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New species and new records of mites of the family Laelapidae (Acari: Mesostigmata) associated with Coleoptera in Iran

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Abstract

We report on a collection of mites in the family Laelapidae associated with scarabaeid beetles in Iran. Five known species are recorded from Iran for the first time: *Coleolaelaps asiaticus* Karg, 1999, *Hypoaspis integer* Berlese, 1911, *Hypoaspis pentodoni* Costa, 1971, *Hypoaspis phyllognathi* Costa, 1971, and *Hypoaspis terrestris* (Leonardi, 1899). Four new species are described: *Coleolaelaps costai* **sp. nov.**, *Hypoaspis larvicolus* **sp. nov.**, *Hypoaspis maryamae* **sp. nov.**, and *Hypoaspis melolonthae* **sp. nov.** The ecological relationship between these mites and their beetle hosts has not been analysed in detail, but they probably do not play a major role as biological control agents of pest scarabs.

Key words: Laelapidae, Iran, Coleoptera, *Coleolaelaps*, *Hypoaspis*

Introduction

The classification of the mite family Laelapidae is unstable as a result of continued confusion about the definition and status of some of its genera. Different concepts of genera and subgenera have been used by, for example, Evans & Till (1966), Van Aswegen & Loots (1970), Tenorio (1982) and Karg (1993). Very few species from western Asia have contributed to the existing classification, and the family Laelapidae in Iran is very poorly known. Faraji *et al*. (2008) published a key to 21 Iranian species in the genus *Hypoaspis sensu lato*, but commented that the identification of some of these species remains unconfirmed. The present paper is part of a project which has the objective of increasing the knowledge of this poorly studied regional fauna of Laelapidae, based on extensive recent collections of free-living and insect-associated species.

This paper deals with the genera *Coleolaelaps* Berlese, 1914 and *Hypoaspis* Canestrini, 1884. These two genera are superficially similar in morphology and have often been confused with each other. Species in both genera have long setae on the dorsal shield and on some leg segments, and these setae often appear wavy in slide-mounted specimens. Species in both genera are also similar in their biology, occurring in symbiotic relationships with soil-dwelling Coleoptera. This problem was discussed in detail by Costa & Hunter (1971). Their results are summarised in Table 1, which allows a clear separation of these genera.

Material and methods

Laelapidae phoretic on beetles were collected in the Tehran, Yazd and Shiraz areas of Iran in the years 2008 and 2009. Beetles of the family Scarabaeidae were collected at light traps and placed individually in vials of 70% ethanol. Beetle larvae with their associated mites were also excavated from soil. Mites were removed from the beetles, cleared in Nesbitt's solution and mounted in Hoyer's medium. The nomenclature used for the dorsal idiosomal chaetotaxy is that of Lindquist & Evans (1965), the leg chaetotaxy is that of Evans (1963a), the palp chaetotaxy that of Evans (1963b), and names of other anatomical structures mostly follow Evans & Till (1979). Holotypes and

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paratypes of the new species are deposited in the Jalal Afshar Zoological Museum, College of Agriculture, University of Tehran, Iran (JAZM); paratypes and representative specimens are also deposited in the Australian National Insect Collection, CSIRO Ecosystem Sciences, Canberra ACT, Australia (ANIC).

Genus *Coleolaelaps* Berlese

Coleolaelaps Berlese, 1914: 141. Type species *Laelaps* (*Iphis*) *agrestis* Berlese, 1887, by original designation.

Diagnosis. Laelapidae in which the podonotal section of the dorsal shield is distinctly wider than the opisthonotal section, and the podonotal and opisthonotal sections are separated by lateral incisions at a level between setae j6 and J1. Podonotal shield with a maximum of 17 pairs of setae and opisthonotal section with a maximum of 11 pairs; dorsal idiosomal setae variable in length, marginal setae longest and often appearing wavy in slide-mounted specimens. Sternal shield usually reduced in size and longer than wide, its anterior margin often poorly defined; genital shield with one pair of setae, or genital setae inserted in soft skin adjacent to genital shield. Anal shield with post-anal seta usually distinctly longer than para-anal setae. Hypostome with six rows of minute teeth; hypostomal seta h3 not distinctly longer than other hypostomal setae. Legs III longer than legs I, legs IV longest; legs without blunt spurs or spines; greatly elongate macrosetae present on femur, genu and tarsus IV, but not on femur II and III.

Notes on the genus. The only species that causes difficulties with this genus diagnosis is *Coleolaelaps abnormalis* Costa & Hunter, 1971, which lacks incisions in the dorsal shield, and has leg III shorter than or equal to leg I. In other characters, *C. abnormalis* is clearly a species of *Coleolaelaps*. The most recent detailed revision of the genus *Coleolaelaps* was by Costa & Hunter (1971), who listed nine species. Since then new species have been described from Turkey, Kazakhstan, China, and Japan, to bring the total to 14 species (Karg, 1999). It is possible that some species described in other genera would be better placed in *Coleolaelaps*; for example *Hypoaspis lepisternalis* Ma, 2004 appears to be a species of *Coleolaelaps*. All known species are associated with Melolonthine beetles in the genera *Anoxia* and *Polyphylla*, and the genus therefore has a Holarctic distribution which follows that of the host beetles. Costa & Hunter (1971) described extensive intra-species variation in some species of *Coleolaelaps*, and that observation is confirmed by the species described here. The dorsal and sternal shields often have irregular and asymmetrical edges, and some setae may be found either on the edges of the shields or in the adjacent soft skin in different specimens, or on left and right sides of the same specimen.

Coleolaelaps asiaticus Karg

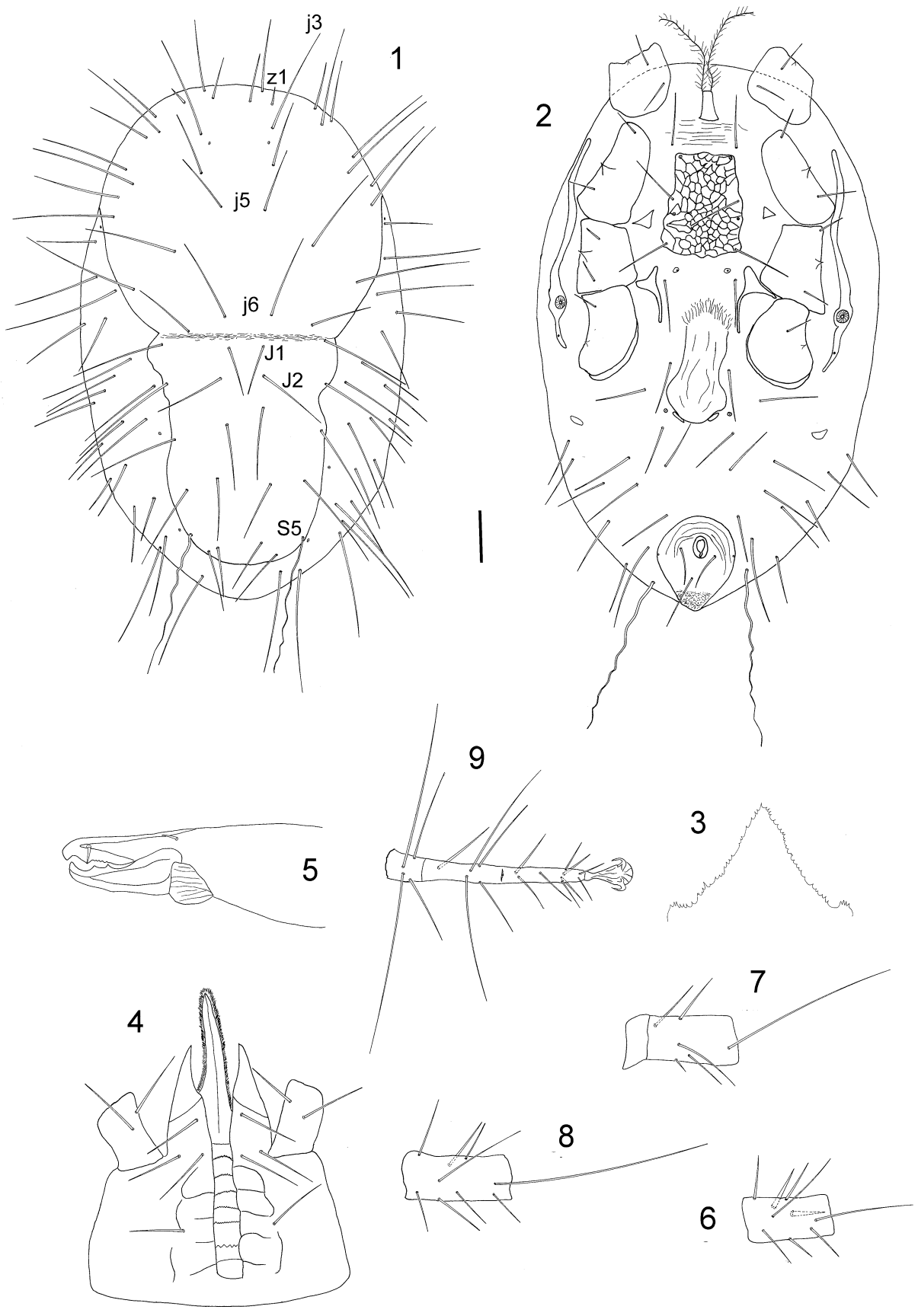
Coleolaelaps asiaticus Karg, 1999: 431.
Coleolaelaps asiaticus.— Karg & Rössner, 1999: 225.

