6) the presence of six setae on trochanter IV; (7) genu IV with two ventral setae (occasional in Laelapidae); (8) internal malae with a series of thick, elongate filaments.

Key words: Parasitiformes, Dermanyssoidea

Introduction

The family Laelapidae as currently defined (e.g. Lindquist *et al*., 2009, generally in agreement with Casanueva, 1993), is remarkably disparate morphologically and ecologically, including predators, vertebrate parasites, nest dwellers, and associates of arthropods with poorly-known feeding habits (Evans, 1955; Evans & Till, 1965; Domrow, 1988). Knowledge of the laelapid fauna of Iran remains limited, although it has undergone a rapid growth recently, with several species of free-living or arthropod-associated laelapids newly described or reported from the country lately (e.g. Joharchi & Halliday, 2011; Moraza & Kazemi, 2012; Kazemi, 2013, 2015; Kazemi & Rajaei, 2013; Joharchi & Babaeian, 2014; Kazemi *et al*., 2014, 2016; Nemati & Gwiazdowicz, 2016). One of us (SK) discovered a new mite from decaying wood, in Golestan Province of Iran. We herein describe the mite species, and erect a new genus to accommodate it, which possesses some distinctive features.

The new genus can be readily classified as Laelapidae, based on at least one attribute putatively unique to the family: opisthonotal (1) setae *px2–3* (*Zx2–3* of other authors; note that other forms of neotrichy may also occur in the opisthonotal areas in other families); as well as on a series of homoplastic or plesiomorphic attributes, individually possessed (but never in full combination) by various taxa in other families of the infraorder Gamasina: (2) median, unpaired setae *Jx* (frequently present in Laelapidae, but also in other families, e.g. *Spadiseius*, Melicharidae, Lindquist & Moraza, 2008; some *Antennoseius* spp., Ascidae, Kazemi & Moraza, 2013; some *Gamasiphis*, Womersley, 1956); (3) a holodorsal shield, essentially holotrichous, including (4) setae *Z5* inserted posterior to *J5*; (5) a single epigynal shield, rounded posteriorly, well-separated from (6) an inversely subtriangular anal shield; (7) a well-developed leg chaetome (normal for Laelapidae, Evans & Till, 1965, with two exceptions, see genus diagnosis, features #6–7), including femur I with 13 setae, including four ventrals, tibia and genu I each with 13 setae (2 3/2 3/1 2), tibia III with eight setae (2 1/1 2/1 1), and tibia IV with 10 setae (2 1/1, 3/1 2); (8) female movable cheliceral digit bidentate; (9) sternal shield with three pairs of setae and two pairs of poroids; (10)

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peritrematal shield free posteriorly; (11) palp tarsal claw two-tined; (12) deutosternal groove relatively narrow, with six rows of denticles; (13) gnathotectum with anterior margin denticulate and with a simple, single moderate prominence; (14) arthrodial envelope of movable cheliceral digit a simple fimbriae. These features of the new genus are also characteristic of most genera typically included in the subfamily Hypoaspidinae (Karg 1965; Krantz 1978; Casanueva 1993, including parts of 'Melittiphidinae' defined therein), as well as a setiform, simple pilus dentilis, without or with minimal hypertrichy of the idiosoma, and coxal and idiosomal setae not modified into spines like many Laelapinae and related groups of facultative or obligate haematophagous laelapids (Tipton, 1960; Evans & Till, 1966; Radovksy & Gettinger, 1999).

Material and methods

Mites were collected in northern Iran, Golestan and Mazandaran provinces, from (1) the humus-like layer developed in the surface of a rotting stump, and from (2) a sample of soil and litter. Mites were extracted from the material using Berlese-Tullgren funnels. Specimens were then cleared in Nesbitt's fluid and slide-mounted on microscope slides in Hoyer's medium before examination.

Morphological observations, measurements and illustrations were made using compound microscopes equipped with differential interference contrast and phase contrast optical systems, and a drawing tube. Measurements were made in micrometres. The length and width of the dorsal shield were respectively taken from the anterior to posterior shield margins along the midline and from the lateral margins at the broadest point, between setae *s6* and *S1*. The sternal shield length was measured from the anterior to posterior margins along the midline, and its width from the lateral margins at the level of setae *st2*. The epigynal shield length was taken from the anterior margin of the hyaline extension to the posterior margin along the midline, and shield widths taken both at the level of *st5* and at the broadest point. The anal shield length was measured along the midline from the anterior to posterior margins, including the cribrum, and the width at the broadest point. The length of legs were taken from the base of the coxa to the apex of the tarsus, excluding the ambulacrum (stalk, claws and pulvillus). The length of the second cheliceral segment was measured from its base to the apex of the fixed digit, and its width at the broadest point. The fixed cheliceral digit was measured from the dorsal poroid to the apex, and the movable digit from its base to apex.

The notation for idiosomal setae follows that of Lindquist & Evans (1965) adapted by Evans & Till (1965, 1966) and Lindquist (1994); notation for leg and palp setae follows that of Evans (1963a, 1963b), and that for idiosomal pore-like structures as gland pores and poroids (proprioceptors or stress receptors, often called 'lyrifissures', perhaps most appropriately when lyre-shaped or slit-like) (Athias-Henriot, 1969, 1971) follows mostly that of Athias-Henriot (1971, 1975) adapted by Kazemi *et al*. (2014).

Taxonomy

Persicolaelaps new genus

(Figs 1–21)

Type species: *Persicolaelaps hallidayi* **sp. nov.**, by monotypy.

Diagnosis (adult female). The genus can be readily distinguished from other laelapids by the following characters, unique or rarely observed in the family: (1) an epigynal shield widened and expanded anteriorly, overlapping much of posterior half of sternal shield, axe-shaped posteriorly; well removed from anal shield, bearing *st5*. Anteroventral region of idiosoma well sclerotised, showing (2) fusion of sternal shield with endopodal and exopodal plates between acetabula I and II, and (3) a strip of small subrectangular sclerites extending from anterior extension of exopodals and flanking dorsally coxae I and gnathosomal base. (4) An anal shield normally shaped (inversely subtriangular), capturing one pair of ventral setae (*JV3*). (5) Metasternal setae *st4* absent. Legs with (6) trochanter IV bearing six (1 1/1 1/2 0) setae, including *pd*, and (7) genu IV bearing 10 setae (2 2/1 3/1 1), including *pv* (this seta is present in a few other laelapid genera); leg setation otherwise normal for Laelapidae (*sensu* Evans 1963b). (8) Gnathotectum triangular, acuminate, finely denticulate laterally. (9) Internal malae composed of several

thick, tentacle-like projections. The genus is further defined by this combination of characters variously shared with other Laelapidae: dorsal shield covering all dorsal idiosoma, oval, somewhat dome-like, bearing 39 pairs of setae, including *px2–3*, and a few unpaired setae *Jx*; dorsal setae short, mostly smooth and slender; *r6* and *R* series absent; shield with 23 pairs of pore-like structures, including seven pairs of gland pores (*gd1–2*, *gd4–6*, *gd8–9*). A pair of well-sclerotised presternal platelets. Sternal shield well sclerotised, wider than long. Peritremes long, narrow. Deutosternal groove moderately narrow, with six rows of denticles, each with 2–6 denticles. Chelicera moderately stout, chelate-dentate; pilus dentilis normal, short, setiform. Palp tarsal claw two-tined.

