

A NEW SPECIES OF *PRASADISEIUS* WAINSTEIN, 1970 (ACARI:
OTOPHEIDOMENIDAE) FROM HAWK MOTHS
(LEPIDOPTERA: SPHINGIDAE) IN PERU

Vikram PRASAD¹; Alberto D. GUANILO², Juan GRADOS³ and Indira PRASAD¹

(Received 14 January 2011; accepted 08 March 2011; published online 30 March 2011)

¹ 7247 Village Square Drive, West Bloomfield, MI 48322, USA. v.prasad@ix.netcom.com

² Bugs for Bugs, 1 Bowen Street, Mundubbera, QLD 4626, Australia. a_guanilo@yahoo.co.uk

³ Departamento de Entomología, Museo de Historia Natural, Universidad Nacional Mayor de San Marcos, Avenida Arenales 1256, Apartado Postal 14-0434, Lima, Peru. gradosjuan@hotmail.com

ABSTRACT — During an expedition to Peru in August 2010, a new species of otopheidomenid mite, *Prasadiseius incanus* Prasad and Guanilo, **n. sp.** (Acari: Otopheidomenidae), was collected from *Xylophanes fusimaculata* (Felder, 1874) and *Xylophanes undata* Rothschild and Jordan, 1903 (Sphingidae). The female and male of the new species are described using current nomenclature for the idiosomal chaetotaxy and illustrated in a series of photographs. A key for the identification of all species of the genus is provided.

KEYWORDS — adults; description; new species; Peru

INTRODUCTION

The species of the genus *Prasadiseius* Wainstein, 1972 (Mesostigmata: Otopheidomenidae) are only known to parasitize hawk moths (Lepidoptera: Sphingidae) and have been found primarily in the neotropical region with two species from other tropical regions of the world (Prasad 1976, 2011d). So far, the following seven 7 species of the genus *Prasadiseius* have been described: *P. achlora* (Prasad 1972) and *P. aporodes* (Prasad 1972) from Uganda, *P. cocytes* (Prasad 1970a) and *P. donahuei* (Prasad 1970a) from Peru, *P. indicus* (Prasad 1973) from India, *P. kayosiekeri* (Prasad 1970b) from Honduras, Panama Canal Zone and Peru, and *P. pholusis* (Prasad 1970b) from Bolivia and Honduras (Prasad 1970a, b, 1972, 1973). Recently, *P. cocytes* was

found to be widely distributed in several neotropical countries: Brazil, Ecuador, Guatemala, and Peru (Prasad 2011d). All stages of the mite are found dorsally mainly in the rectangular area of the tympanum, the metathorax, and first abdominal tergite of the moths; occasionally, they are found on the proboscis, around eyes, and the dorsum or venter of the head, thorax, abdomen, and wings.

All the species were described from dead specimens collected from museum preserved dead hawk moths that, in some cases, were collected over 50 years before the mites were discovered by the first author. Although the eggs, larvae, protonymphs, deutonymphs, females and males of these mites are often found on these moths when they are heavily infested, the biological parameters of these mites

have not been studied yet.

Species of Otopheidomenidae are known to parasitize insects of Hemiptera, Isoptera, Lepidoptera and Orthoptera (Treat 1975; Fain and Lukoschus 1983; Syed and Goff 1983; Halliday 1994; Zhang 1995; Mo 1996). Presently, the family is subdivided into the following 3 subfamilies: Katydiseiinae Fain and Lukoschus, 1983 which infests grasshoppers (Orthoptera) and termites (Isoptera); Otopheidomeninae Treat, 1955 which infests noctuid and sphingid moths (Lepidoptera); and Treatiinae Wainstein, 1972 which infests various true bugs (Hemiptera). The subfamily Otopheidomeninae is comprised of 3 genera: *Noctuiseius* Prasad, 1968 and *Otopheidomenis* Treat, 1955 which infest noctuid moths, and *Prasadiseius* Wainstein, 1972 which infests sphingid moths. The family Otopheidomenidae is considered to be closely related to the Phytoseiidae (Krantz and Khot 1962; Evans 1963; Chant 1965; Chant and Yoshida-Shaul 1992; Chant and McMurtry 2007) but have adapted to parasitizing various insects. Unlike the chelicerae of phytoseiids which have a fixed digit and movable digit, the otopheidomenids only have the movable digit. In addition, there is a reduction in the number of setae in Otopheidomenidae. The spermatheca of the species in which it is known, are cup-shaped or tubular-shape similar to those found in some of the phytoseiid species. Because of these unique features and their close relation to phytoseiids, otopheidomenid mites have received more attention in recent years, including DNA studies, which are still in progress (pers. comm., 2010, Kreiter – France, Ragusa di Chiara – Italy). Detailed studies of the morphology of these mites using scanning electron micrographs are also being conducted (Prasad and Walker 2011).

Since live otopheidomenid mites on live hawk moths had never been observed before and consequently their biology never studied, the first author organized an international expedition in August 2010 involving Alberto D. Guanilo, an acarologist from Peru; Juan Grados, a lepidopterist from Peru; and Indira Prasad, expedition supporter and life-long companion of the first author. During this expedition, not only were live otopheidomenid mites

observed for the first time on live sphingid moths captured in the Amazonian Forest of Cusco Department, but an interesting new species of *Prasadiseius* was found which is described herein, thus, making a total of 8 species of *Prasadiseius* known worldwide.

MATERIALS AND METHODS

After obtaining permit from the Government of Peru months ahead of our visit for collecting the moths and mites, the live sphingid moths were collected at night in transparent plastic jars with screw caps (100 ml, 7.5 x 4.5 cm, NCS Diagnostics Inc., Mississauga, Canada) during August 10 – 18, 2010 in different localities of Cusco Department from 7 – 10 pm using a mercury vapor light. A Honda generator was used to produce the electricity for the light bulb as no electricity was available in the jungle. Each live moth was photographed before collection using a Ricoh (R8) camera, labeled with a corresponding collection number, and examined next day by first two authors under a Bausch and Lomb stereo binocular microscope having total magnification of 25x for the presence of mites. When mites were observed, the moths with the mites were photographed and a video was taken using a High Definition Kodak EasyShare Z812 IS camera and/or Ricoh camera. After observation on live moths, the mites were collected in 70% ethanol, stored in small glass vials (4.5 x 1.5 cm) having screw caps, and brought to USA for preparation and identification by the first author. The moths were euthanized with 0.2 ml of wind shield washing liquid which was injected into the thorax and then taken to Natural History Museum, Lima, Peru for the identification.

The mites were extracted from the 70% ethanol, and mounted in Hoyer's medium, one specimen per glass microscope slide (3 x 1 inch; 75 x 25 mm), and covered with a #18 mm, zero-thickness round cover slip. Each slide was dried for a week between 45 – 47°C on a slide-warming hot plate, rung with Glyptal, and labeled. The mites were identified by the first author using a Accu-Scope 3000 phase-contrast microscope (Accu-Scope, New York, USA) under 400x. Occasionally, mag-

nification of 1000x was needed to see the structural and setal details under the oil immersion lens. Many photographs of the mites were taken using the mounted Micrometrics™ camera on the microscope and saved in Photoshop CS2. Measurements were taken directly from the slide mounted specimens using the Micrometrics system.

The hawk moth hosts on which this paper is based were identified by Mr. Juan Grados, lepidopterist and a team member of the expedition. The species of the mite was identified and description details were prepared by the first author. The second author made significant contribution not only by coming from Australia to join the expedition but took hundreds of photos of live sphingid moths at night before the collection from UV light screen and helped in observation and collection of the mites on which this paper is based. The fourth author not only helped in tagging of moths with the collection data at night in the Amazon forest but provided hand-held torch light daily for hours as no electricity was available in the room and provided every supply during examination of the moths.

Prasad (2011a) recently provided idiosomal chaetotaxy of all known species of *Prasadiseius* which is followed in this paper. All measurements were taken from the slide mounted specimens and given in micrometers (μm) with the range and average given in brackets. These were taken, unless otherwise mentioned, at the longest and widest part of the structure. Length of the setae were measured from base to the tip and the distance between the two setae were measured, excluding setae, from inner base of one seta to the inner base of the other seta. Measurements of the length and width of idiosoma and the length of legs (taken in center of each leg from base of coxa to tip of pretarsus) were taken at 100x, the length and width of idiosomal shield and length of palps was taken in 200x, and all other measurements, including the length of setae and distance between the bases of the setae were taken in 400x. Occasionally, some details of setae and structures were observed in 1000x. As most dorsal idiosomal setae were minute and could not be seen clearly at low magnification at the same time (up to 200x), several photos were taken from

different locations (up to 400x) to show all the setae. Each photo shows the magnification in which it was taken (200x vs 400x), followed by mite collection number (VP10-36 or VP10-38) and the photo number. These are taken from holotype and paratype mites and are to be used as 'type photos' for the new species described in this paper.