Specimens examined. Eleven females, Karaj, 35°48'N, 50°59' E, alt. 1384 m, O. Joharchi coll., 11 June 2009, on *Polyphylla olivieri* adults; three females, Shiraz, 10 May 2008, O. Joharchi coll., on *Polyphylla olivieri* adults; two females, Yazd, 31°33' N, 54°11' E, alt 2300 m., O. Joharchi coll., on *Polyphylla olivieri* adults.

Notes. *Coleolaelaps asiaticus* was described from Kazakhstan, and is now recorded for only the second time. All the specimens have come from beetles in the genus *Polyphylla* (Karg & Rössner, 1999). This species may be distinguished from most other species of *Coleolaelaps* by the presence of two postero-lateral setae on genu IV, the relatively short dorsal shield setae in the J series, and the short peritreme, which reaches only to the posterior margin of coxa I.

Coleolaelaps costai sp. nov.

Specimens examined. Holotype, female, Tehran, Karaj, Shahrestanak, 35°57' N, 51°21' E, alt 2130 m, 27 June 2009, O. Joharchi coll., on adult *Polyphylla olivieri* (in JAZM). Paratypes: four females, same data as holotype (in JAZM and ANIC).



FIGURES 1–9. *Coleolaelaps costai* **sp. nov.**, female. 1. Dorsal idiosoma; 2. Ventral idiosoma; 3. Epistome; 4. Hypostome; 5. Chelicera; 6. Genu III; 7. Femur IV; 8. Genu IV; 9. Tarsus IV. Scale bar = 100 μm for 1, 2, 6, 7, 8, 9, 50 μm for 3, 4, 5.

Female. *Dorsal idiosoma*. Dorsal shield length 1064–1184 µm, width at level of r3 596–602 µm (n = 2) (Fig. 1). Opisthonotal section narrower than podonotal section, podonotal and opisthonotal sections separated by lateral incisions at a level between j6 and J1. Podonotal region with 17 pairs of setae plus five pairs of setae on lateral soft skin, z3 absent. Opisthonotal region with weak reticulation, with 11 pairs of setae on shield (J1-J5, Z1-Z5, S5) and approximately 19 pairs on lateral soft skin, S5 on the shield (length 336–344 µm), other S series setae outside shield, S5 very long and wavy. All setae except z1 long, j3 and z2 210–231 µm, j3 long enough to reach past j5, j6 (168–176 µm), J1 long enough to reach past J2, j5 (142–147 µm) not long enough to reach j6.

Ventral idiosoma (Fig. 2). Tritosternum with paired pilose laciniae; pre-sternal area with indistinct granular ornamentation. Sternal shield longer than wide, with straight anterior margin, entire surface with distinct polygonal ornamentation. Sternal setae long and smooth, st1 outside shield, one pair of circular pores on anterior margin of sternal shield and a pair of circular pores between st2 and st3. Metasternal setae st4 located in soft skin, metasternal pores located on minute platelets. Endopodal plates II/III triangular, fused to sternal shield to varying degree in different specimens, endopodal plates III/IV elongate, narrow, curved. Genital shield short and tongue-shaped, length 218–231 µm, maximum width 100–126 µm, posterior edge rounded with two minute platelets outside the shield, surface smooth with a few longitudinal lines, genital setae st5 outside the shield. Paragenital pores located on soft skin close to JV1. Anal shield triangular, its anterior half with lineate ornamentation, para-anal setae shorter than unpaired post-anal seta, cribrum large, anal pores indistinct, located on lateral edge of anal shield. Opisthogastric skin with one pair of oval metapodal plates and 14 pairs of smooth setae including st5, JV5 very long and wavy. Exopodal plates behind coxa IV small and narrow. Peritrematal shields free, peritremes short, extending from coxa IV to mid level of coxa II, post-stigmatal section long and narrow, with one pair of post-stigmatal pores.

Gnathosoma. Epistome triangular, irregularly denticulate (Fig. 3). Hypostomal groove with six rows of denticles, each with about 8–10 small teeth except sixth row with only five teeth, and smooth anterior and posterior transverse lines. Hypostome with four pairs of setae, all similar in length (Fig. 4). Corniculi robust and horn-like, reaching mid-level of palp femur. Palp chaetotaxy: trochanter 2, femur 5, genu 6, tibia 12, tarsus 15, genu with a distinct dorso-distal triangular condyle, all setae smooth and needle-like, palp tarsal claw two-tined. Fixed digit of chelicera with about seven small teeth and one large distal tooth (Fig. 5), pilus dentilis short and robust, dorsal seta short, thick, prostrate, movable digit with two large teeth, arthrodial membrane with a rounded flap and a few short filaments.

Legs. Legs II and III short, leg IV longest. Chaetotaxy: Leg I: coxa 0 0/1 0/1 0, trochanter 1 1/1 1/1 1, femur 2 3/1 2/3 2, genu 2 3/2 3/1 2, tibia 2 3/2 3/1 2. Leg II: coxa 0 0/1 0/1 0, trochanter 1 0/1 0/1 1, femur 2 3/1 2/2 1 (*pd*1 and *pd*2 long), genu 2 3/1 2/1 2 (ventral setae thick), tibia 2 2/1 2/1 2 (ventral setae thick). Leg III: coxa 0 0/1 0/1 0, trochanter 1 1/1 0/1 1, femur 1 2/1 1/0 1, genu 2 2/1 2/1 1 (*ad*1 long, 184–192 µm, *ad*2 long 147–160 µm, ventral setae all thick, Fig. 6), tibia: 2 1/1 2/1 1 (*pl* and ventral setae thick). Leg IV: coxa 0 0/1 0/0 0, trochanter 2 1/1 0/1 1, femur 1 2/1 1/0 1 (macroseta *ad*1 336–348 µm, *ad*2 long 130–142, Fig. 7), genu 2 2/1 3/0 1 (macrosetae *ad*1 394–420 µm, *ad*2 184–189 µm, Fig. 8), tibia 2 1/1 3/1 2 (lateral and ventral setae thick). Tarsi I–IV with 18 setae, 3 3/2 3/2 3 + *mv, md*. On tarsus IV macrosetae *ad*2 (231–240 µm), *pd*2 (248–252 µm), *ad*3 (320–336 µm), *pd*3 (344 – 356 µm) (Fig. 9). All pre-tarsi with a pair of claws and a long thin membranous ambulacrum.

Insemination structures: Insemination ducts opening on posterior margin of coxae III, sacculus indistinct, apparently unsclerotised.

Etymology. This species is named in honour of Michael Costa, who made many important contributions to the systematics of the family Laelapidae.

Notes. *Coleolaelaps costai* differs from all other species in the genus by the presence of nine setae on genu IV, a short peritreme, and 17 pairs of setae on the podonotal shield. Podonotal setae j6 are unusually long, z3 is absent, and S5 is very long and wavy. On the legs, both genua III and IV have two long dorsal setae.

Genus *Hypoaspis* Canestrini

Hypoaspis Canestrini 1884: 1569. Type species *Gamasus krameri* G. & R. Canestrini, 1881, designated by Berlese (1904).