Description. *Dorsal idiosoma* (Fig. 1). Dorsal shield covering all dorsal idiosoma, oval-shaped, dome-like, slightly extending to venter laterally, bearing 39 pairs of short, slender setae (Fig. 2); setae *Jx* may be present; *r6* and *R* series absent. Dorsal shield with a complement of 23 pairs of pore-like structures, including seven pairs of gland pores (*gd1–2*, *gd4–6*, *gd8–9*) and 16 pairs of poroids.

Ventral idiosoma (Fig. 5). Tritosternum with a pair of free pilose laciniae and columnar base. A pair of well-developed sclerotised presternal platelets. Sternal shield wider than long (Figs 5, 17), well sclerotised, fused to endopodal elements between coxae I–II into arms that join exopodal strips; a series of small sclerites extending from anterior extension of podal elements and dorsally flanking gnathosomal base and coxae I (Fig. 5). Metasternal setae *st4* absent; *iv3* on soft cuticle. Epigynal shield (Fig. 20) expansive, broadened posteriorly, angled posterolaterally behind coxae IV, rounded posteromedially, well separated from anal shield, lineate-reticulate, with a wide Λ-shape lineation, bearing pair of epigynal setae (*st5*). Anal shield inversely subtriangular (Fig. 19), capturing one pair of ventral setae (*JV3*). Peritrematal shield well developed, widely fused anteriorly to dorsal shield, free posteriorly, bearing five discernible pairs of pore-like structures, including two gland pores and three poroids. Endopodal platelets between coxae III–IV well developed, free from sternal shield, although may overlap it. Opisthogastric region not hypertrichous.

Gnathosoma (Figs 3–4, 6–7, 21). Gnathotectum a subtriangular, acuminate projection, denticulate laterally (Figs 3, 21). Corniculi horn-like; internal malae longer than corniculi, composed of a pair of fringed median projections, and lateral tentacle-like projections; hypostomal and capitular setae smooth; deutosternal groove with six rows of denticles, and a smooth ridge anteriorly (Fig. 4). Chelicera moderately stout, chelate-dentate, with relatively thick, setiform dorsal seta, fixed digit with few small teeth, pilus dentilis short and setiform, movable digit bidentate (Fig. 6). Palp chaetotaxy normal for Gamasina (*sensu* Evans, 1963a) with 2-5-6-14-15 setae on trochanter-femur-genu-tibia-tarsus; tarsal claw two-tined (Fig. 7).

Legs (Figs 8–16, 18). Legs moderately long, leg I approximately as long as idiosoma, leg IV longer than idiosoma; all legs with well-developed paired subequal claws and rounded pulvilli borne on ambulacral stalk. Setation of legs I-II-III-IV: coxae 2, 2, 2, 1; trochanters 6, 5, 5, 6, trochanter IV with a *pd* seta (1 1/1 1/2 0) (Fig. 18); femora 13 (2 3/1 2/3 2), 11 (2 3/1 2/2 1), 6 (1 2/1 1/0 1), 6 (1 2/1 1/0 1); genua 13 (2 3/2 3/1 2), 11 (2 3/1 2/1 2), 9 (2 2/1 2/1 1), 10 (2 2/1 3/1 1) (Fig. 20); tibiae 13 (2 3/2 3/1 2), 10 (2 2/1 2/1 2), 8 (2 1/1 2/1 1), 10 (2 1/1 3/1 2); tarsi II-IV 18 (3 3/2 3/2 3 + *mv*, *md*). Many setae on tarsi II–IV slightly thickened or spine-like, especially ventral setae, dorsal and ventral setae of femur I, and ventral setae of genua and tibiae (Figs 12–15).

Remarks. In addition to the attributes mentioned in the introduction, the well-developed internal malae of *Persicolaelaps* are indicative of Laelapidae in general, and their thick, elongate filaments show a resemblance (or possible relation) to some laelapids species such as *Cosmolaelaps cuneifer* (Michael) (Evans & Till, 1966), *Cosmolaelaps vacua* species group (Michael), *Laelaspis* spp., *Pneumolaelaps* spp. (FB & SK pers. obs.), *Androlaelaps walkerae* Till, 1963, *Gaeloaelaps saboori* Joharchi & Babaeian, 2014 and '*Hypoaspis' cavitatis* Karg, 1982, (which, at least superficially, resemble some *Laelaspisella* species). The internal malae of *Mesolaelaps accessoria* Tenorio & Radovsky, 1974 also have thick projections, but they appear shorter and originate from the lateral margin of the main, median processes. Some *Laelaspisella* and the apparently related *Pogonolaelaps* species have elongate fringed internal malae, but composed of hair-like and thinner filaments, based on illustrations and personal examination of some species (Marais & Loots, 1969; Nemati & Gowiazdowicz, 2016; SK pers. obs.).

Persicolaelaps actually shares most of the character states of the putative early-derivative lineage of dermanyssoids, best exemplified by some members of *Gaeolaelaps* or the '*Hypoaspis* complex' (Laelapidae), from which other groups of facultative and obligate haematophagous groups of laelapids and other dermanyssoids theoretically evolved (Evans & Till, 1966; Radovsky, 1969, 1994). These basal laelapids are part of the subfamily Hypoaspidinae, which includes a large portion of the free-living (putatively predatory) laelapids and many insect

symbionts. Like many hypoaspidines, *Persicolaelaps* also has a strong leg chaetome, with many setae thickened or spine-like. *Persicolaelaps* can suitably be placed in this subfamily, until laelapid classification improves to better reflect phylogenetic relationships. The departure of *Persicolaelaps* from the basic laelapid or dermanyssoid type (see Evans & Till, 1966: 111) corresponds to the main diagnostic features of the genus (features #1–9 listed in genus diagnosis), as well as the addition of dorsal unpaired setae *J*, the loss of setae *r6*, *R* and *UR*, and a dorsal shield that covers the idiosoma entirely. However, each of these features also occur in at least a few other members of laelapids, with the exception of the anal shield bearing setae *JV3*, which may well be unique in Laelapidae, and trochanter IV with six setae, which appears as a unique attribute within Mesostigmata (Evans, 1963a, 1972). The fragmented band of sclerites extending anteriorly from fused endo-exo-sternal elements is also exceptional, and may be rare in Mesostigmata. Note that other laelapids, e.g. *Pseudoparasitus jilensis* Ma, 2004 and *Urozercon robustisetae* Rosario & Hunter, 1988, and other dermanyssines (some Veigaiidae, Evans & Till, 1979) also have a normally-sized anal shield bearing five setae, including a pair of opisthogastric setae in addition to the circumanals. Some *Haemogamasus* species have several additional setae on a normally-sized anal shield, but this is due to strong opisthogastric hypertrichy (Evans & Till, 1966).