Different standardized abbreviations used in the description of mites in the present study are as given below. It should be noted that if the idiosoma (= ID) is covered dorsally by one shield as in female and male of most Otopheidomeninae, it is called idiosomal shield (= IDS) or dorsal shield (DS) which is divided anteriorly in podosoma or podosomal region (= PO) having podonotal shield (POS) and posteriorly in opisthosoma or opisthosomal region (= OP) having opisthonotal shield (OPS). Chant and McMurtry (2007) used term 'podonotum' for podonotal shield and 'opisthonotum' for opisthonotal shield (OPS). Zhang (1995) used terms podonotal shield and opisthonotal shield for above and referred podonotal area and opisthonotal area when giving the number of setae. The dorsal shield in the adults of Otopheidomenidae is either entire (*Eickwortius termes*, Zhang 1995), partially incised laterally (*Prasadiseius* spp.), or separated into 2 shields (*Noctuiseius* spp. or male of *P. pholusis*). When together as DS, these are called podonotal shield (podonotum) and opisthonotal shield (opisthonotum) in the description. When both shields are separate from each other, the former is still called podonotal shield and latter is called as opisthonotal shield which has also been called as pygidial shield to indicate its separation from the former. Both above shields in larvae, protonymphs and deutonymphs could be separate (*N. treati*), together as 1 dorsal shield in female but 2 separate shields in male (*P. pholusis*) (Prasad, 2011c), or separate in larvae and protonymphs but fused in deutonymphs (some species of *Prasadiseius*, unpublished data).

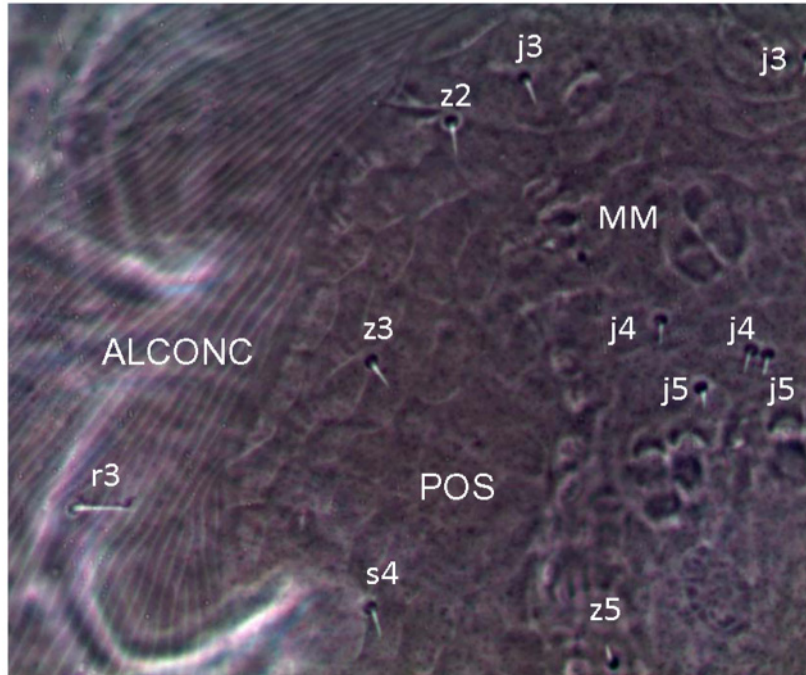


FIGURE 1: *Prasadiseius incanus* Prasad and Guanilo, **n. sp.** (Female). Left anterior idiosoma showing podonotal shield (POS), anterolateral concavity (ALCONC), seta r3 on the lateral integument, muscle marks (MM), and setae j3, j4, j5, z2, z3, z5, and s4 (400x, VP10-33: 9).

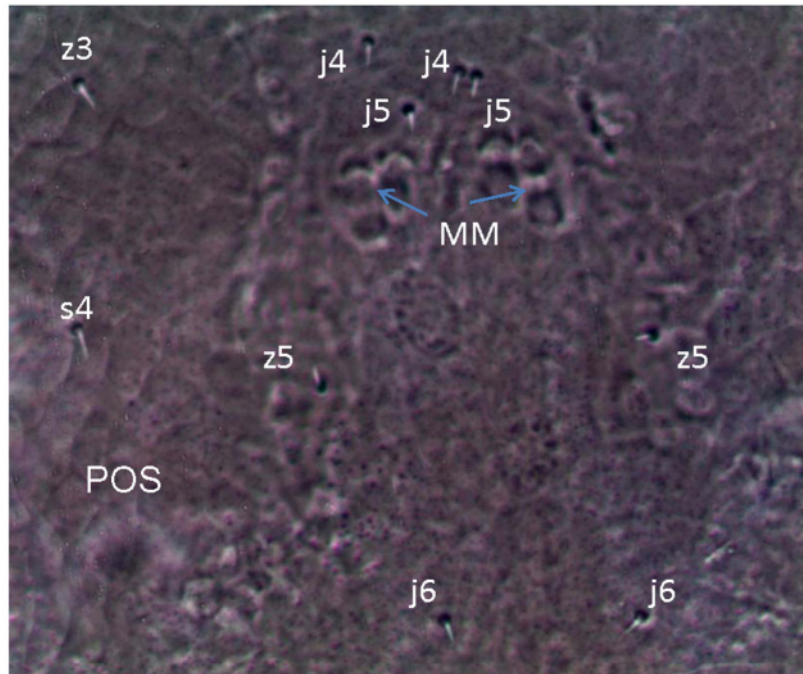


FIGURE 2: *Prasadiseius incanus* Prasad and Guanilo, **n. sp.** (Female). Left anterior podonotal shield (POS) showing muscle marks (MM) and setae j4, j5, j6, z3, z5, and s4 (400x, VP10-33: 11).

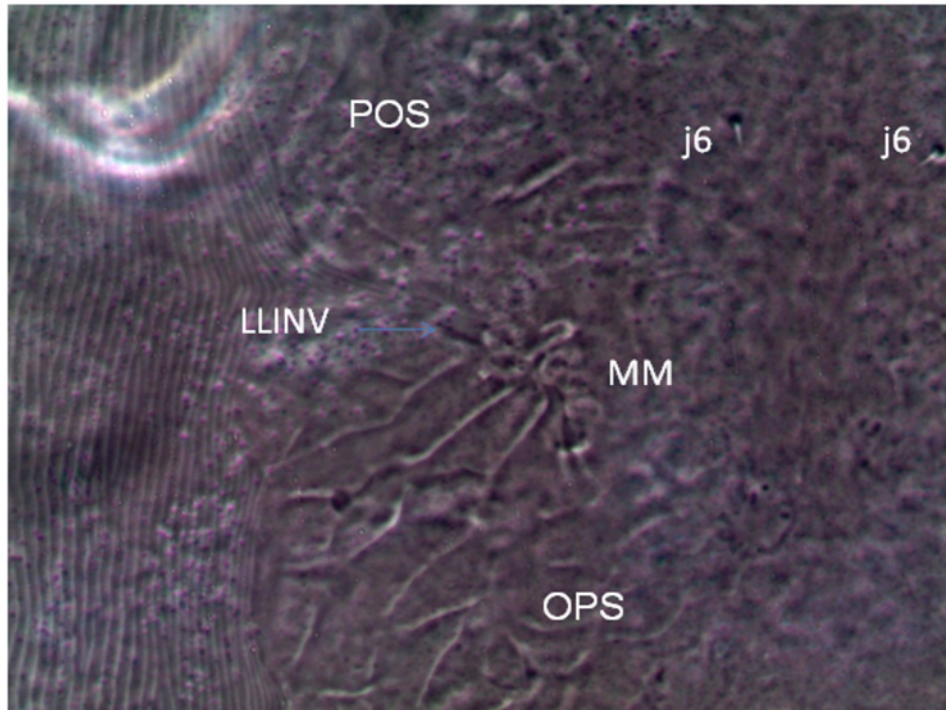


FIGURE 3: *Prasadiseius incanus* Prasad and Guanilo, **n. sp.** (Female). Left midanterior idiosoma showing podonotal (POS) and opisthonotal shield (OPS), muscle marks (MM), and setae j6 (400x, VP10-33: 12).

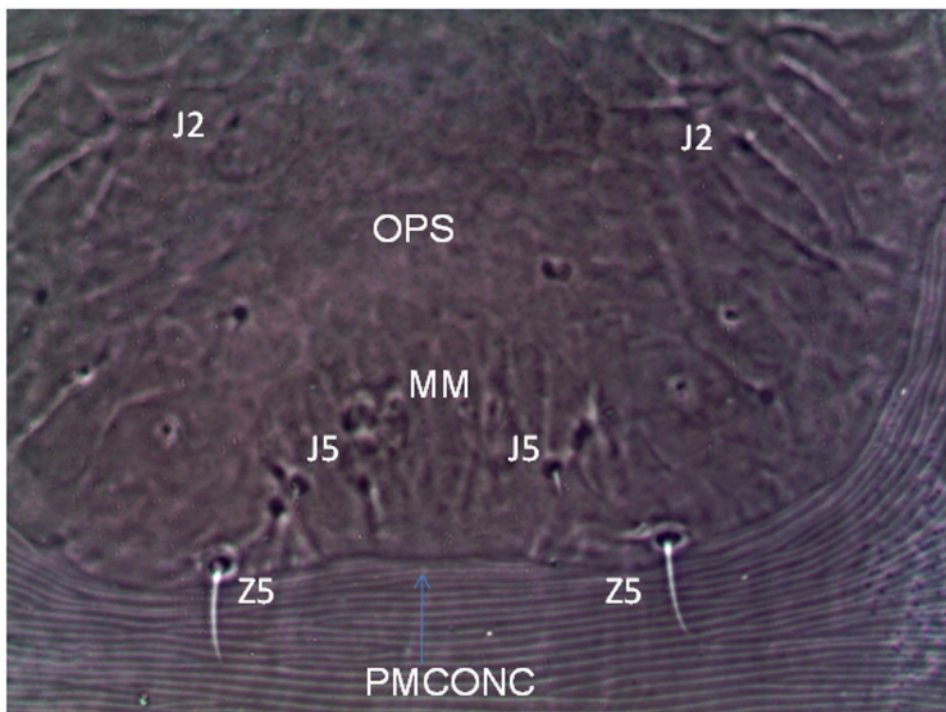


FIGURE 4: *Prasadiseius incanus* Prasad and Guanilo, **n. sp.** (Female). Posteromedial idiosoma showing posteromedial concavity (PM-CONC) in opisthonotal shield (OPS), muscle marks (MM), and setae J2, J5 and Z5 (400x, VP10-33: 14).