Diagnosis. Laelapidae with an oval-shaped dorsal shield without lateral incisions, bearing 35–40 pairs of setae, including one or more pairs of Zx setae between the J and Z setae, all dorsal shield setae smooth and pointed,

except a few occasionally very slightly pilose. Some opisthonotal setae greatly elongated and often appearing wavy in slide-mounted specimens, especially Z4, which is at least three times as long as J5. Post-anal seta distinctly shorter than para-anal setae. Hypostomal setae h3 distinctly longer than other hypostomal setae. Sternal shield fully developed with distinct anterior margin, approximately as wide as long, fused with endopodal plates between coxae II and III. Greatly elongated macrosetae present on femora II and III. Tarsus II with two subterminal blunt spines (*al*1 and *pl*1).

Notes on the genus. The genus *Hypoaspis* as defined here corresponds to the subgenus *Hypoaspis* (*Hypoaspis*) or *Hypoaspis sens. strict.* of most other authors. Great numbers of species have been described in a very loosely-defined genus *Hypoaspis*, but *Hypoaspis sens. strict.* is quite small. Karg (1979) listed only 13 species, which are most easily recognised by the greatly elongate setae Z4 on the dorsal shield. Most species that have been placed in *Hypoaspis* actually belong to other genera, especially *Gaeolaelaps* Evans & Till, 1966 (reviewed by Beaulieu, 2009), because they lack the diagnostic long setae Z4. Other species that we include in *Hypoaspis*, but which were not listed by Karg (1979), include *H. boas* (Ryke & Meyer, 1957), *H. longchuanensis* Gu & Duan, 1991 (= *H. longchuanensis* Gu & Duan, 1993), *H. hunanensis* Ma & Zheng, 2000, and *H. terrestrisimilis* Ma *et al*., 2003. The only species of *Hypoaspis* (*Hypoaspis*) previously recorded from Iran are *H.* (*H.*) *krameri* and *H.* (*H.*) *polyphyllae* Khanjani & Ueckermann, 2005 (Faraji *et al*., 2008). Kamali *et al*. (2001) listed several other species of *Hypoaspis* from Iran, but we place most of those species in other genera.

Hypoaspis integer Berlese

Hypoaspis integer Berlese, 1911: 186.
Hypoaspis integer.— Costa, 1971: 76; Costa & Hunter, 1971: 324.
Hypoaspis (*Hypoaspis*) *integer*.— Karg, 1979: 70, 1982: 236, 1993: 136.
Coleolaelaps integer.— Berlese, 1914: 142; Grandi, 1925: 212; Samšiňák, 1960: 280.

Specimens examined. 20 females, Karaj, Nazarabad, 20 June 2009, O. Joharchi coll., on *Polyphylla* sp.; 20 females, Karaj, Damavand, 20 June 2009, O. Joharchi coll., on *Polyphylla* sp; 20 females, Karaj, Sharestanak, 20 June 2009, O. Joharchi coll., on *Polyphylla* sp.; 20 females, Yazd, 17 June 2008, O. Joharchi coll., on *Polyphylla* sp.; 10 females, Shiraz, 7 September 2008, O. Joharchi coll., on *Polyphylla* sp.; 20 females, Gilan, 10 May 2009, O. Joharchi coll., on *Polyphylla* sp.; 15 females, Tabriz, 10 September 2008, O. Joharchi coll., on *Polyphylla* sp.; five females, Isfahan, 7 September 2008, O. Joharchi coll., on *Polyphylla* sp.

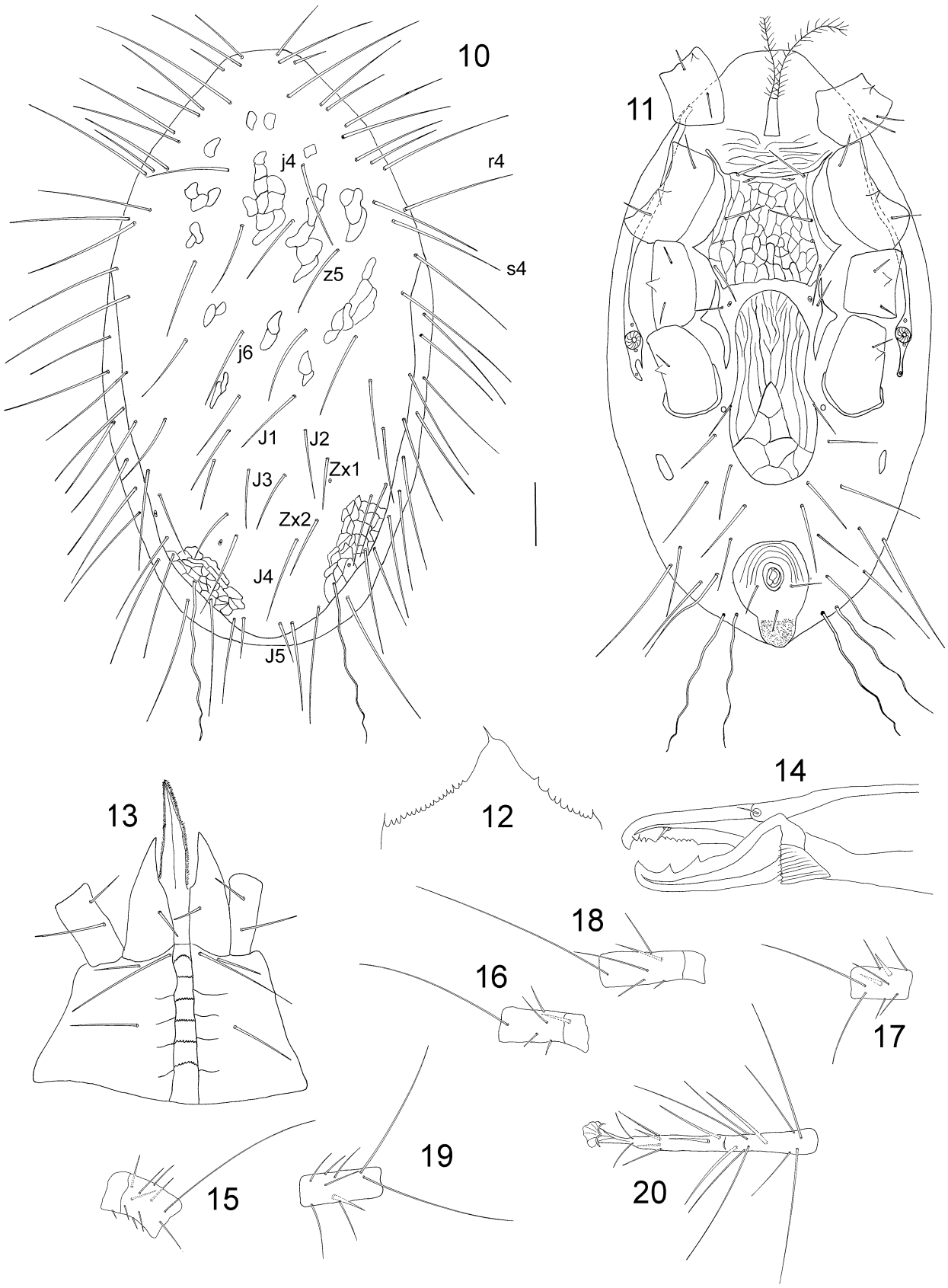
Notes. Willmann (1935) described and illustrated the female of a species identified as *Coleolaelaps integer*, but this appears to be a completely different species, with very short setae in the central area of the dorsal shield.

Hypoaspis larvicolus sp. nov.