A number of genera that are generally classified as hypoaspidines (e.g. Vitzthum, 1940–1943: 762; Karg, 1965) share several of the diagnostic features of *Persicolaelaps*, which in some cases, might reflect a phylogenetic relationship, or alternatively, morphological convergence, or even plesiomorphies. In particular, species of *Ololaelaps* share with *Persicolaelaps* a strongly developed, well-sclerotised (thick, as indicated by the brownish tint), rounded dorsal shield (more elongate in some *Ololaelaps*, Jordaan & Loots, 1987, SK pers. obs.), bearing attenuate (slender) dorsal setae; an epigynal shield broadly expanded anteriorly; a pair of sclerotised presternal platelets; endopodals, exopodals and sternal shield more or less coalesced anteriorly; well-developed endopodals mesad coxae III–IV; relatively broad peritrematal shield; parapodal plate thicker than usual; a gnathotectum somewhat triangular (less acuminate in *Ololaelaps*), finely denticulate (more sparingly in *Ololaelaps*); and a deutosternal groove with few denticles per row (Evans & Till, 1966; Jordaan & Loots, 1987; FB & SK, pers. obs. on *Ololaelaps* spp. from North America, Iran and Australia). Furthermore, at least some *Ololaelaps* have a band of sclerotised cuticle extending anteriorly from the podal plates between coxae I and II, and flanking coxae I laterally (Jordaan & Loots, 1987; we have seen such a cuticular band, although weakly sclerotised, in some specimens of at least two species examined by us, FB & SK). It is possible that this band extends and dorsally surrounds the gnathosomal base (but observation is difficult in this dark, crowded region), just as the series of (more conspicuous) sclerites do in *Persicolaelaps*. *Ololaelaps* is otherwise readily distinguished from *Persicolaelaps* by its epigynal shield hyperdeveloped posteriorly and fused to the anal shield, the presence of setae *st4* in adult female, more slender leg setae, as well as by not having several other features characterising *Persicolaelaps* (#2, 4, 6, 7, 9 in genus diagnosis above).

Although also exhibiting many differences from *Persicolaelaps*, species of *Oloopticus*, *Laelaspisella*, *Pogonolaelaps* and *Reticulolaelaps* share with it a salient attribute: the absence of metasternal setae (Marais & Loots, 1969; Karg, 2003; Nemati *et al*., 2013; Nemati & Gwiazdowicz, 2016; Joharchi *et al*., 2016). Except for *Oloopticus*, which has a well-developed sternal shield (and apparently bearing deep pits at the region usually occupied by *st4*), the absence of *st4* in these genera and *Persicolaelaps* may be a result of a marked anterior expansion of the epigynal shield, leaving too little space, and little functional role (being so close to another pair of setae, *st3*) for them to develop. An intermediate stage may be exhibited by *Ololaelaps*, for which seta *st4* is inserted in the posterolateral margins of an otherwise normal sternal shield, near setae *st3*. Setae *st4* are also lost in some species of the insect-associated laelapid genera *Myrmozercon*, *Urozercon* and *Dinogamasus* (Lundqvist, 1998; Klimov & OConnor, 2004; Ghafarian *et al*., 2013). The sternal shield is also broader than long in *Ololaelaps*, *Laelaspisella* and *Pogonolaelaps*, and concave posteriorly (also in *Reticulolaelaps*), seemingly also to accommodate the anterior expansion of the epigynal shield, a correlation seen in some members of many other genera of laelapids or relatives, especially associated with insects (e.g. *Pneumolaelaps*, *Holostaspis*, *Laelaspis*, *Bisternalis*, insect-associated *Gaeolaelaps*, *Gymnolaelaps myrmophila* (Michael), *Melittiphisoides*, *Melittiphis alvearius* (Berlese); Evans & Till, 1966; Baker *et al*., 1983; Delfinado-Baker *et al*., 1984; Kazemi *et al*., 2014) or vertebrates (*Androlaelaps*, *Haemogamasus*; Till, 1963) and more strikingly in dermanyssids, macronyssids and hirstionyssids (Evans & Till, 1966; Domrow, 1988), for which this may represent an adaptation for an increased capacity for engorgement in blood by having the opisthogastric region mostly covered by soft cuticle (Radovsky, 1969).

Laelaspisella, *Pogonolaelaps* and *Reticulolaelaps* share an additional feature with *Persicolaelaps*: the presence of two ventral setae on genu IV. This character also occurs in several disparate laelapid genera (e.g. *Pneumolaelaps*, *Melittiphis*, and some *Laelaps* and *Myrmozercon* species, Shaw & Seeman, 2009), as well as several genera of macronyssids (Evans & Till, 1965), and a few species of '*Hypoaspis'* s. lat. that are difficult to classify (e.g. *H. giffordi* Evans & Till, *H. lubrica* Voigts & Oudemans, *H. atomarius* Berlese; Evans & Till, 1966; van Aswegen & Loots, 1970). This indicates the plasticity in the development of seta *pv* of genu IV. Indeed, genu IV bears a *pv* seta in members of various other gamasine families, while being absent in many others (Evans, 1963a).

Etymology. The generic name *Persicolaelaps* refers to the ancient name of Iran, Persia, the country of origin of the genus (feminine).