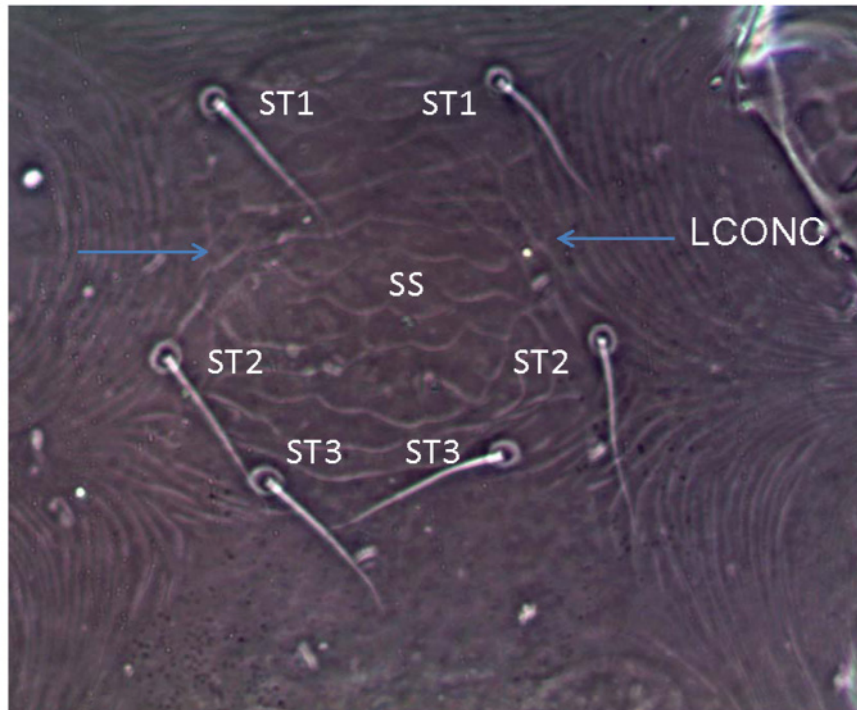


FIGURE 5: *Prasadiseius incanus* Prasad and Guanilo, **n. sp.** (Female). Sternal shield (SS) showing lateral concavity (LCONC) and 3 pairs of sternal setae (ST1-ST3) on it (400x, VP10-33: 20).

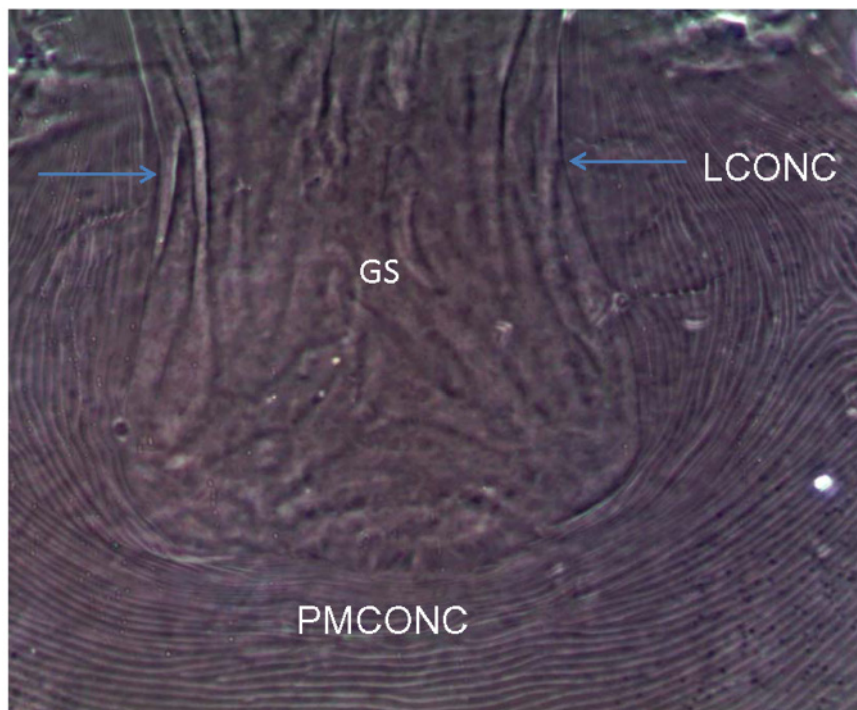


FIGURE 6: *Prasadiseius incanus* Prasad and Guanilo, **n. sp.** (Female). Genital shield (GS) showing lateral (LCONC) and posteromedial concavity (PMCONC) without genital shield setae (ST5) (400x, VP10-33: 17).

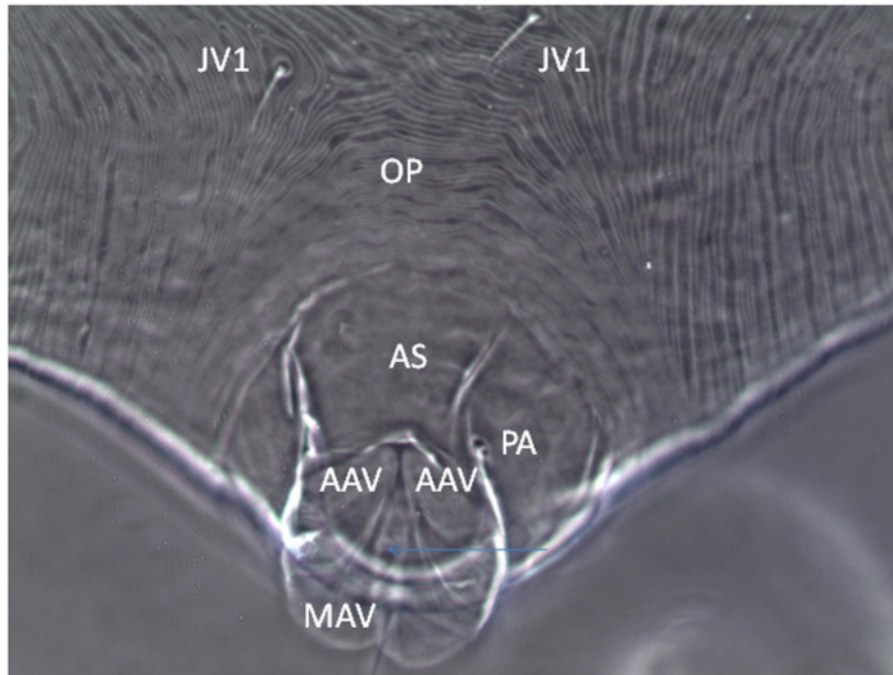


FIGURE 7: *Prasadiseius incanus* Prasad and Guanilo, **n. sp.** (Female). Posterior opisthosoma (OP) showing 1 pair ventral setae (JV1), anal shield (AS), anterior anal valves (AAV), anal expelled membranous valves (MAV) and paraanal setae (PA) (400x, VP10-33: 1).

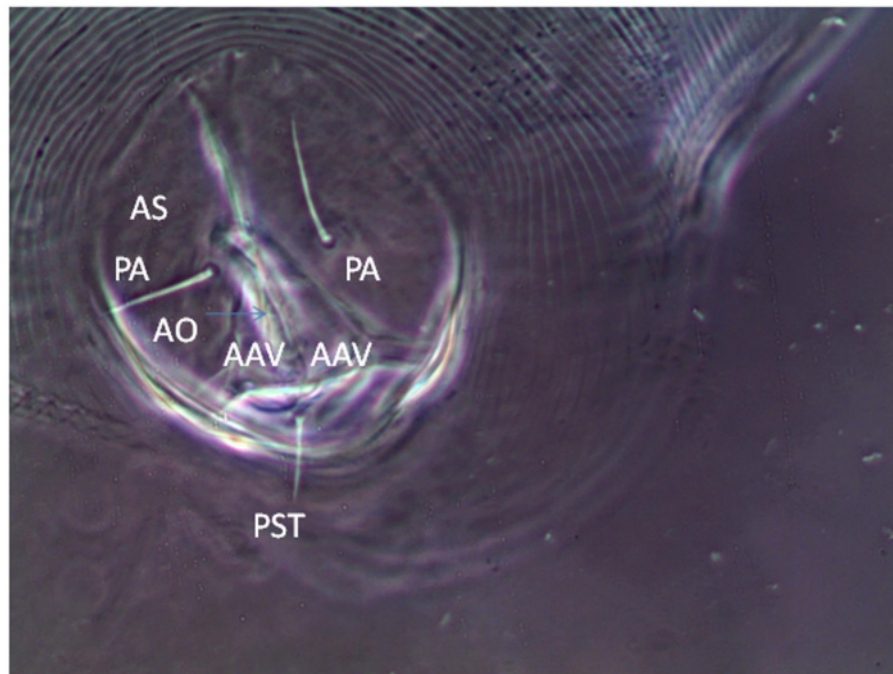


FIGURE 8: *Prasadiseius incanus* Prasad and Guanilo, **n. sp.** (Female). Another view of posterior opisthosoma showing anal shield (AS), anterior anal valves (AAV), anal opening (AO), without expelled membranous valves (MAV), paraanal setae (PA) and postanal seta (PST) (400x, VP10-33: 8).