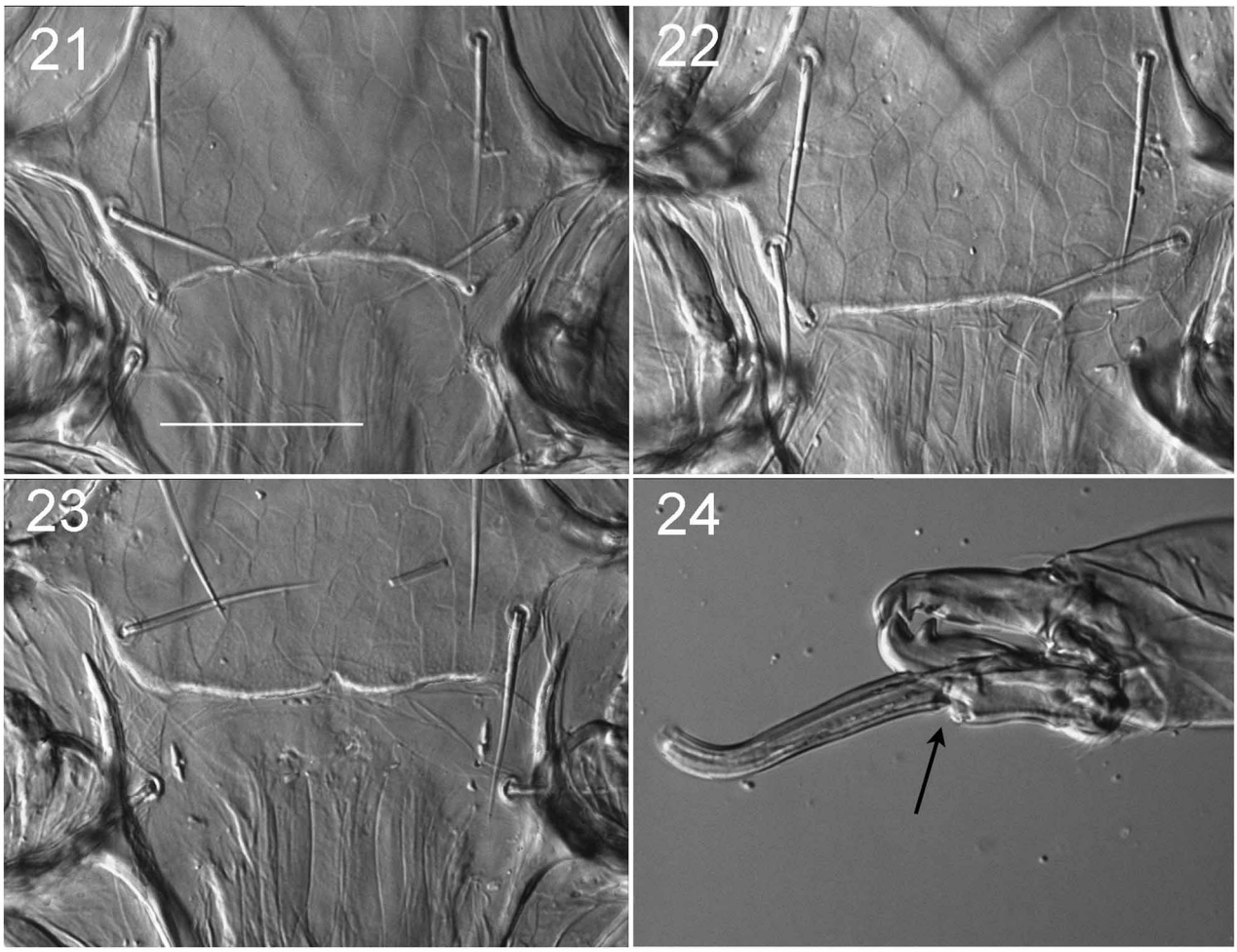
Specimens examined. Holotype, female, Iran, Karaj, 35°48' N, 50°59' E, alt 1384 m, 10 June 2008, O. Joharchi coll., on larva of *Polyphylla* sp. (in JAZM). Paratypes: five females, two males, same data as holotype (in JAZM and ANIC).

Description. Female. *Dorsal idiosoma*. Dorsal shield oval shaped, length 956–1008 µm, width at level of r3 516–525 µm (n = 4), with weak posterolateral reticulation (Fig. 10). Shield with 38 pairs of long setae, 21 pairs of podonotal setae on shield, plus s6 and r6 outside shield, and 17 pairs of opisthonotal setae on shield, including two pairs of Zx setae between J and Z setae; Z4 longest (310–365 µm), s4 (194–231 µm), r4 (252–260 µm), j3 (252–273 µm) also long, j4 long enough to reach z5, j6 long enough to reach past J1 but not long enough to reach to J2, J1 long enough to reach Zx1 but not long enough to reach J3, J4 long enough to reach J5. Soft skin surrounding shield with nine pairs of setae.

Ventral idiosoma (Fig. 11). Tritosternum with paired pilose laciniae, pre-sternal area weakly sclerotised. Sternal shield with straight anterior margin and slightly concave posterior margin, with three pairs of smooth sternal setae, one pair of lyrifissures adjacent to setae st1, and a pair of circular pores between st2 and st3, surface of sternal shield with distinct polygonal ornamentation throughout. Metasternal platelets absent, metasternal setae st4 and metasternal pores located on small circular or elongate platelets in soft skin, some specimens with one or both



FIGURES 10–20. *Hypoaspis larvicolus* **sp. nov.**, female. 10. Dorsal idiosoma; 11. Ventral idiosoma; 12. Epistome; 13. Hypostome; 14. Chelicera; 15. Femur II; 16. Femur III; 17. Genu III; 18. Femur IV; 19. Genu IV; 20. Tarsus IV. Scale bar = 100 μm for 10, 11, 15–20, 50 μm for 12–14.



FIGURES 21–24. *Hypoaspis larvicolus* **sp. nov.** 21. female, sternal shield with both metasternal pores on sternal shield; 22. female, sternal shield with one metasternal pore on sternal shield and one off shield; 23, female, sternal shield with both metasternal pores on separate elongate platelets; 24. male, chelicera, unsclerotised section of spermatodactyl arrowed. Scale bar = 100 μm for figures 21–24.

pores on posterior edge of sternal shield (Figs 21–23). Endopodal plates II/III completely fused to sternal shield, endopodal plates III/IV elongate, narrow, curved. Genital shield tongue-shaped, length 327–336 μm, maximum width 155–147 μm, posterior margin rounded, surface with polygonal ornamentation, bearing the genital setae st5. Paragenital pores located on soft skin close to st5. Anal shield triangular, its anterior half with lineate ornamentation, para-anal setae longer than unpaired post-anal seta, cribrum large, anal pores variable in position, located either on edge of anal shield or on minute platelets outside anal shield. Opisthogastric soft skin with one pair of oval metapodal plates and 11 pairs of smooth setae, ZV5 and JV5 very long and wavy. Exopodal plates behind coxa IV small and narrow. Peritrematal shield free, peritreme extending from coxa IV to mid level of coxa I, post-stigmatal section conspicuous and narrow, with two pairs of post-stigmatal pores, and one pair of pores anterior to the stigmata.