Persicolaelaps hallidayi **new species**

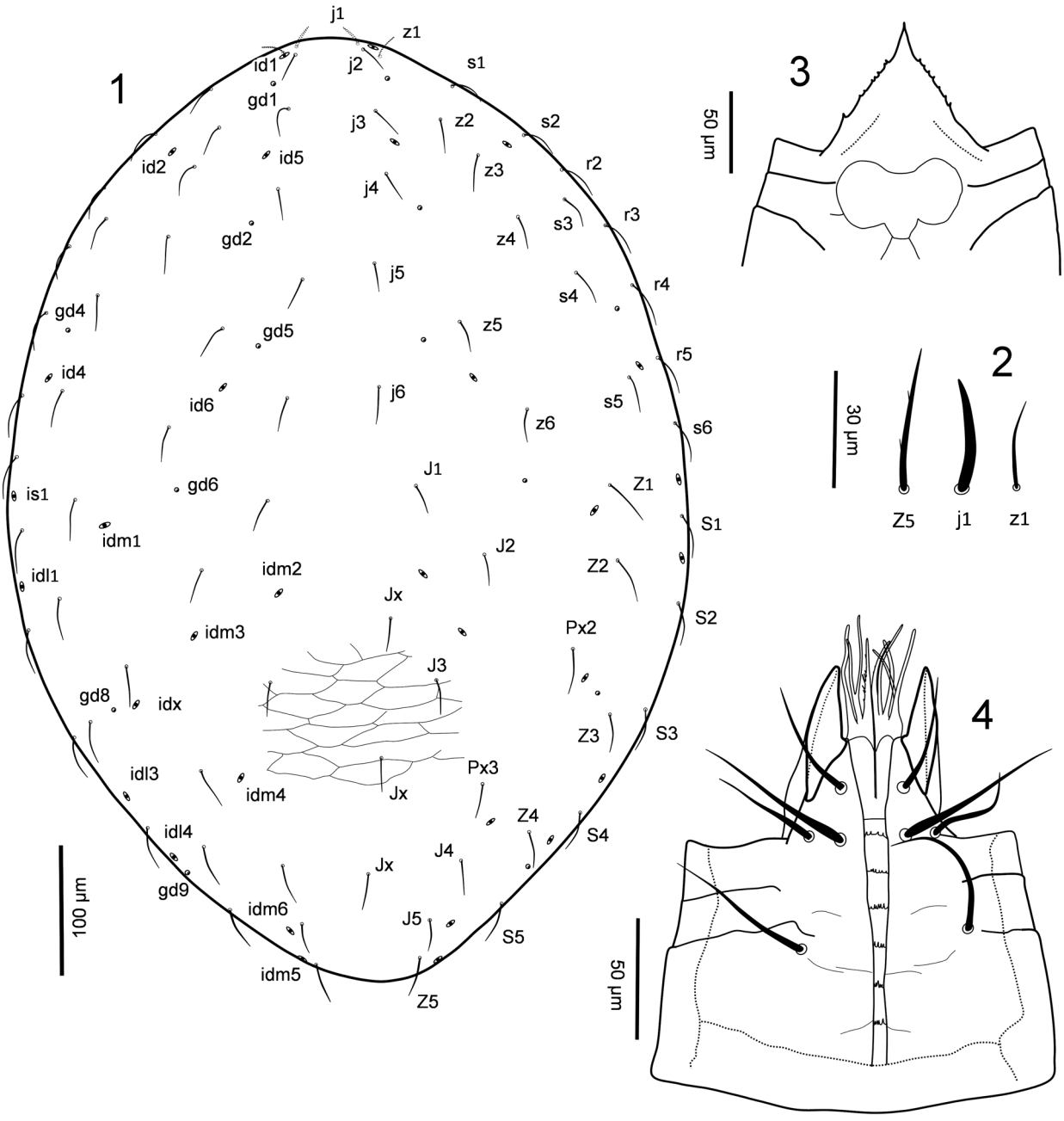
(Figs 1–21)

Diagnosis. In addition to attributes given in the genus diagnosis, the new species can be further distinguished from other Mesostigmata, including other laelapids: dorsal shield oval, extending slightly onto ventrolateral aspect of idiosoma; anteriorly smooth, finely reticulate in posterior half (posterad *J2* and *s6*), bearing 2–3 unpaired setae *Jx* between level of *J2* and *J4*; setae *j1*, *z1* situated more or less ventrally, dorsal setae much shorter than distance to following setal base, mostly smooth and slender, except setae *J4–5*, *Z5*, *S5* slightly thicker, sparsely barbed, and *j1* stout, blunt apically. Sternal shield strongly concave posteriorly, bearing long setae; reticulate, except smooth posterior area covered by expansive epigynal shield, reaching almost half-way of sternal shield medially, and anterolaterally setae *st3* and edges of acetabula III; epigynal shield 1.2 x as long as wide, reticulate, with lineae almost reaching anterior shield margin; with variably-shaped cells, well separated from anal shield, with setae *JV2* in-between. Anal shield with two small projections anteriorly; shield slightly wider than long. Setae *JV3* longer than circumanal setae, post-anal seta slightly longer than para-anals. Peritremes anteriorly reaching level of coxae I. Soft opisthogastric cuticle with eight pairs of setae, *JV1–2* longest. Metapodal plates divided, primary metapodals narrow, elongate. Internal malae with pair of median projections, flanked by 3–4 pairs of longer, tentacle-like projections. Deutosternal groove narrowing posteriorly. Leg setae moderately long, with many setae thickened or spine-like.

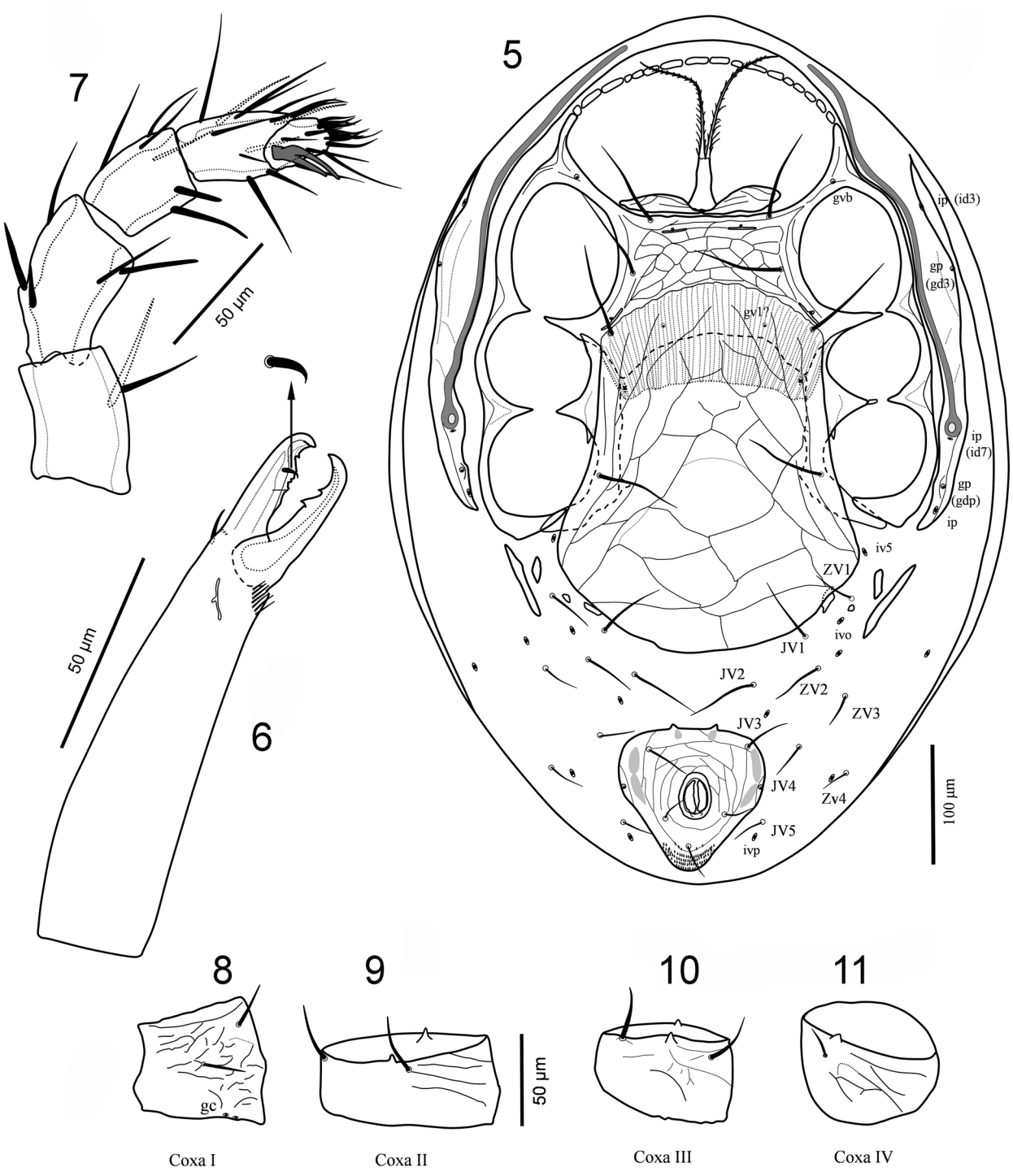
Female (n=3). (Figs 1–21). *Dorsal idiosoma* (Fig. 1). Dorsal shield length 847–922, width 615–672, broadest at level of setae *s6–S1*, extending slightly onto ventrolateral aspect of idiosoma, with *j1*, *z1* and occasionally some marginal (*r2–5*) and lateral (*s6*, *S1–3*) setae inserted more or less ventrally; shield smooth anteriorly, with fine reticulate ornamentation posterad level of setae *J2* medially and level of *s6* laterally; 39 pairs of setae, 2–3 unpaired setae *Jx*, all setae relatively short, slender, mostly 26–38 long, *j1* slightly thicker than other setae, apically blunt, 27–29 long, *z1* shortest (21–23); *J4*, *J5*, *Z5*, *S5* sparsely barbed. Adenotaxy and poroidotaxy as in genus description.