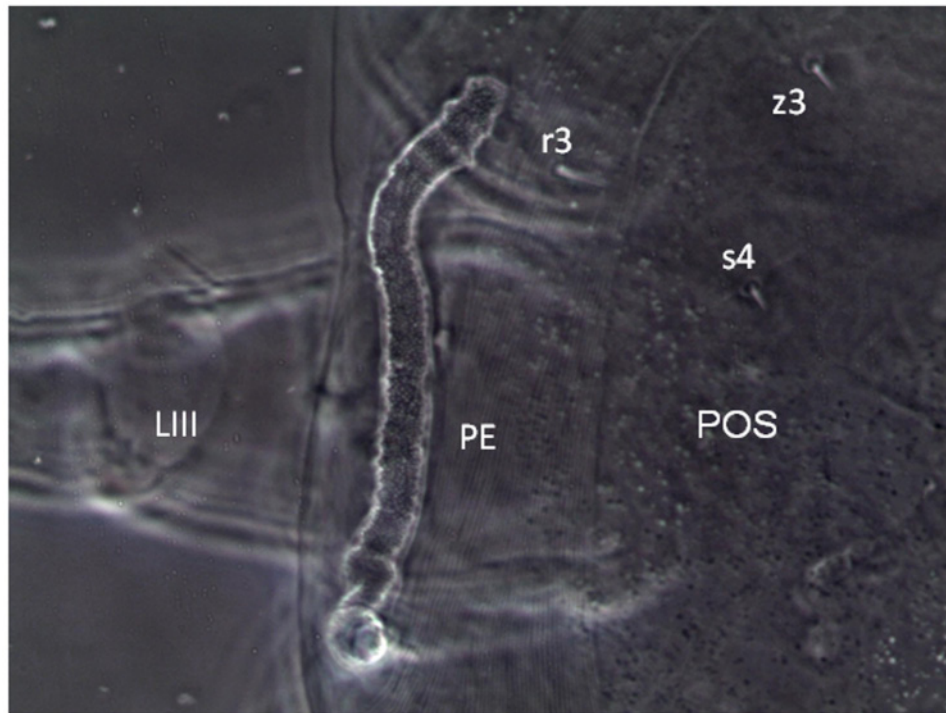


FIGURE 9: *Prasadiseius incanus* Prasad and Guanilo, **n. sp.** (Female). Left midlateral idiosoma near leg III showing peritreme (PE), seta r3, and podonotal shield (POS) showing setae z3 and s4 (400x, VP10-34: 8).

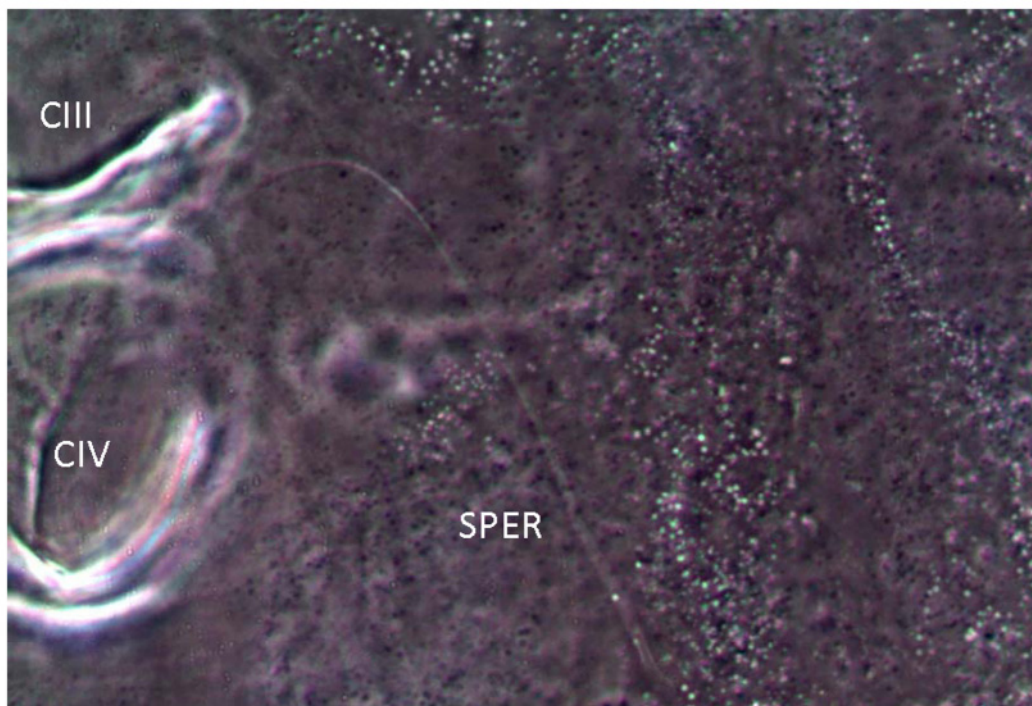


FIGURE 10: *Prasadiseius incanus* Prasad and Guanilo, **n. sp.** (Female). Ventral idiosoma showing tubular spermatheca (SPER) entering coxa of leg III (400x, VP10-33: 19).

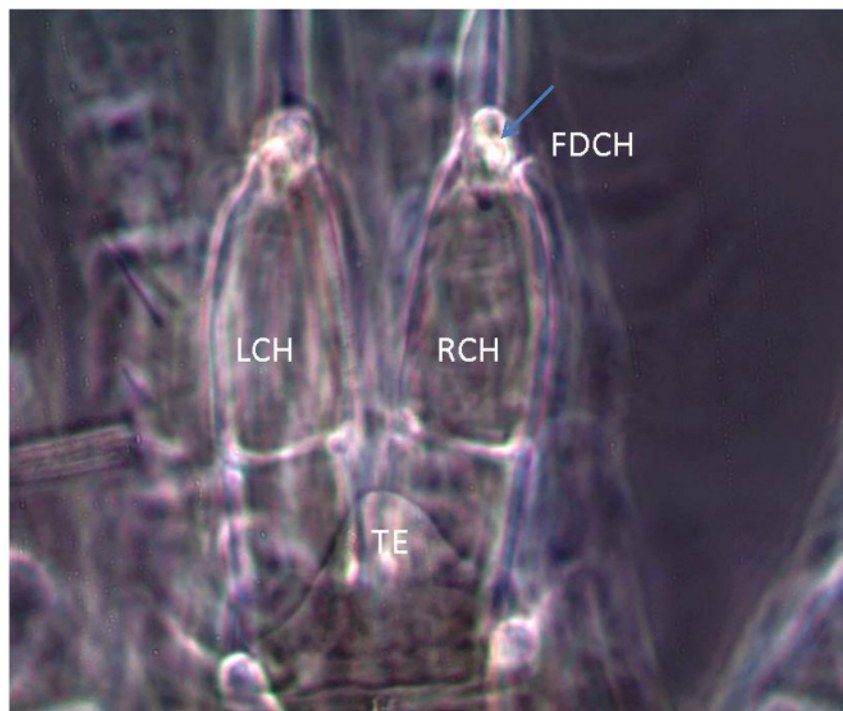


FIGURE 11: *Prasadiseius incanus* Prasad and Guanilo, **n. sp.** (Female). Part of dorsal gnathosoma showing tectum (TE), left (LCH) and right chelicera (RCH) and fixed digit of chelicera (FDCH) (400x, VP10-33: 21).



FIGURE 12: *Prasadiseius incanus* Prasad and Guanilo, **n. sp.** (Female). Fixed digit of chelicera (FDCH), movable digit of chelicera (MDCH), and denticles (DE) (400x, VP10-34: 1).

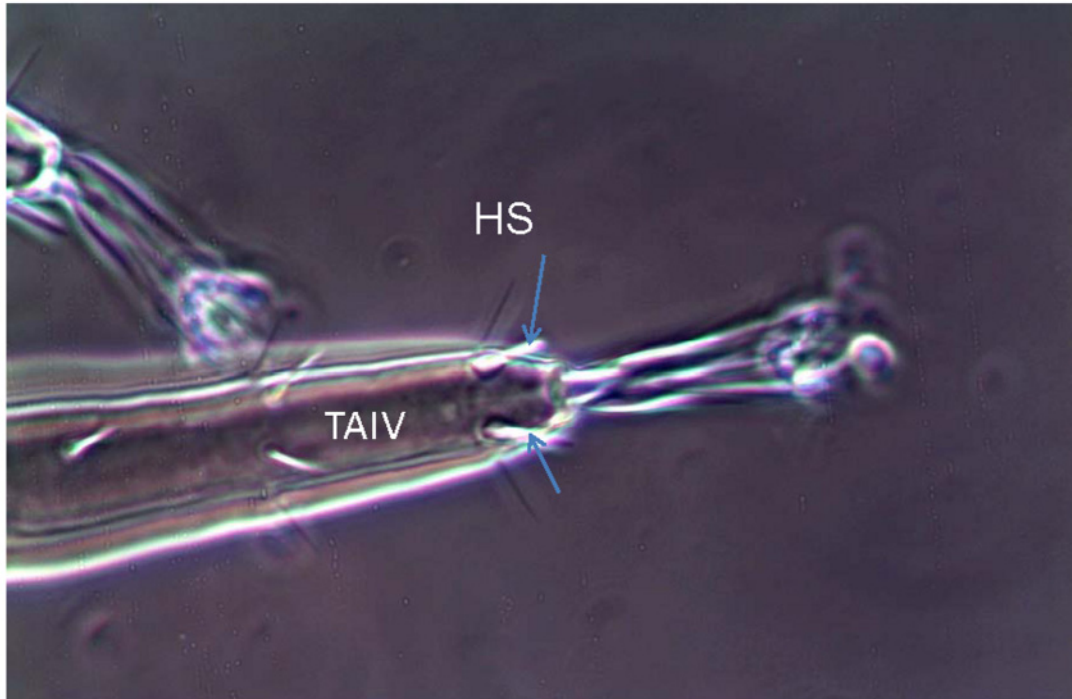


FIGURE 13: *Prasadiseius incanus* Prasad and Guanilo, **n. sp.** (Female). Tarsus of leg IV (TAIV) showing a pair of heavy setae (HS) (400x, VP10-33: 7).