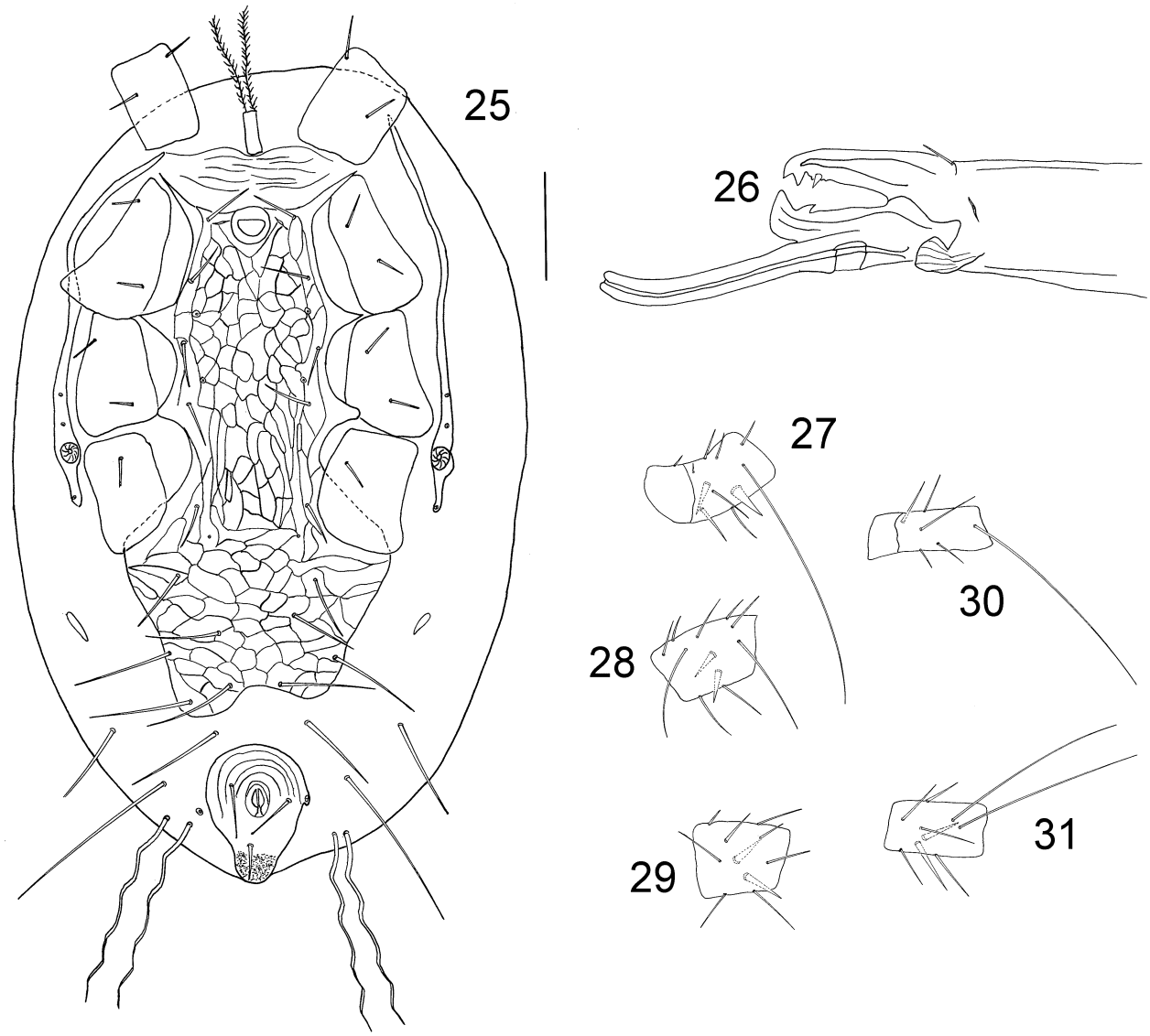
Gnathosoma. Epistome irregularly denticulate laterally, central margin smooth with apical point (Fig. 12). Hypostomal groove with six rows of denticles, each row with about ten small teeth, and smooth anterior transverse line. Hypostome with four pairs of setae, internal posterior hypostomal setae h3 longest (Fig. 13). Corniculi robust and horn-like, reaching mid-level of palp femur. Palp chaetotaxy: trochanter 2, femur 5, genu 6, tibia 12, tarsus 15, genu with a distinct dorso-distal triangular condyle, all setae smooth and needle-like, palp tarsal claw two-tined. Fixed digit of chelicera with a small triangular proximal tooth, about ten small teeth, a larger median tooth, and one large distal tooth (Fig. 14), pilus dentilis short and robust, dorsal seta short, thick, prostrate, movable digit with two large teeth, arthrodial membrane with a rounded flap and a few short filaments.

Legs. Legs II and III short, leg IV longest. Chaetotaxy: Leg I: coxa 0 0/1 0/1 0, trochanter 1 0/1 1/2 1, femur 2 3/1 2/3 2, genu 2 3/2 3/1 2, tibia 2 3/2 3/1 2. Leg II: coxa 0 0/1 0/1 0, trochanter 1 0/1 0/2 1, femur 2 3/1 2/2 1 (mac-

roseta *pd*1 252–284 µm, Fig. 15), genu 2 3/1 2/1 2 (*pd*1 and *pd*2 longest), tibia 2 2/1 2/1 2. Leg III: coxa 0 0/1 0/1 0, trochanter 1 1/1 1/1 0, femur 1 2/1 1/0 1 (macroseta *ad*1 281–298 µm, Fig. 16), genu 2 2/1 2/1 1 (*ad*1 long 147–178 µm, *pd*1 long 165–172 µm, ventral setae all thick, Fig. 17), tibia: 2 1/1 2/1 1 (*pl* and ventral setae thick). Leg IV: coxa 0 0/1 0/0 0, trochanter 1 1/1 0/1 1, femur 1 2/1 1/0 1 (macrosetae *ad*1 370–400 µm, *ad*2 134–144 µm, Fig. 18), genu 2 2/1 3/0 1 (macrosetae *ad*1 275–290 µm, *pd*1 253–268 µm, *av* thick, Fig. 19), tibia 2 2/1 3/1 2 (*pl*1 and ventral setae thick). Tarsi I–IV with 18 setae 3 3/2 3/2 3 + *mv, md*. On tarsus II, *al*1, *pl*1 and all ventral setae thick. On tarsus IV macrosetae *ad*2 (218–222 µm), *pd*2 (228–243 µm), *ad*3 (240–253 µm), *pd*3 (240–260 µm) (Fig. 20). All pre-tarsi with a pair of claws and a long thin membranous ambulacrum.

Insemination structures. Insemination ducts opening on posterior margin of coxa III; sacculus indistinct, apparently unsclerotised.

Male. *Dorsal idiosoma*. Dorsal shield length 740–810 µm, width at level of r3 441–462 µm (n = 2) structure and chaetotaxy as for female.



FIGURES 25–31. *Hypoaspis larvicolus* **sp. nov.**, male. 25. Ventral idiosoma; 26. Chelicera; 27; femur II; 28. Genu II; 29. Tibia II; 30. Femur III; 31. Genu III. Scale bar = 100 µm for 25, 27–31, 50 µm for 26.

Ventral idiosoma (Fig. 25). Sternal, genital, endopodal and ventral shields fused to form a strongly ornamented composite shield with nine to ten pairs of setae and five pairs of pores, posterior margin of this shield concave and irregular, with unpaired setae in both specimens. Anal shield free, triangular, its anterior half with lineate ornamentation, para-anal setae longer than unpaired post-anal seta, cribrum large, anal pores either on edge of shield or in adjacent soft skin.

Gnathosoma (Figs 24, 26). Movable digit of chelicera with one large tooth, spermatodactyl long slender, more than double length of movable digit, with truncate tip and an apparently unsclerotised ventral section near its base, fixed digit with one large distal tooth and minute pilus dentilis.

Legs. Chaetotaxy as in female, leg II with several stout pointed spine-like setae on ventral surface of femur (Fig. 27), genu (Fig. 28), tibia (Fig. 29) and tarsus, *av*1 on femur II very stout, leg III with one macroseta on femur (Fig. 30) and two macrosetae on genu (Fig. 31).

Etymology. The name of this species refers to the fact that the specimens were found on the larva of *Polyphylla* sp. and not the adult.

Notes. *Hypoaspis larvicolus* differs from almost all other species in the genus by its long dorsal setae and the presence of four long macrosetae on tarsus IV, as well as the two macrosetae on genu III and IV, and 11 setae on tibia IV instead of the usual 10. The male is distinctive in having a separate anal shield, which in other species is fused to the sternal-genital-ventral shield.

Hypoaspis maryamae sp. nov.

Specimens examined. Holotype, female, Iran, Yazd, 31°38'N, 53°59'E, alt. 2250 m, 15 May 2010, O. Joharchi coll., on *Polyphylla olivieri* (in JAZM). Paratypes: eight females, same data as holotype; four females, Tehran, Karaj, 36°04'N, 51°19'E, alt. 2200 m, 28 July 2009, O. Joharchi coll., on *Polyphylla olivieri* (in JAZM and ANIC).