Ventral idiosoma (Figs 5–6, 17, 19–20). Tritosternal base 38–41 long, 25–27 wide proximally and 13–15 apically, with two entirely free, pilose laciniae (96–108). A pair of relatively large (71–73 x 15–17) and well-sclerotised presternal platelets flanking tritosternum base. Sternal shield length 98–106, width 156–164 (ratio of length/width ≈ 0.65), anterior margin irregularly straight, posterior margin strongly concave, shield mostly reticulate, smooth posteriorly where epigynal shield overlaps, including a pair of putative gland openings *gv1*; sternal setae smooth and long, *st1* 82–86, *st2* 88–93, *st3* 94–98 long, poroids *iv1–2* slit-like, *iv1* aligned transversally, *iv2* oblique (Figs 5, 17). Poroids *iv3* ovoid, on soft cuticle, adjacent to endopodals between coxae III–IV. Endopodal element between coxae I–II fused to sternal shield, bearing gland pore *gvb*, and fused anteriorly to exopodal strip that flanks coxae I–IV; endopodal platelets between coxae III–IV well-developed, slightly overlapping posterolateral corners of sternal shield; parapodal element behind coxae IV relatively thick (Figs 5, 17). Epigynal shield expansive, length 304–319, width at level of *st5* 207–216, at broadest point behind coxae IV 252–263 (ratio of length/width at broadest point ≈ 1.2), anterior hyaline margin of shield reaching beyond level of *iv2* anteriorly and beyond *st3* laterally, posterior margin rounded medially, angled posterolaterally; shield well removed from anal shield, lineate-reticulate, with variously shaped cells, Λ-shaped linea enclosing nine variously-shaped cells (sometimes irregularly arranged in rows of two, Fig. 20); setae *st5* (69–73) inserted on shield at mid-

level of coxae IV (Fig. 5). Anal shield inversely subtriangular, length 112–120, width 122–128, anterior margin almost straight with two small projections medially, reticulate; setae on shield smooth, ventral setae *JV3* (40–44) longer than circumanal setae, para-anal setae (34–36) inserted at posterior level of anal opening, slightly shorter than post-anal seta (25–28); cribrum well-developed, extending anterolaterally to level of post-anal seta; anal opening located midway of shield length; pair of gland pores *gv3* on lateral shield margins at level near that of anterior margin of anus (Figs 5, 19). Peritrematal shields well-developed, broadly fused anteriorly to dorsal shield at level of coxae I, bearing three pairs of poroids and two pairs of gland pores; poststigmatic region extending to posterior level of coxae IV. Peritremes long (171–175) and narrow (6 wide), extending to level of anterior margin of coxae I. Soft opisthogastric integument with two pairs of small paragenital platelets between *ZV1*and *JV1*; pair of primary, outer metapodals long and narrow (61–75 x 8–9), secondary, inner metapodals small (20–22 x 7–8); eight pairs of smooth opisthogastric setae *JV1* (55–59), *JV2* (51–52), *JV4–5* (25–29), *ZV1* (41–43), *ZV2* (44–46), *ZV3* (30–31), *ZV4* (26–26); seven pairs of poroids, including paragenital poroids *iv5* (Fig. 5). Spermathecal apparatus not seen.