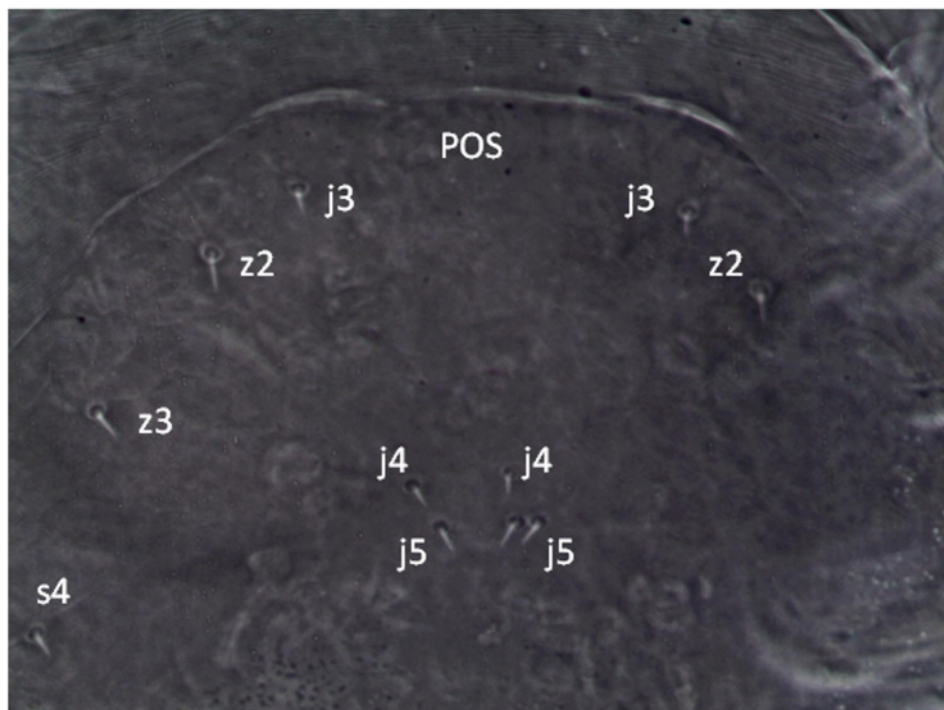


FIGURE 14: *Prasadiseius incanus* Prasad and Guanilo, **n. sp.** (Female). Part of mid dorsoanterior idiosoma showing midanterior podonotal shield (POS) and setae j3, j4, j5, z2, z3, and s4 (400x, VP10-34: 2).

TAXONOMY

Subfamily Otopheidomeninae Treat, 1955

Otopheidomeninae Treat, 1955: 556, type genus: *Otopheidomenis* Treat, by original designation.

Diagnosis — Dorsal shield entire (*O. ascalaphae*) or incised laterally (females of all remaining species except *P. pholusis* in which the dorsal shield of the male is divided into 2 separate shields). Dorsal shield with 14 or fewer pairs of setae. Tritosternum absent (*Noctuiseius* spp. and *Prasadiseius* spp.) or vestigial (*Otopheidomenis* spp.). Metasternal setae (ST4) absent. Genital (= epigynial) shield rounded posteriorly and with or without genital setae. Ventrianal shield present by anal shield having only 3 anal setae (PA, PST) surrounding the anus. One or 3 pairs of setae present in between genital shield and anal shield or lateral to anal shield. Metapodal plates absent (in all species except *O. zalelestes*). Movable digit of chelicera with 3 – 13 teeth. Palp trochanter without seta (except in *O. ascalaphae* with 1 seta). Spermatheca tubular (except in *N. batoridgi* which is cup-shaped). Males with specialized seta on venter of femur II in several species (e.g. *Prasadiseius*). No macrosetae on tibia or tarsus of legs I – IV (except *O. ascalaphae* with 4 large setae on the dorsum of tarsus IV). Parasites of noctuid and sphingid moths.

Genus *Prasadiseius* Wainstein, 1972

Prasadiseius Wainstein, 1972: 453, type species: *Otopheidomenis pholusis* Prasad, by original designation.

Diagnosis — Dorsal shield large, covering almost entire idiosoma, incised laterally, partially dividing the shield into two parts — the podonotal shield which covers approximately the anterior two-thirds of the dorsum, and the opisthonotal shield which covers approximately the posterior third (except in *P. pholusis* in which the dorsal shield of the male is completely divided into 2 separate shields which also differs by having a very short and wide, rectangular-shaped opisthosomal shield). Dorsal shield in female with 10 pairs (*P. achlora*, *P. aporodes*, *P. kayosiekerei*, *P. pholusis*), 11 pairs (*P. cocytes*, *P. donahuei*, *P. incanus* n. sp.), or 12

pairs (*P. indicus*) of setae. Podonotal shield with 7 pairs (*P. achlora*, *P. aporodes*, *P. kayosiekerei*, *P. pholusis*) or 8 pairs (*P. cocytes*, *P. donahuei*, *P. indicus*) of setae while opisthonotal shield with 3 pairs (*P. achlora*, *P. aporodes*, *P. cocytes*, *P. donahuei*, *P. kayosiekerei*, *P. pholusis*) or 4 pairs (*P. indicus*) of setae in female but only 2 pairs of setae in male of *P. pholusis*. Ventral idiosoma with only 1 pair of setae (JV1) between genital and anal shield. Parasitic on sphingid moths.

***Prasadiseius incanus* Prasad and Guanilo, n. sp.
(Figs. 1 – 26)***Description*

Diagnosis — Dorsal idiosoma with 12 pairs of setae of which 11 pairs (j3, j4, j5, j6, J2, J5, z2, z3, z5, Z5, s4) on the large mediolaterally incised dorsal shield and 1 pair (r3) on the anterolateral integument. Setae j4 present, z2 located posterolateral to j3, and peritremes long in female. Sternal (female) or sternogenital (male) shield with 3 pairs of setae; setae ST1 in both female and male not extending beyond the base of ST2, setae ST2 reaching or extending beyond the base of ST3 in same vertical row in female but not in male. Genital shield without genital setae. Male with a very large and thick spinose spur on ventral basifemur of leg II.

Differential — The new species *P. incanus* Prasad and Guanilo is close to *P. indicus* but can easily be separated from the latter by having short peritreme, absent S2 and by having a very large and thick spinose spur on ventral basifemur of leg II in the male. None of the species of *Prasadiseius* or other genera in the subfamily Otopheidomeninae have such a spur.

Female (*n* = 8, *Figures*. 1–14, 21, 22A,B, 23, 24)

Dorsum — Idiosoma large; length 440 – 534 (503), width 294 – 353 (328); with 12 pairs of setae, of which 11 pairs are on the dorsal shield and 1 pair (r3) on the lateral integument. Dorsal shield large, length 304 – 415 (369), width 219 – 251 (236), lightly sclerotized, covered with polygonal reticulations and with several muscle marks (*Figures* 1,2), having a well pronounced lateral invagination on each side between setae j6 and J2 (*Figure* 3) which partially divides the dorsal shield into 2 parts — the

podonotal shield comprising approximately the anterior two-thirds, and the opisthonotal shield comprising the posterior one-third of the shield (Figure 3). Dorsal shield may also have shallow concavities or convexities on the margin of the shield near setae z3, r3 (Figure 1) and in between Z5 (Figures 1, 4).

Soft integument with striate pattern all around the dorsal shield, with pair of smooth r3 setae, largest of all podonotal setae 12 – 22 (16), located posterolateral to z3 and anterolateral to s4 (Figure 1). Peritreme long, curved anteriorly, 105 – 135 (122), reaching close or little beyond base of r3 (Figure 9).