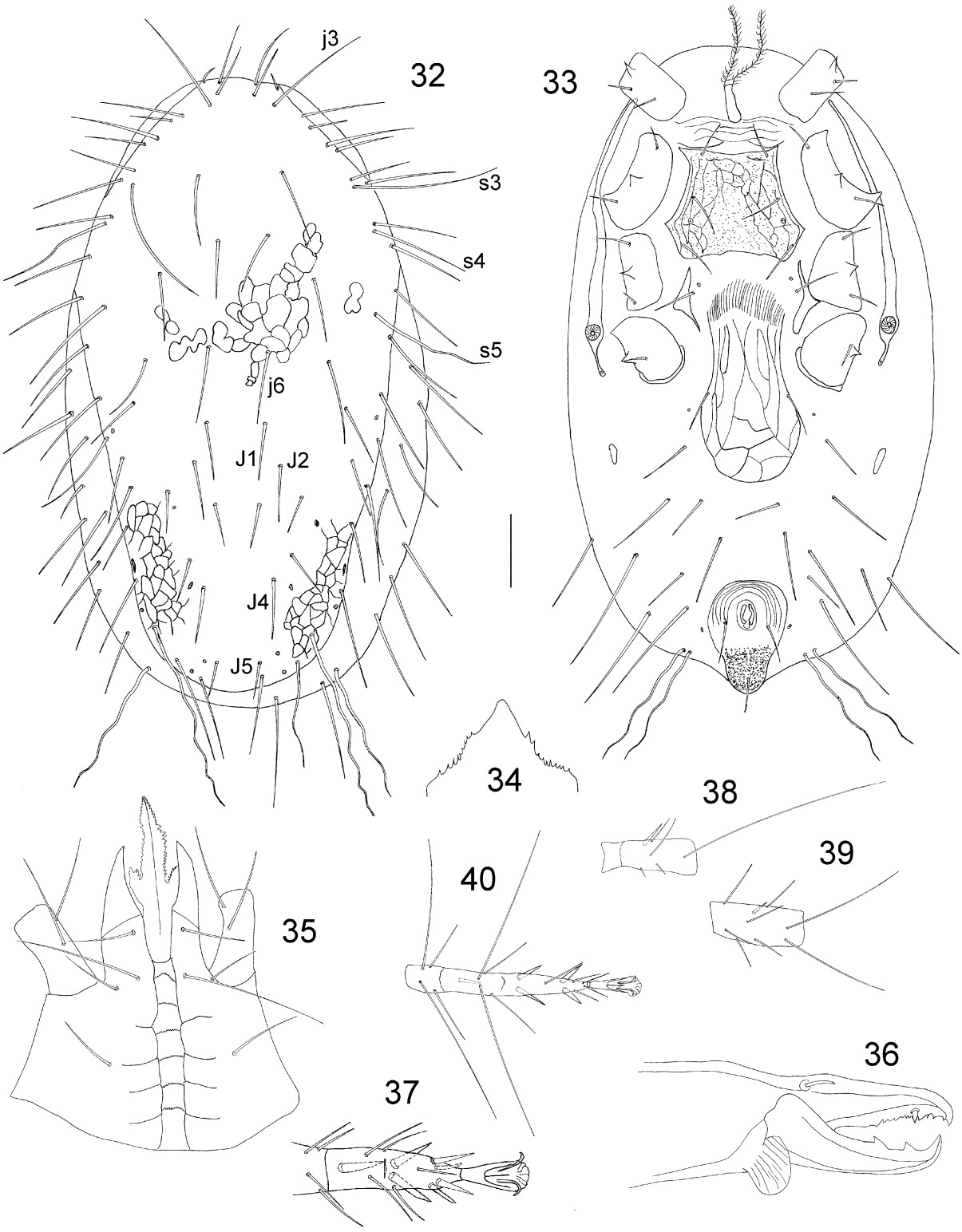
Description. Female. *Dorsal idiosoma*. Dorsal shield length 860–966 µm, width at level of r3 504–546 µm (n = 4) (Fig. 32). Dorsal shield oval, narrower posteriorly, with weak postero-lateral reticulation, with 39 pairs of long setae, 22 pairs on podonotal section plus r6 outside the shield, and 17 pairs on opisthonotal section, including two pairs of Zx setae between J and Z setae. Seta Z4 longest (240–265 µm), s3, s4, s5 (210–218 µm) and j3 (170–180 µm) also long, j6 long enough to reach to J1, J1 long enough to reach J2 but not to J3, J4 not long enough to reach J5. Soft skin surrounding shield with ten pairs of setae.

Ventral idiosoma (Fig. 33). Tritosternum with paired pilose laciniae, pre-sternal area weakly sclerotised. Sternal shield with straight anterior margin and slightly concave posterior margin, with three pairs of smooth sternal setae, one pair of lyrifissures adjacent to setae st1, and a pair of circular pores between st2 and st3, anterior and antero-lateral surface of sternal shield with polygonal ornamentation, central and posterior are smooth. Metasternal platelets absent, metasternal setae st4 and metasternal pores located in soft skin; endopodal plates II/III completely fused to sternal shield, endopodal plates III/IV elongate, narrow, curved. Genital shield tongue-shaped, length 327–332 µm, maximum width 143–168 µm, posterior edge rounded, surface with polygonal ornamentation, bearing the genital setae st5. Paragenital pores located on soft skin close to seta st5. Anal shield triangular, its anterior half with lineate ornamentation, unpaired post-anal seta shorter than para-anal setae, cribrum large, anal pores located on minute platelets outside anal shield. Opisthogastric skin striated, with one pair of oval metapodal plates and 11 pairs of smooth setae, ZV5 and JV5 very long and wavy. Exopodal plates behind coxa IV small and narrow. Peritrematal shield free, peritreme extending from coxa IV to posterior level of coxa I, post-stigmatal section conspicuous and narrow, with one pair of pores.

Gnathosoma. Epistome irregularly denticulate laterally, with smooth apical section (Fig. 34). Hypostomal groove with six rows of denticles, each with about ten small teeth, and a smooth anterior transverse line. Hypostome with four pairs of smooth pointed setae, internal posterior hypostomal setae h3 longest (Fig. 35), corniculi robust and horn-like, reaching mid-level of palp femur. Palp chaetotaxy: trochanter 2, femur 5, genu 6, tibia 12, tarsus 15, genu with a distinct dorso-distal triangular condyle, all setae smooth and needle-like, palp tarsal claw two-tined. Fixed digit of chelicera with a small basal triangular tooth about ten smaller teeth, and a larger median tooth (Fig. 36), pilus dentilis short and robust, dorsal seta long, thick, prostrate, movable digit with two large teeth, arthrodial membrane with a rounded flap and a few short filaments.

Legs. Legs II and III short, and leg IV longest. Chaetotaxy: Leg I: coxa 0 0/1 0/1 0, trochanter 1 1/1 0/2 1, femur 2 3/1 2/3 2, genu 2 3/2 3/1 2, tibia 2 3/2 3/1 2. Leg II: coxa 0 0/1 0/1 0, trochanter 1 0/1 0/2 1, femur 2 3/1 2/2 1 (*pd*1 longest), genu 2 3/1 2/1 2 (*pd*1 and *pd*2 longest), tibia 2 2/1 2/1 2. Leg III: coxa 0 0/1 0/1 0, trochanter 1 1/1 0/1 1, femur 1 2/1 1/0 1 (*ad*1 a macroseta), genu 2 2/1 2/1 1 (ventral setae all thick, *pd*1, *ad*1 longest), tibia: 2 1/1 2/1 1 (*pl* and ventral setae thick). Leg IV: coxa 0 0/1 0/0 0, trochanter 1 1/1 0/1 1, femur 1 2/1 1/0 1 (macroseta *ad*1 342–350 µm, *ad*2 84–85 µm, Fig. 38), genu 2 2/1 3/0 1 (macrosetae *ad*1 163–172 µm, *pd*1 152–155 µm, Fig. 39), tibia 2 1/1 3/1 2 (*pl*1 and ventral setae thick), tarsi I–IV with 18 setae 3 3/2 3/2 3 + *mv*, *md*, tarsus II with *al*1, *pl*1

and all ventral setae thick (Fig. 37), tarsus IV with four macrosetae *ad*2 (210–230 µm), *pd*2 (210–230 µm), *ad*3 (210–222 µm), *pd*3 (184–185 µm) (Fig. 40). All pre-tarsi with a pair of claws and a long thin membranous ambulacrum.



FIGURES 32–40. *Hypoaspis maryamae* **sp. nov.**, female. 32. Dorsal idiosoma; 33. Ventral idiosoma; 34. Epistome; 35. Hypostome; 36. Chelicera; 37. Tarsus II; 38. Femur IV; 39. Genu IV; 40. Tarsus IV. Scale bar = 100 µm for 32, 33, 37–40, 50 µm for 34–36.

Insemination structures: Insemination ducts opening on posterior margin of coxa III, sacculus indistinct, apparently unsclerotised.

Etymology. This species is named in honour of Maryam Moradi, who supported this project in many ways.

Notes. *Hypoaspis maryamae* differs from almost all other species in the genus by the presence of four long macrosetae on tarsus IV and two macrosetae on genu IV. Only *H. integer* has two macrosetae on genu IV; *H. maryamae* differs from *H. integer* by its longer sternal setae and the very long and wavy form of ZV5. It also differs from *H.* (*H.*) *polyphyllae* by its longer setae in the central area of the dorsal shield, especially j6, J1 and J2, and by having a greater number of opisthogastric setae.