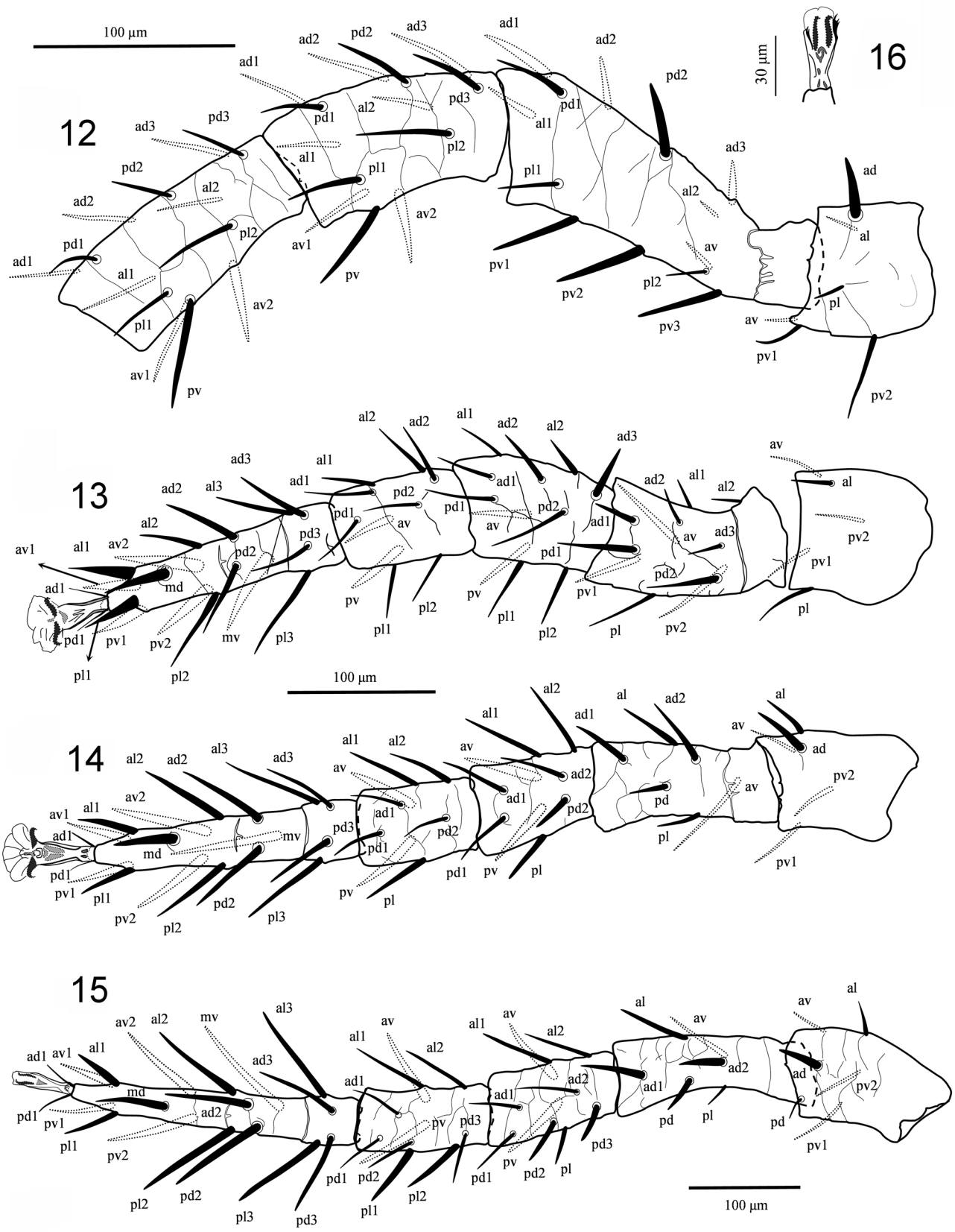


FIGURES 1–4. *Persicolaelaps hallidayi*. Female. 1. Dorsal idiosoma; 2. Enlarged view of some dorsal shield setae; 3. Gnathotectum; 4. Subcapitulum.

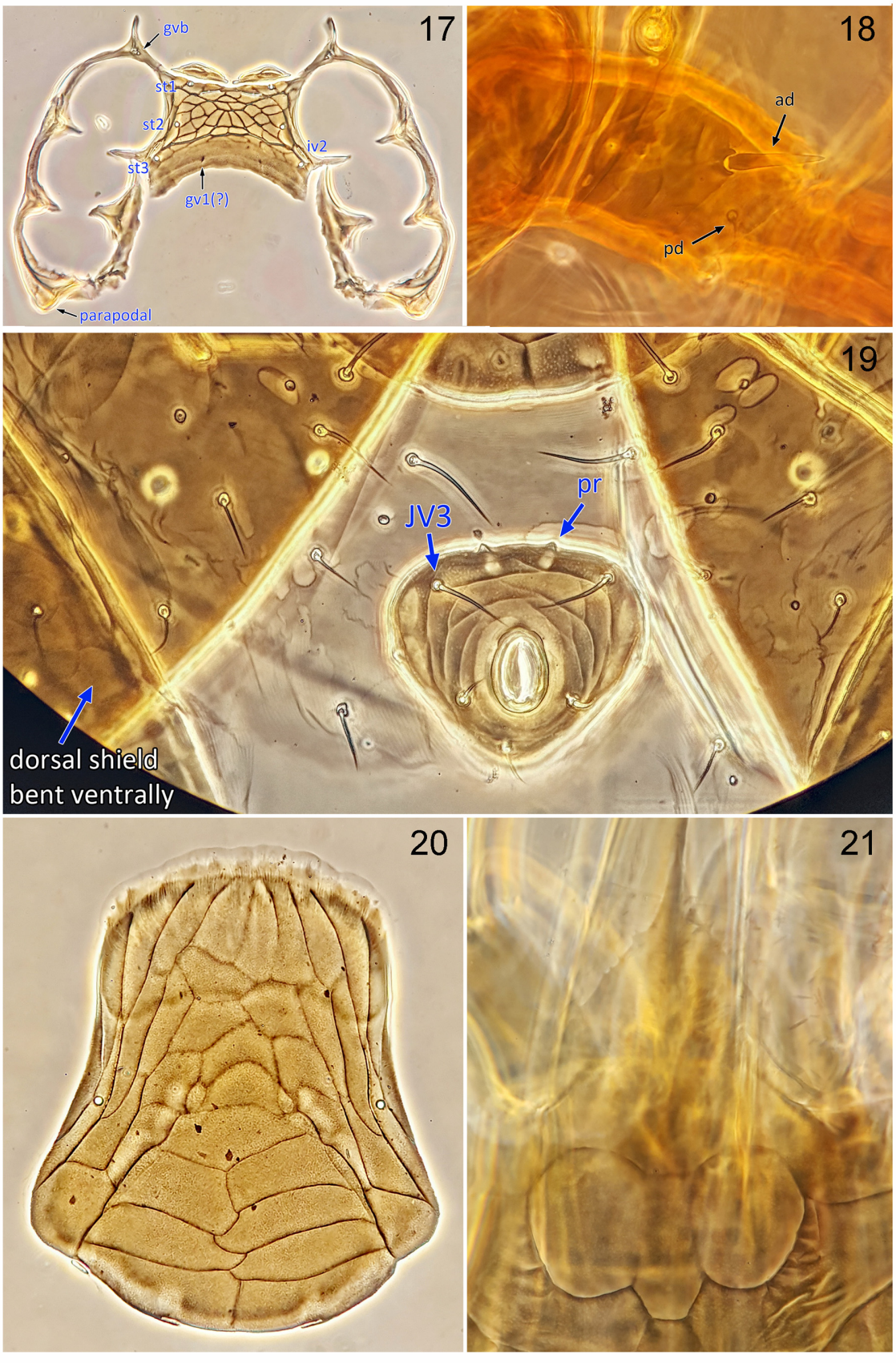


FIGURES 5–11. *Persicolaelaps hallidayi*. Female. 5. Ventral idiosoma; 6. Chelicera; 7. Palp; 8–11. Coxae of legs I–IV (ventral view).