Podonotal shield with 8 pairs of smooth setae (j3, j4, j5, j6, z2, z3, z5, s4) of which z2 is located posterolateral to j3, z3 approximately at the same level as with j5, and s4 in line but slightly anterior to z5; s4 located well posterior and lateral to z3 and j5 and well anterior and lateral to z5; j4 present; j5, z5 and j6 forming hexagonal pattern; j3, z2, z3 and s4 slightly longer than j4, j5, j6 and z5. Length of setae on podonotal shield: j3 = 5 – 7 (6), j4 = 4 – 8 (6), j5 = 5 – 7 (6), j6 = 5 – 7 (6), z2 = 8 – 11 (9), z3 = 8 – 10 (9), z5 = 5 – 8 (6), and s4 = 8 – 10 (9). Distance between setal pairs: j3 – j3 = 64 – 75 (70), j4 – j4 = 14 – 31 (22), j5 – j5 = 15 – 20 (17), j6 – j6 = 33 – 47 (41), z2 – z2 = 106 – 110 (108), z3 – z3 = 144 – 150 (146), z5 – z5 = 68 – 94 (79), and s4 – s4 = 164 – 181 (174). Distance between different setae: j3 – j4 = 57 – 72 (66), j3 – j5 = 63 – 87 (72), j4 – j5 = 8 – 20 (12), j5 – j6 = 107 – 114 (110), j3 – z2 = 19 – 27 (22), z2 – z3 = 41 – 52 (48), z3 – z5 = 76 – 78 (77), z3 – s4 = 45 – 68 (53), s4 – j6 = 96 – 112 (104), z5 – j6 = 51 – 63 (58), and j6 – J2 = 82 – 90 (85).

Opisthonotal shield, surrounded by striate integument, very similar to podonotal shield in sclerotization and reticulation but with only a few muscle marks and much fewer setae. Only 3 pairs of setae (J2, J5, Z5) present (Fig. 4); J2 = 4 – 8 (6), and J5 = 4 – 5 (4) minute and Z5 18 – 28 (22) largest of all dorsal idiosomal setae, located at posterior edge of the shield and with minute serrations. Distance between setal pairs J2 – J2 = 71 – 80 (75), J5 – J5 = 40 – 51 (46), and Z5 – Z5 = 71 – 90 (78). Distance between different setae: J2 – J5 = 89 – 113 (101) and J5 – Z5 = 19 – 29 (23).

Venter — Tritosternum laciniae and basal sclerite absent. Sternal shield lightly sclerotized, with a polygonal reticulation pattern (Figure 5), located in between coxae I – II, rounded anteriorly and posteriorly but may be slightly concave posteromedially, widest and pointed laterally between ST2 and ST3, length = 95 – 102 (98), width = 94 – 104 (99). Three pairs of comparatively long and marginally located sternal setae (ST) on shield. Distance between ST3 – ST3 [39 – 48 (44)] less than that of ST1 – ST1 [52 – 64 (56)] and ST2 – ST2 [74 – 88 (81)], the last located farthest apart from each other. Setae ST1 comparatively short [33 – 38 (36)], not reaching base of ST2 [36 – 44 (40)], the latter passing beyond the base of ST3 [32 – 44 (40)]. Distance between different setae: ST1 – ST2 = 51 – 59 (54) and ST2 – ST3 = 30 – 36 (34).

Genital (= epigynial) shield lightly sclerotized, narrow medially having lateral concavity on each side, wider anteriorly than posteriorly and rounded posterolaterally. In some, with small posteromedial concavity (Fig. 6), width = 92 – 114 (106). Genital setae (ST5) absent.

Ventral integument between genital and anal shields with moderately large and smooth pair of JV1 = 14 – 18 (16). Distance between JV1 – JV1 = 46 – 66 (61). Spermatheca long and tubular, in between coxae III – IV (Fig. 10).

Anal shield (Figures 7, 8) lightly sclerotized, rounded anteriorly and laterally (Figures 7, 8), width = 88 – 104 (97), with a pair of para-anal (PA) and a postanal seta (PST). Anus comprised of two anterior anal valves and a posterior anal valve, typical of most mesostigmatid mites. Length of setae: PA = 27 – 30 (28) and PST = 18 – 24 (22). Distance between PA – PA = 34 – 48 (41) and between PA and PST setae = 40 – 42 (41). Membranous anal valves (MAV, Figure 7) with anal opening may be seen in some if expelled out of anal opening.

Legs — Each leg with pretarsus having pulvillus and pair of tiny claws. No macrosetae on any leg segments but legs II – IV each with 2 thick and heavy setae = 20 – 22 (21) on ventrodiscal margin of the tarsus (Figure 13). Legs IV (524) longest of the legs, legs I – III more or less the same length. Length of legs I – IV: I = 422 – 466 (441), II = 412 – 470 (438), III = 423 – 466 (444), and IV = 504 – 545

(524). Length of pretarsus of legs I – IV: I = 71 – 79 (74), II = 66 – 76 (71), III = 67 – 73 (69), and IV = 69 – 80 (76). Number of setae on legs (coxa, trochanter, femora, genua, tibia) as follows: leg I: 2, 5, 11, 9, 8; leg II: 2, 5, 9, 9, 8; leg III: 2, 5, 6, 8, 7; and leg IV: 1, 5, 6, 8, 7.

Gnathosoma – Tectum triangular, rounded anteriorly (Fig. 11), length = 35 – 43 (39), width = 60 – 64 (62). Palp length = 125 – 142 (135). Number of setae on palp segments as follows (trochanter to tibia): = 0, 4, 5, 9. Palpal apotele not seen. Each chelicera with reduced fixed digit and a long, movable digit = 72 – 82 (78), with 8 – 10 denticles. Venter of gnathosoma with 3 pairs of hypostomal setae. Corniculi long and slender. Salivary stylets long and pointed.

Male ($n = 4$, Figures 15–20, 22C, D, 25, 26)

Dorsum — Idiosoma about similar in size and shape to female, but dorsal shield covered with fewer and less sclerotized polygonal reticulations and muscle marks, length = 507 – 651 (565), width = 327 – 412 (374), length = 398 – 448 (414), width = 218 – 311 (262) and with a total of 12 pairs of setae, of which 11 pairs are on the dorsal shield and 1 pair (r3) is on the integument. Soft integument with striate pattern, r3 smooth, = 12 – 31 (19), longer than the podonotal setae, located posterolateral to z3 and anterolateral to s4. Peritreme short, = 65 – 161 (123), extending lateral to coxae III and IV from middle or anterior margin of coxae IV, not reaching base of r3.

Gnathosoma – Similar to that of female, tectum triangular, rounded and smooth anteriorly (Figure 19). Movable digit of chelicera bearing a pointed spermatodactyl. Hypostome with 3 setae set in a triangle on each side. Posterior medial seta set slightly posterior to posterolateral seta. Corniculi with pointed to blunt apices. Palp length (trochanter to tarsus) = 91 – 197 (125). Number of setae on palp segments (palptrochanter to tibia) as in female.

Podonotal shield similar to female, with 8 pairs of setae (j3, j4, j5, j6, z2, z3, z5, s4) of which z2 is located posterolateral to j3, z3 roughly in a transverse line with j4 or j5, and s4 in anteriolateral to z5. Distance between j5 pair of setae less than that between j4 setae. One of the j4 pair of setae sometimes

located more anteriorly than the other j4 seta and thus having much more distance on one side in j4 – j5 than other side of j4 – j5. Variation in location of j4 more pronounced than j5. Distance between j4 – j4 setae more than that of j5 – j5. Setae j3, z2, z3 and s4 slightly longer than j4, j5, j6 and z5. All podonotal setae smooth (serrations not evident even at 1000x). Length of setae on podonotal shield: j3 = 5 – 11 (7), j4 = 5 – 11 (7), j5 = 4 – 10 (7), j6 = 6 – 11 (8), z2 = 8 – 19 (11), z3 = 7 – 20 (11), z5 = 6 – 11 (8), and s4 = 8 – 19 (12). Distance between setal pairs: j3 – j3 = 54 – 87 (75), j4 – j4 = 26 – 40 (33), j5 – j5 = 21 – 27 (23), j6 – j6 = 49 – 55 (58), z2 – z2 = 112 – 225 (147), z3 – z3 = 161 – 181 (171), z5 – z5 = 78 – 90 (83), and s4 – s4 = 184 – 216 (197). Distance between different setal pairs: j3 – j4 = 75 (66), j3 – j5 = 76 – 86 (80), j3 – z2 = 21 – 28 (23), j4 – j5 = 9 – 28 (15), j5 – j6 = 111 – 116 (113), j6 – j2 = 94 – 98 (96), s4 – j6 = 118 – 122 (120), z2 – z3 = 45 – 49 (48), z2 – z5 = 110 – 115 (113), z3 – s4 = 34 – 61 (46), z5 – j6 = 50 – 64 (61).

Opisthonotal shield surrounded by striate integument, similar to that of female in sclerotization, reticulation, having only 3 pairs of setae (J2, J5, Z5) and Z5 the largest of all dorsal idiosomal setae, with a few fine serrations seen in 400x and located at posterior edge of the shield (Figure 15). Setae J2 and J5, similar to hexagonal setae (j5, j6 and z5), minute and occasionally absent or difficult to see. Length of setae: J2 = 4 – 12 (8), J5 = 5 – 13 (8), and Z5 = 16 – 34 (23). Distance between the bases of setal pairs: J2 – J2 = 57 – 124 (91), J5 – J5 = 46 – 63 (55), and Z5 – Z5 = 83 – 90 (86). Distance between different setal pair: J5 – Z5 = 22 – 30 (25).

Venter — As in female, tritosternum laciniae and basal sclerite absent. Sternogenital shield large, moderately sclerotized, located between coxae of legs I – IV (Figures. 16, 17), anterior and posterior margin rounded, much wider anteriorly near ST1, very narrow medially near ST3, and slightly wider between coxae IV (Figure 17). Sternogenital shield lacking polygonal reticulations, 187 – 252 (209) long, 67 – 149 (98) wide, with setae similar to those of female, but with only 3 pairs located on the margin and moderately long and smooth setae (ST1, ST2, ST3) on the shield. Setae ST5 absent.