***Hypoaspis melolonthae* sp. nov.**

Specimens examined. Holotype, female, Iran, Yazd, 31°33'N, 54°11'E, alt 2300 m, 17 May 2010, O. Joharchi coll., on *Melolontha melolontha* (in JAZM). Paratypes: six females, same data as holotype; three females, Tehran, Savojbolagh, Taleghan, 36°09' N, 50°40'E, alt 1909 m, 1 July 2009, on *Melolontha melolontha* (in JAZM and ANIC).

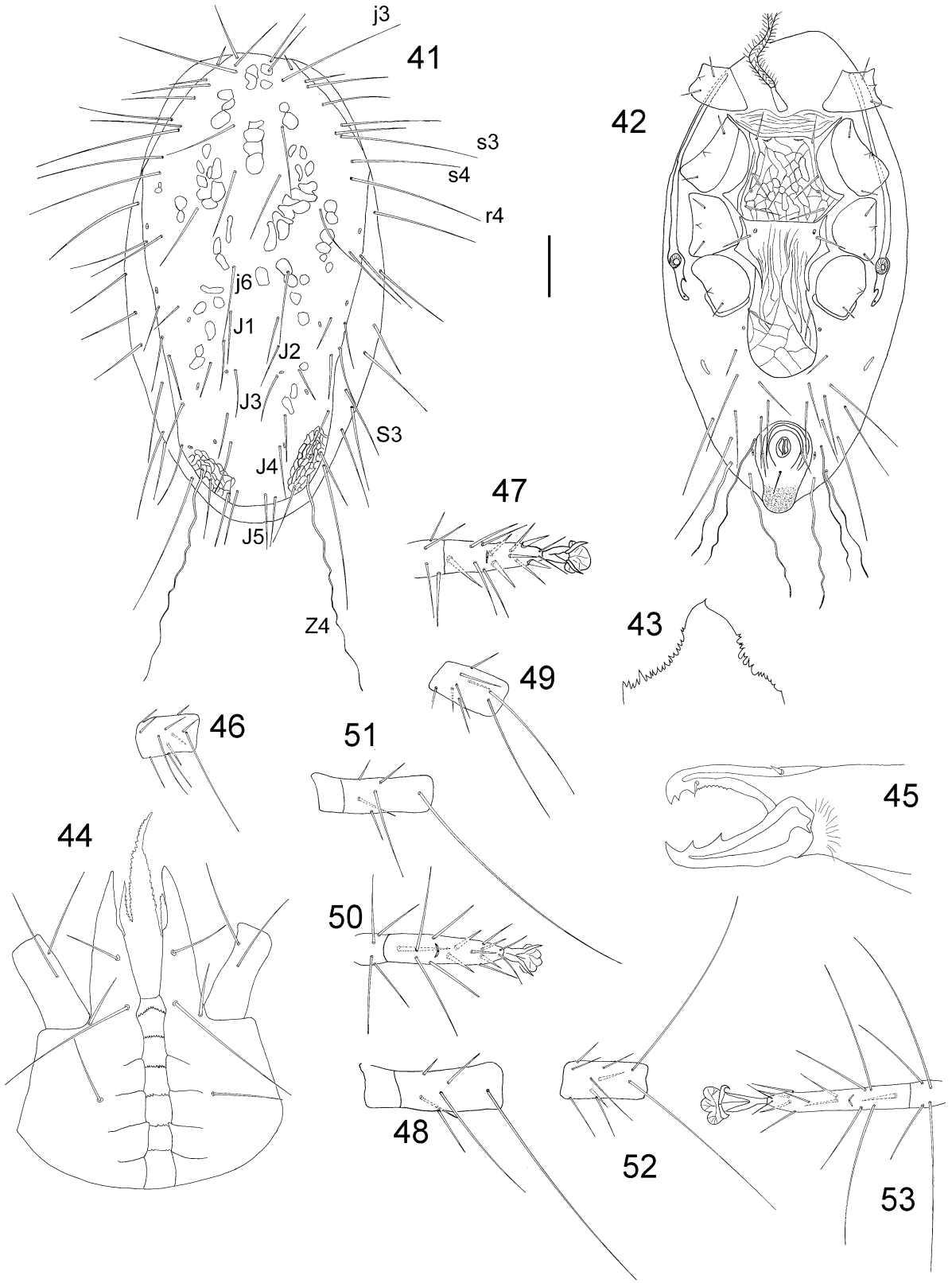
Description. Female. *Dorsal idiosoma*. Dorsal shield length 796–840 µm, width at level of r3 399–428 µm (n = 4) (Fig. 41). Shield oval shaped, narrower posteriorly, with weak posterolateral reticulation, with 37 pairs of long setae, 20 podonotal, 16 opisthonotal, including two pairs of Zx setae between J and Z setae, S3 outside shield in soft skin, z6, r2, r3 absent. Seta Z4 longest (336–357 µm), s3 (239–247 µm), s4 (201–231 µm), r4 (285–294 µm) and j3 (231–252 µm) also long. Seta j6 long enough to reach J2, J4 long enough to reach J5, J5 and Z5 similar in length, J1 not long enough to reach J3, soft skin surrounding shield with eight pairs of setae including S3.

Ventral idiosoma (Fig. 42). Tritosternum with paired pilose laciniae, pre-sternal area weakly sclerotised. Sternal shield with straight anterior margin, entire surface with distinct polygonal ornamentation, with three pairs of smooth setae, one pair of lyrifissures adjacent to setae st1, and a pair of circular pores between st2 and st3. Metasternal platelets absent, metasternal setae st4 and metasternal pores located in soft skin. Endopodal plates II/III completely fused to sternal shield, endopodal plates III/IV elongate, narrow, curved. Genital shield tongue-shaped, length 285–294 µm, maximum width 118–134 µm, posterior edge rounded, surface with polygonal ornamentation, bearing the genital setae st5. Paragenital pores located on soft skin close to edge of shield. Anal shield triangular, its anterior half with lineate ornamentation, para-anal setae similar in length to unpaired post-anal seta, cribrum large, anal pores on minute elongate platelets adjacent to shield. Opisthogastric skin strongly striated, with one pair of oval metapodal plates and 11 pairs of long smooth setae, ZV4, ZV5, JV4, JV5 very long and wavy. Exopodal plates behind coxa IV small and narrow. Peritrematal shield free, peritreme extending from coxa IV to anterior level of coxa I, post-stigmatal section conspicuous and narrow, with one pair of pores.

Gnathosoma. Epistome irregularly denticulate laterally, apical section smooth with terminal point (Fig. 43). Hypostomal groove with six rows of denticles, each row with about ten small teeth, and a smooth anterior transverse line. Hypostome with four pairs of setae, internal posterior hypostomal setae h3 longest (Fig. 44). Corniculi robust and horn-like, reaching mid-level of palp femur. Palp chaetotaxy: trochanter 2, femur 5, genu 6, tibia 12, tarsus 15, genu with a distinct dorso-distal triangular condyle, all setae smooth and needle-like, palp tarsal claw two-tined. Fixed digit of chelicera with about ten small teeth, a larger median tooth, and one large distal tooth (Fig. 45), pilus dentilis short and robust, dorsal seta short, thick, prostrate, movable digit with two large teeth, arthrodial membrane with a rounded flap and a few short filaments.

Legs. Legs II and III short, and leg IV longest. Chaetotaxy: Leg I: coxa 0 0/1 0/1 0, trochanter 1 1/2 1/0 1, femur 2 3/1 2/3 2, genu 2 3/2 3/1 2 (*pd*1 long), tibia 2 3/2 3/1 2. Leg II: coxa 0 0/1 0/1 0, trochanter 1 0/1 0/2 1, femur 2 3/1 2/2 1 (macroseta *pd*1 302 µm), genu 2 3/1 2/1 2 (macrosetae *pd*1 181–197 µm, *pd*2 93–105 µm, Fig. 46), tibia 2 2/1 2/1 2 (*pv* thick). Leg III: coxa 0 0/1 0/1 0, trochanter 1 1/1 0/1 1, femur 1 2/1 1/0 1 (macrosetae *ad*1 380–400 µm, *ad*2 195–208 µm, Fig. 48), genu 2 2/1 2/1 1 (macrosetae *pd*1 184–200 µm, *ad*1 181–200 µm, lateral and ventral setae all thick, Fig. 49), tibia: 2 1/1 2/1 1 (*pl* and ventral setae thick). Leg IV: coxa 0 0/1 0/0 0, trochanter 2 1/1 0/1 0, femur 1 2/1 1/0 1 (macrosetae *ad*1 420–450 µm, *ad*2 155–160 µm, Fig. 51), genu 2 2/1 3/1 1 (macrosetae *ad*1 300–330 µm and *pd*1 312–355 µm, Fig. 52), tibia 2 1/1 3/1 2 (*pl*1 and ventral setae thick). Tarsi I–IV with 18 setae 3 3/2 3/2 3 + *mv, md*. On tarsus II, *al*1 and *pl*1 thick, all ventral setae thick (Fig. 47). Tarsus III with four moderately long setae, *ad*2, *pd*2, *ad*3, *pd*3, 130–160 µm (Fig. 50). On tarsus IV *ad*2 (193–210 µm), *pd*2

(200–220 µm), *ad*3 (252–268 µm), *pd*3 (235–246 µm) macrosetae (Fig. 53). All pre-tarsi with a pair of claws and a long thin membranous ambulacrum.