Gnathosoma (Figs 3–4, 6–7, 21). Gnathotectum with broad triangular projection, with smooth median spike and minute denticles laterally (7–9 denticles on each side), lineate posteriorly (Figs 3, 21). Corniculi horn-like, relatively short (56–57); salivary stylets apically blunt. Internal malae longer than corniculi, comprising a pair of pilose median projections, and 3–4 lateral, longer, tentacle-like, smooth projections; labrum acuminate, considerably longer than internal malae, fringed; hypostomal and capitular setae smooth, *h3* (75–78) > *pc* (61–63) > *h1* (53–55) > *h2* (43–46); deutosternal groove with six rows of 2–6 denticles each, and a smooth anterior ridge, narrowing posteriorly, anteriormost row slightly convex (Fig. 4). Basal cheliceral segment 75–76 long, second



FIGURES 12–16. *Persicolaelaps hallidayi*. Female. 12. Leg I, trochanter-tibia (posterolateral view); 13. Leg II, trochanter-tarsus (dorsal view); 14. Leg III, trochanter-tarsus (dorsal view); Leg IV, trochanter-tarsus (dorsal view); 16. Pretarsus I.



FIGURES 17–21. *Persicolaelaps hallidayi*. Female. 17. Sternal, endopodal and exopodal shields; 18. Trochanter IV; 19. Anal shield and surrounding setae; 20. Epigynal shield; 21. Gnathotectum.

segment 237–247 long, 50–52 wide; fixed digit 57–58 long, with 4–6 small teeth, including a subapical, small offset tooth; movable digit 65–67 long, bidentate; dorsal cheliceral seta stout, relatively long (15–16), setiform; pilus dentilis apically curved (Fig. 6). Palpgenu setae *al1* and *al2* and palpfemur *al* slightly thickened and spatulate apically; palpfemur *pl* and *pd2* thickened; palp tarsal claw with two tines (Fig. 7).

Legs (Figs 8–16, 18). Leg chaetotaxy as in genus description, including two ventral setae on genu IV (Fig. 18), and six setae, including a small *pd*, on trochanter IV (Figs 15, 18). All legs with ambulacrum (ambulacral stalk, pretarsus and claws), that of leg I (40–43) shorter than those of legs II (53–55), III (57–61) and IV (62–65) (Figs 13–16). Lengths of legs I: 727–744, II 611–625, III 587–601, IV 837–852. Lengths of femora I 178–179, II 123–129, III 124–129, IV 173–185; genua I 107–113, II 94–97, III 73–81, IV 115–118; tibiae I 119–123, II 88–94, III 79–81, IV 118–120; tarsi I 194–200, II 168–170, III 179–185, IV 253–262. Setae simple, smooth, moderately long, except some shortened and many thickened setae: trochanter I with *al*, *av* and *pl* short and fine, *ad* spur-like, *pv2* elongate; trochanter III–IV with *ad* thickened or spur-like; trochanter IV with *pd* short and fine. Femur I with *al2*, *av* and *pl2* short and fine, all other setae except *pl2* thickened, *ad3* short; femur II with *al1–2* and *ad2–3* short, *ad1*, *av*, *pd1–2*, *pv1–2* slightly thickened; femur III with *al*, *ad1–2* thickened, *av* elongate, *pd* and *pl* shorter; femur IV with *al*, *av*, *pd* slightly thickened, *ad1–2* thickened, *pl* short and fine. Genu I with *av2* and *pv* slightly thickened; genu II with *al2*, *ad2–3*, *av*, *pv* thickened; genu III with *av* and *pv* spine-like, *pd2* and *pl* slightly thickened; genu IV with *al1–2*, *pd2–3* thickened, *av* and *pv* spine-like. Tibia I with *av2* and *pv* thickened, *pv* longest; tibia II with ventral setae thickened; tibia III with *al1–2*, *pl* thickened, *av*, *pv* spine-like; tibia IV with *al1–2*, *pd2* slightly thickened, *pl1–2*, *av*, *pv* thickened. Tarsi II–IV with nearly all setae thickened or spine-like, especially *al1*, *pl1*, and ventral setae of tarsus II; tarsus IV with longest setae, although not whip-like; *ad1*, *pd1* as fine apical processes.

Material examined. Holotype: female, from rotten wood, northern Iran, Golestan Province, Qarn-Abad Forest, (36°47' N; 54° 37' E), 522 m above sea level, 2 June 2012, coll. A. Katuli, deposited in Acarological Collection, Institute of Science and High Technology and Environmental Sciences, Graduate University of Advanced Technology, Kerman, Iran (ACISTE). Paratypes: one female with same collection data, deposited in ACISTE; two females collected in soil and litter, northern Iran, Mazandaran Province, Noor City (36° 34' N; 52° 03' E), -22 m above sea level, summer 2013, coll. unknown, deposited in ACISTE.

Etymology. The species is named in honour of Bruce Halliday, for his valuable work on Acari, especially Mesostigmata.

Discussion

Some morphological features of *Persicolaelaps hallidayi* suggests a predatory lifestyle rather than a parasitic one, at least not obligatorily so, since well-developed chelate-dentate chelicerae also occur in facultative haematophagous laelapids (e.g. Laelapinae: *Laelaps* spp.) or relatives (e.g. *Haemogamasus* spp.), some of which are morphologically similar to hypoaspidines, such as *Androlaelaps* (Laelapinae) (Evans, 1955; Radovsky, 1969). Other features suggestive of a free-living lifestyle other than strong chelicerae include normally developed deutosternum and corniculi, as well as well-armoured, essentially holotrichous idiosoma, and long legs with spine-like setae. Strong idiosoma and legs are probably adaptations for defense or escape against predators—therefore may be indicative of an environment thriving with natural enemies, such as litter or decaying wood. Note, however, that feeding habits of most laelapids remain speculative, and even groups such as *Hypoaspis* (*s. str.*), associated with scarab beetles have unresolved feeding habits (Joharchi & Halliday, 2011).

The many thick, elongate thread-like projections of the internal malae of *P. hallidayi* have unknown significance, but seem to occur in laelapids that are associated with ants or bees (some *Cosmolaelaps*, *Laelaspis*, and *Pneumolaelaps* spp.; see Remarks above). It has been suggested that internal malae (and corniculi) are for preventing debris adhering to the chelicerae from entering the internal spaces between the gnathotectum and hypostome (Evans & Till, 1979).

A gnathotectum with denticulate margins, such as that of *P. hallidayi*, is typical of free-living laelapids, although its well-defined triangular shape is unusual. For instance, some *Laelaspis*, *Laelaspisella* and *Pogonolaelaps* species have (sub)triangular gnathotecta, but have a smooth margin or only a few denticles (Marais & Loots, 1969; Kazemi, 2015; Nemati & Gwiazdowicz, 2016). Species of *Hypoaspis* s. str. and *Coleolaelaps* have a denticulate, subtriangular gnathotectum, although it is more rounded apically, somewhat tongue-shaped (Costa &

Hunter, 1970; Joharchi & Halliday, 2011). Exceptionally, some *Gaeolaelaps*, at least one species associated with cockroaches, have a triangular, denticulate gnathotectum (Faraji & Halliday, 2009). More distant laelapid genera such as *Mesolaelaps* have somewhat triangular gnathotecta although more extended anteriorly (Tenorio & Radovsky, 1974).