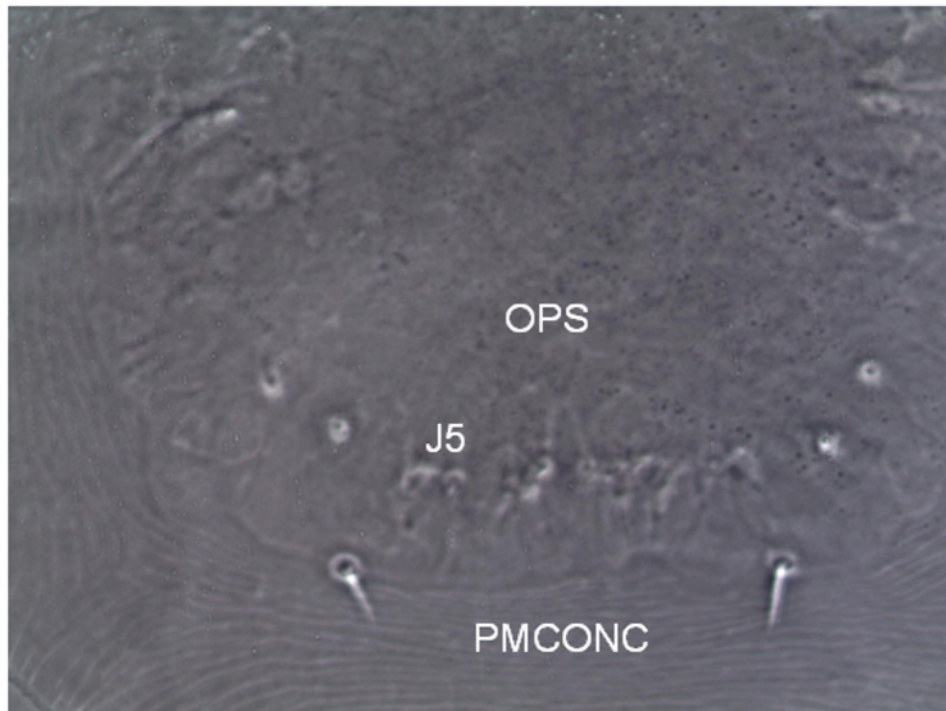


FIGURE 15: *Prasadiseius incanus* Prasad and Guanilo, **n. sp.** (Male). Part of dorsal posteromedial idiosoma showing opisthonotal shield (OPS) with posteromedial concavity (PMCONC) and setae Z5 (setae J5 not clearly visible) (400x, VP10-33: 22).

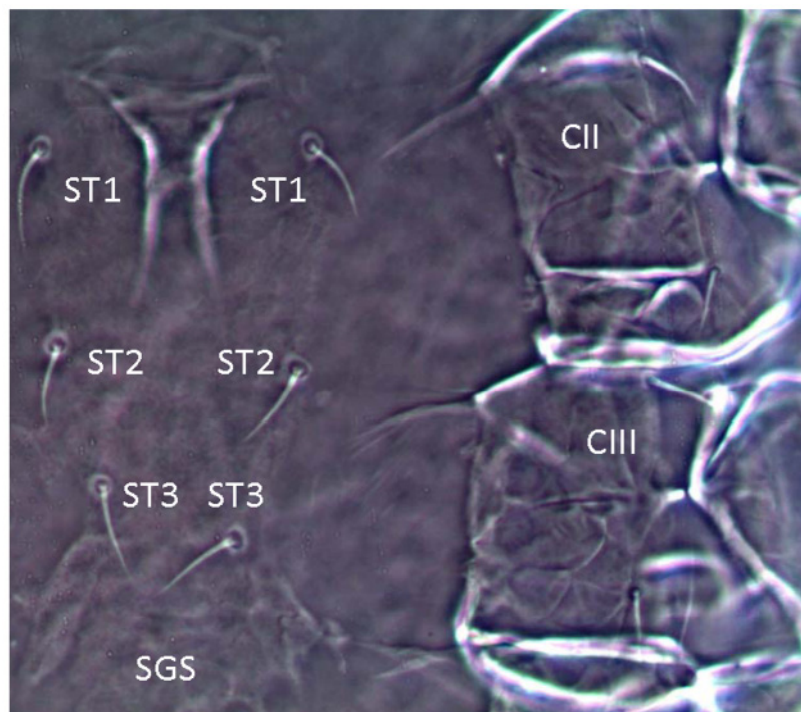


FIGURE 16: *Prasadiseius incanus* Prasad and Guanilo, **n. sp.** (Male). Anterior sternogenital shield (SGS) in between coxae II-III (CII-CIII) showing sternal setae ST1, ST2 and ST3 (400x, VP10-33: 28).

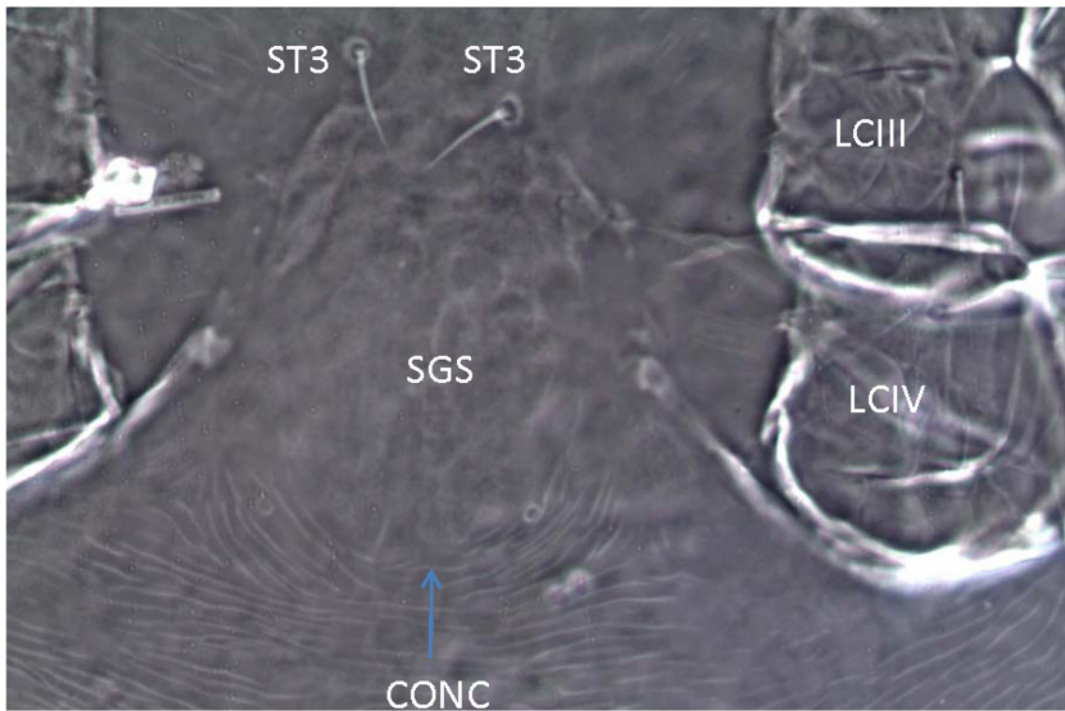


FIGURE 17: *Prasadiseius incanus* Prasad and Guanilo, **n. sp.** (Male). Posterior sternogenital shield (SGS) in between coxae III-IV (CIII-CIV) showing rounded posterior margin and short concavity (CONC) and sternal setae ST3 (400x, VP10-33: 29).

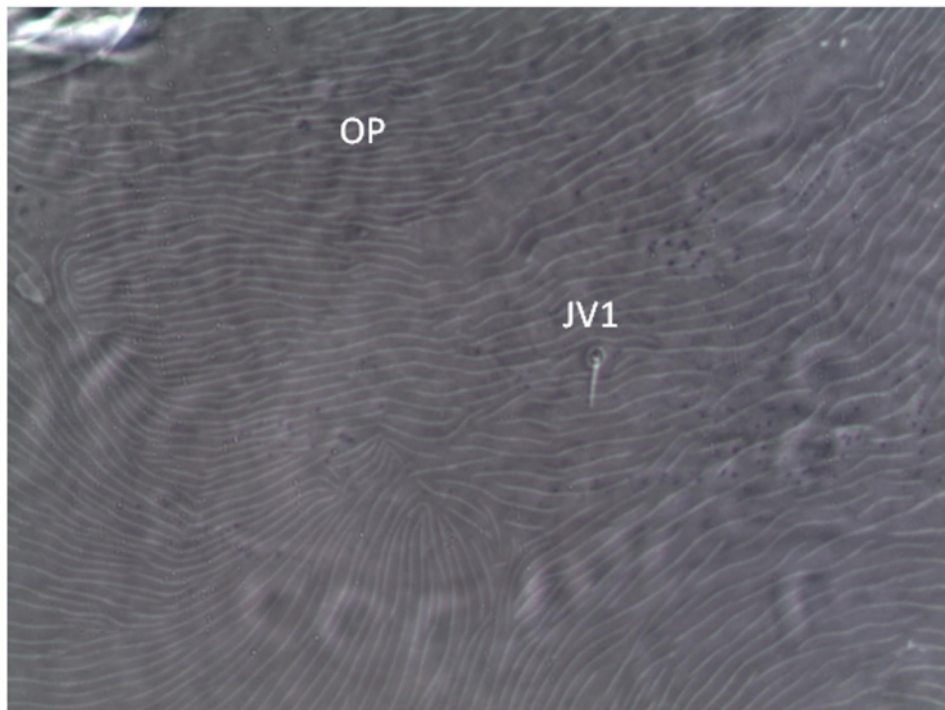


FIGURE 18: *Prasadiseius incanus* Prasad and Guanilo, **n. sp.** (Male). Ventral opisthosoma (OP) showing ventral seta (JV1) (400x, VP10-33: 25).