FIGURES 41–53. *Hypoaspis melolonthae* **sp. nov.**, female. 41. Dorsal idiosoma; 42, ventral idiosoma; 43. Epistome; 44. Hypostome; 45. Chelicera; 46. Genu II; 47. Tarsus II; 48. Femur III; 49. Genu III; 50. Tarsus III; 51. Femur IV; 52. Genu IV; 53. Tarsus IV. Scale bar = 100 µm for 41, 42, 46–53, 50 µm for 43–45.

Insemination structures: Insemination ducts opening on posterior margin of coxa III; sacculus indistinct, apparently unsclerotised.

Etymology. The name of this species is taken from its host beetle, *Melolontha melolontha*.

Notes. *Hypoaspis melolonthae* differs from almost all other species in the genus by the presence of four long macrosetae on tarsus IV, two macrosetae on each of genu II, genu III and genu IV, and very long opisthogastric setae ZV4, ZV5, JV4, and JV5. It is also distinctive in lacking podonotal setae z6, r2 and r3.

Hypoaspis pentodoni Costa

Hypoaspis pentodoni Costa, 1971: 71.

Specimens examined. Two females, Karaj, Nazarabad, 35°54' N, 50°38' E, alt 1230 m, 12 July 2009, O. Joharchi coll., on adult *Polyphylla olivieri*.

Notes. This species was described from Israel, on the beetle *Pentodon bispinosus*. It is now recorded from Iran on a different species of host. Costa (1971) reported a macroseta on genu IV in this species, but his illustration and the type specimens show only setae of normal length (A.S. Baker, *pers. comm.*), and that is consistent with our specimens. This species may be recognised by the short setae in the central area of the dorsal shield and its relatively small sternal shield, which is wider than long.

Hypoaspis phyllognathi Costa

Hypoaspis phyllognathi Costa, 1971: 74.
Hypoaspis (*Hypoaspis*) *phyllognathi*.— Karg, 1979: 70, 1982: 236, 1993: 137.

Specimens examined. Two females, Shiraz, Khaf, 25 October 2009, O. Joharchi coll., on *Phyllognathus* sp.

Notes. *Hypoaspis phyllognathi* was described from beetles in the genus *Phyllognathus* in Egypt and Israel by Costa (1971), and has not been reported since. There are no published records of this species from Iran. The species is easily recognised by the long dorsal shield setae (apart from z1 and Z5, which are short), and the long dorso-distal seta *ad*1 on genu IV.

Hypoaspis terrestris (Leonardi)

Laelaps terrestris Leonardi, 1899: 508 (page 16 in reprint).
Laelaps terrestris.— Costa & Hunter, 1971: 324.
Hypoaspis (*Hypoaspis*) *terrestris*.— Bregetova, 1977: 496; Karg, 1979: 70, 1982: 236.
Coleolaelaps terrestris.— Grandi, 1925: 212.
not *Laelaps terrestris* Berlese, 1908: 14.

Specimens examined. Nine females, Nazarabad, 27 August 2008, O. Joharchi coll., on *Pentodon idiota*; four females, Karaj, 20 May 2009, O. Joharchi coll., on *Polyphylla olivieri* larvae and adults.

Notes. *Hypoaspis terrestris* is very distinctive in the extreme length of dorsal shield setae j3 and S5. The length of these setae separates this species from the related species *H. polyphyllae*, which was also present in our collections. Our specimens of *H. terrestris* show some variation in the length of seta j6, which sometimes reaches past the base of J1, but is noticeably shorter in other specimens. The only available illustrations of this species appear to be those of Bregetova (1977), which does not show the length of these setae. This species has been reported from USSR and Italy, in soil and on *Copris hispanus* and an unidentified species of Cetoniinae. We now record it on two species of beetles in Iran, *Pentodon idiota* and *Polyphylla olivieri*. Our specimens were found both on the larvae of *P. olivieri* in soil, and phoretic on the adult beetles. This is consistent with the original observations of Leonardi (1899).

Discussion

Our observations of the species discussed here support the separation of the genera *Coleolaelaps* and *Hypoaspis*, as detailed in Table 1, with two exceptions. First, Costa & Hunter (1971) described the opisthonotal portion of the dorsal shield in *Hypoaspis* as not markedly narrower than the podonotal portion. In *H. maryamae* and *H. melolonthae*, the widest point on the dorsal shield is at the level of seta r3, and the opisthonotal section of the shield is slightly narrower than the podonotal section. However, in these species the dorsal shield gradually tapers from r3 back to S5, and does not have a clear division into podonotal and opisthonotal sections, with the division marked by lateral incisions, as it does in *Coleolaelaps*. Second, the new species *Coleolaelaps costai* has 17 pairs of setae on the podonotal shield, where Costa & Hunter (1971) reported a maximum of 16 pairs. However, the edges of the podonotal shield are often weakly defined and irregular, so it is difficult to decide whether some setae are inside or outside the edge of the shield, especially s1, s2, s3.

TABLE 1. Distinction between females of *Coleolaelaps* and *Hypoaspis* (based on Costa & Hunter, 1971).

	Coleolaelaps	*Hypoaspis*
Shape of dorsal shield	narrower posteriorly	rounded, oval
Lateral incisions in dorsal shield	present	absent
Setae on podonotal region of dorsal shield	maximum 17 pairs	at least 20 pairs
Setae on opisthonotal region of dorsal shield	11 pairs	17 pairs
Opisthonotal seta Z4	not markedly elongate	very long and wavy
Anterior margin of sternal shield	often weakly defined	distinct
Hypostomal setae	h3 not markedly elongate	h3 clearly longest
Length of leg I	shorter than leg III	longer than leg III
Macrosetae on femur II and III	absent	present
Thick subterminal spines on tarsus II (setae *al*1 and *pl*1)	absent	present
Post-anal seta	at least as long as para-anal setae	shorter than or equal to para-anal setae
Beetle hosts	*Anoxia* and *Polyphylla*	wide variety of hosts

The ecological role of the mites discussed here is unknown. Some authors have reported that species of *Hypoaspis* and *Coleolaelaps* are parasites of the eggs and larvae of plant-feeding Scarabaeidae, and therefore may have potential as biological control agents. Rao (1971), Swan (1974), Lomer (1985) and Gerson *et al*. (2003) reported that *Hypoaspis* or *Coleolaelaps* caused some mortality of the eggs and larvae of rhinoceros beetles in the genus *Oryctes*. Khanjani & Ueckermann (2005) reported that *Hypoaspis polyphyllae* punctured the integument of *Polyphylla olivieri* and allowed the escape of droplets of haemolymph, and Çobanoğlu *et al*. (2003) suggested that injuries of this type might allow the entry of pathogenic microorganisms into the beetle larva. A species of *Hypoaspis* was introduced from West Africa into the Tokelau Islands for control of scarabs attacking coconut plants (Swan, 1974), but there does not appear to be any evidence that these mites are effective biological control agents of pest beetles on a large scale. It is possible that these mites are not parasites of beetles at all, but harmless feeders on exudates from the beetles' body (Costa, 1971), or predators that feed on other small invertebrates in the microhabitats created by the beetles. Wilson & Knollenberg (1987) showed experimentally that commensal mites could be either beneficial, neutral, or harmful to their beetle hosts, and that these relationships depend on a number of variables, including population densities and the presence of other species of mites. Laelapid mites in the genus *Hypoaspis* and related genera appear to offer rich opportunities for exploring the true nature of the relationship between mites and their insect hosts.

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