Based on where it was found (in part), in decaying wood, it is possible that the new mite lives in association with some wood-dwelling arthropods. Furthermore, the additional soil-litter sample in which it was found contained a number of ants. Many hypoaspidines are associated with scarab and passalid beetles (e.g. Costa, 1971; Hyatt, 1964), cockroaches (e.g. Faraji & Halliday, 2009), and particularly bees (Eickwort, 1994) and ants (e.g. Evans & Till, 1966; Kazemi, 2015), insect groups that all comprise wood-nesting species.

Persicolaelaps hallidayi is a well-sclerotised animal, leaving approximately one third of the ventral surface with soft cuticle, posteriorly. The mite is particularly well protected anteriorly, with rather broad peritrematal shields, and sternal shield well coalesced with endo-exopodals, which is adjoined by a series of small sclerites straddling the base of the gnathosoma and forecoxae. We have not come across any mention of such series of sclerites in the literature on Mesostigmata, but we suspect that it occurs in other well-sclerotised laelapids or gamasines, or is present as a weakly sclerotised band of cuticle as we've partially observed in *Ololaelaps* (see Remarks above). This overall high level of idiosomal sclerotisation of *P. hallidayi* is still surpassed by some hypoaspidines (e.g. *Ololaelaps*, *Oloopticus*), haemogamasine (*Eulaelaps*), and clearly by many parasitids, macrochelids, pachylaelapids, and some of the fully armoured ologamasids, uropodoids and trigynaspids (e.g. Evans & Till, 1979). The dome-like dorsal shield also provides protection against predators (or hosts if it was phoretic), as a more convex surface is more difficult to seize or penetrate than a flatter surface. Such a well-armored, dorsally convex idiosoma may compensate for the reduction in size of the dorsal setae, a combination of characters reminiscent of some *Ololaelaps*, as well as some ologamasids (e.g. *Gamasiphis* spp., Lee, 1970). The (anteriorly) broad epigynal shield, wider than twice the width of acetabulum III and IV at their level, and anteriorly wider than a third of the width of the idiosoma at that level (of setae *st3*), might be an adaptation for the laying of large eggs (although compare the supersized eggs of *Opilioseius* (Blattisociidae) relative to its modest epigynal shield; Lindquist & Moraza, 2010). Such a relative width of epigynal shield is close to the maximal observed in Mesostigmata. A wider epigynal shield, occupying nearly half of the idiosomal width at level of coxae III–IV, was illustrated for *Synasponyssus wenzeli* Radovksy & Furman, 1969, a macronyssid that gives birth to protonymphs. Other Mesostigmata have an epigynal shield about as broad as that of *Persicolaelaps* in the anterior portion between coxae III or beyond (e.g. some *Ololaelaps*, *Laelaspis*, *Pneumolaelaps*; *Pogonolaelaps*, Nemati & Gwiazdowicz, 2016; *Laelaps*, Tipton, 1960; Hirstionysiidae, Domrow, 1988; Diarthrophallidae, Hyatt, 1964; Ichtyostomatogasteridae, Lindquist *et al*., 2009; Trachytidae, Błoszyk & Halliday, 2000). The epigynal shields of other species also reach a similar relative width, although only in the region of the anterior hyaline region, whereas it abruptly narrows towards midlevel (e.g. *Androlaelaps fahrenolzi* (Berlese), Evans & Till, 1966; *Coprolactistus* (Macronyssidae), Radovsky & Krantz, 1988; *Proctolaelaps* (Blattisociidae), Lindquist, 1971). This contrasts with species like *Gaeolaelaps aculeifer* (G. Canestrini), exhibiting an epigynal shield about 1/5–1/6 as wide as the idiosoma at level of *st3–4*, or nearly 1/4 of the dorsal shield width (Evans & Till, 1966; pers. obs.).

Female laelapids show a remarkable range of epigynal shields in terms of size and shape. The somewhat axe-shaped shield of *P. hallidayi* is distinctive, but it can be compared to that of other laelapids such as *Hypoaspis passali* Hyatt, 1964, *Laelaspoides ordwayae* Eickwort, 1966, *Euandrolaelaps sardous* (Berlese), and *C. cuneifer* (Evans & Till, 1966), which also have strong inflexion in the margin posterior to level of setae *st5*, although not as developed in width as that of *P. hallidayi*. Females of leptolaelapids such as *Hunteracarus* and *Leptolaelaps* also have a large axe-shaped epigynal shield (Costa, 1975; Evans, 1957), as well as certain *Proctolaelaps* (Melicharidae; Lindquist & Evans, 1965).

The presence of six setae on the trochanter of leg IV, including a small seta in posterodorsal position, appears as a unique or rare apomorphy within Mesostigmata (e.g. Evans, 1963, 1972). Although this added *pd* seta is as weak or weaker than the smallest setae of the legs (*pl* of coxa I and femur IV), it was seen in both trochanters IV of all females of *P. hallidayi* studied. This may make this apomorphy less significant than if it was, say, a stout spine. Six setae have been mentioned for the trochanter IV of a diplogyniid, *Weiseronyssus persicus* Kazemi *et al*. (Trigynaspida, Kazemi *et al*., 2008); however, this is erroneous and the trochanters formula of the species is actually 6-5-5-5 (not 5-5-5-6 as originally published; Kazemi, pers. obs.). Given its rarity, at least in Gamasina, we hypothesize that this seta is added late in the development, probably at the deutonymphal stage.

Persicolaelaps hallidayi, like members of other genera that have two ventral setae on genu IV and lack metasternal seta *st4* (e.g. *Laelaspisella*, *Pogonolaelaps*, *Reticulolaelaps*), may not be identified readily as a Laelapidae when using current identification keys to families of Mesostigmata (e.g. Lindquist *et al*., 2009). These relatively uncommon character states have to be considered when studying character couplet 39(b) and 43(b) of the key in Lindquist *et al.* (2009) (also 44b, where two ventrals on genu IV is mentioned as a possible exception). The absence of *st4* also makes couplet choice 45b problematic, but that seta might always be present in Rhodacaroidea. In addition, at couplet 52, it must be considered that the subapical spur-like setae (*al1*, *pl1*) of tarsus II of *P. hallidayi* and of many other hypoaspidines (e.g. *Gaeolaelaps aculeifer*) are not as developed as the 'distal spurs' (usually *al1*, *pl1*) of many pachylaelapids. The atypical epigynal shield of *P. hallidayi*, with its inflexion posterolaterally, may cause further hesitation in couplet 54. Finally, although a ventrianal shield may be defined as an anal shield expanded sufficiently to include one or more pairs of setae in addition to the three circumanal setae, *Persicolaelaps hallidayi* should be considered to have an anal shield, despite bearing *JV3* setae, so that it does not conflict with couplet choice 60b. Finding the male (and the immature stages), may also facilitate its identification as a Laelapidae in keys (e.g. couplet 43b, 45b; Lindquist *et al*. 2009), and assist in defining further the taxon and its phylogenetic relationships with other hypoaspidines.

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