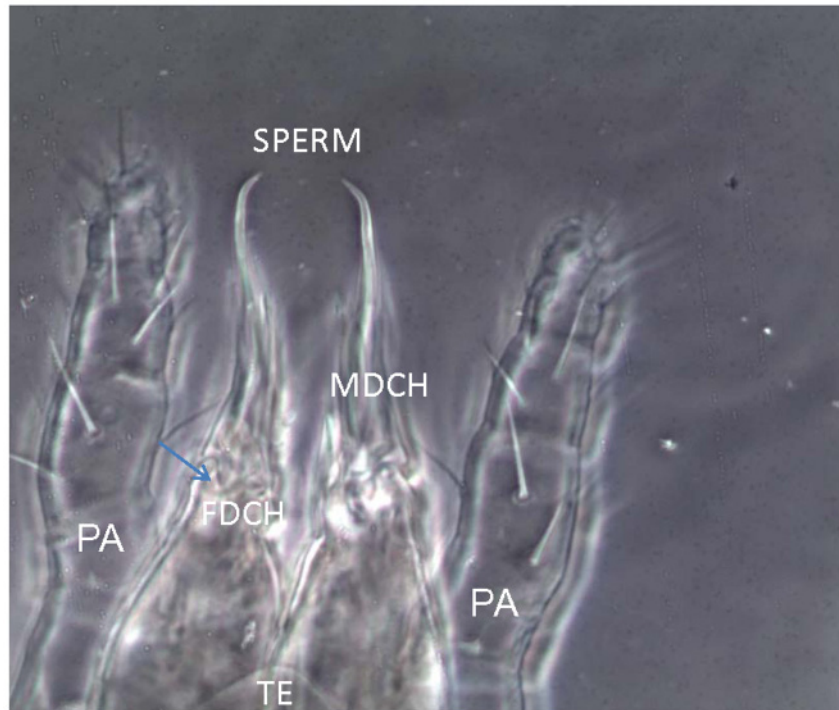


FIGURE 19: *Prasadiseius incanus* Prasad and Guanilo, **n. sp.** (Male). Tectum (TE), palps (PA), fixed digit of chelicera (FDCH), and movable digit of chelicera (MDCH) showing pointed spermatodactyl (SPERM) (400x, VP10-33: 27).

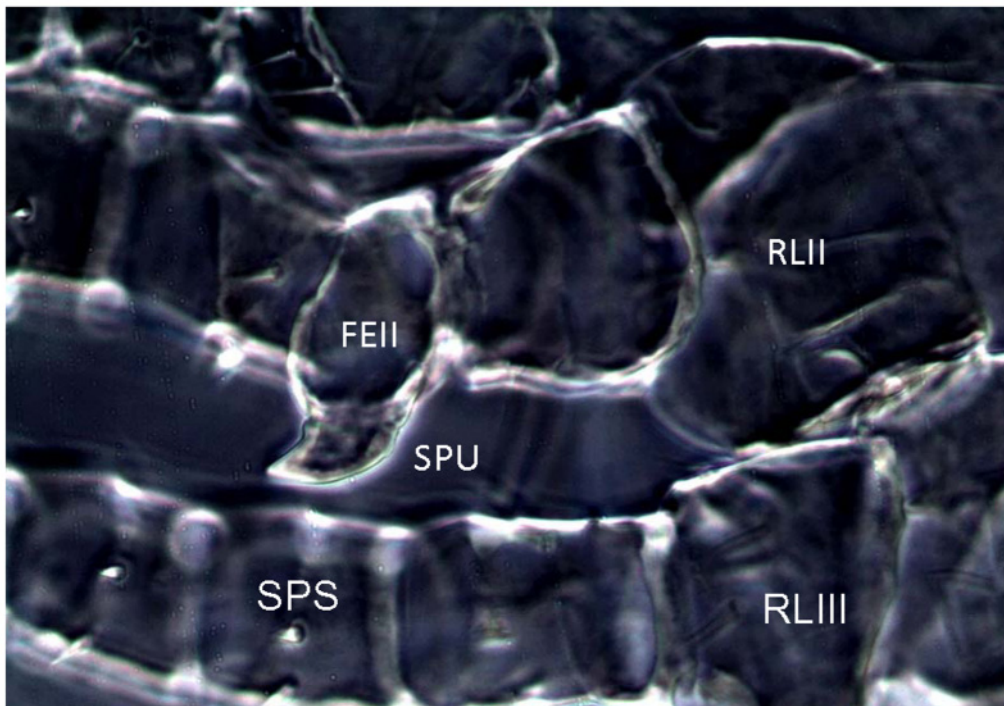


FIGURE 20: *Prasadiseius incanus* Prasad and Guanilo, **n. sp.** (Male). Ventral femur of leg II (FEII) with large spur (SPU) and short spinose seta (SPS) on telofemur II and genu III (400x, VP10-34: 12).

Distance between ST1 – ST1 slightly longer than or equal to distance between ST2 – ST2, but much longer than between ST3 – ST3 (Figure 16). Setae ST1 much shorter than ST2 and ST3, not reaching base of ST2 and these much short of reaching base of ST3 in same row. None of setae surpassing base of next setae in same vertical row. Length of setae as follows: ST1 = 18 – 54 (33), ST2 = 18 – 46 (30), and ST3 = 19 – 47 (30). Distance between setal pairs: ST1 – ST1 = 56 – 105 (69), ST2 – ST2 = 50 – 98 (65), and ST3 – ST3 = 28 – 57 (37). Distance between different setae: ST1 – ST2 = 40 – 92 (55), and ST2 – ST3 = 30 – 70 (43).

Ventral integument between sternogenital and anal shields with 1 pair (JV1) of moderately long, = 9 – 24 (16), and smooth setae (Figure 18). Distance between JV1 – JV1 = 56 – 119 (78).

Anal shield and setae similar to those of female, length = 88 – 100 (94), width = 76 – 168 (110), PA setae = 20 – 46 (31) and PST setae = 17 – 21 (19). Distance between PA pair of setae = 28 – 41 (33) and between PA – PST = 35 – 41 (38).

Legs — Similar to those of female, but shorter and stockier. Length of legs I – IV (including pretarsus) as follows: I = 342 – 380 (360), II = 323 – 390 (366), III = 294 – 353 (320), and IV = 330 – 393 (364). Unlike the female, legs IV more or less of the same length as legs I – II. Pretarsus of legs measure: I = 46 – 53 (50), II = 44 – 51 (48), III = 43 – 46 (45), and IV = 51 – 57 (54). Legs II – IV without 2 thick and heavy setae on ventrodistal tarsus which are present in the female, but having a large, very thick, distally pointed spur (SPU), = 22 – 30 (26) long and 13 – 16 (14) wide on ventral basifemur of leg II (Figure 20) in all males (Figure 22C). Telofemur and genu of legs II – IV each with a short, thick and spinose seta (Figure 20). Number of setae on legs I – IV (coxa to tibia) same as in female.

Collection data

(1) Peru, Cusco Department, Quebrada Quitacalzón, 967 m, 13°01'19.9"S, 71°29'50.7"W, 12 VIII 2010, moth # 212, *Xylophanes fusimacula* (R. Felder) (Lepidoptera: Sphingidae), Grados # 4, coll.

A. Guanilo, J. Grados, V. Prasad, I. Prasad, examined on 13 VIII 2010, mites dorsally on metathorax-first abdominal-tympanic area, mounted in Hoyer's on 9 X 2010, mite # VP10-33, 10 females, 3 males, 1 larva, 3 protonymphs; (2) Collection data as above, but moth # 215, *Xylophanes undata* Rothschild and Jordan (Fig. 27), mite # VP10-34, 2 females, 1 male, 1 larva, 4 protonymphs, and 1 deutonymph. In addition, several in 70% and 100% ethyl alcohol for future studies. Ratio of females to males = 12:4 (3 females to 1 male).

Types

Holotype: Female, with above collection details, deposited in the Natural History Museum, Lima, Peru. Paratypes: 12 females, 4 males, 2 larvae, 5 protonymphs, and 3 deutonymphs on glass slides, and several others in 70% and 100% ethanol for further studies. Slide mounted paratypes deposited as follows: Two females and 1 male in the Natural History Museum, Lima, Peru; 1 female and 1 male in the Museum of Biodiversity, The Ohio State University, 1315 Kinnear Road, Columbus, OH 43212, USA; 1 female and 1 male in the US National Museum, Washington, DC, USA; and others in author's collection.

Etymology

The new species name "*incanus*" is provided to honor famous Inca tribe and Civilization of Peru that once stretched north to south along the high mountainous Andean range from Colombia to Chile and reached west to east from coastal desert of Atacama to rain forest of Amazon.

Remarks

The location of the z2 pair of setae in relation to the j3 setae seems to be a good species specific characteristic; however, a study of a large series of specimens is necessary before reaching this conclusion.

The length of the peritreme and the number of denticles on movable digit of the chelicerae are also significant in defining a species. The number of denticles in different specimens of *P. incanus* varies by 1 – 2 in the material studied so far.

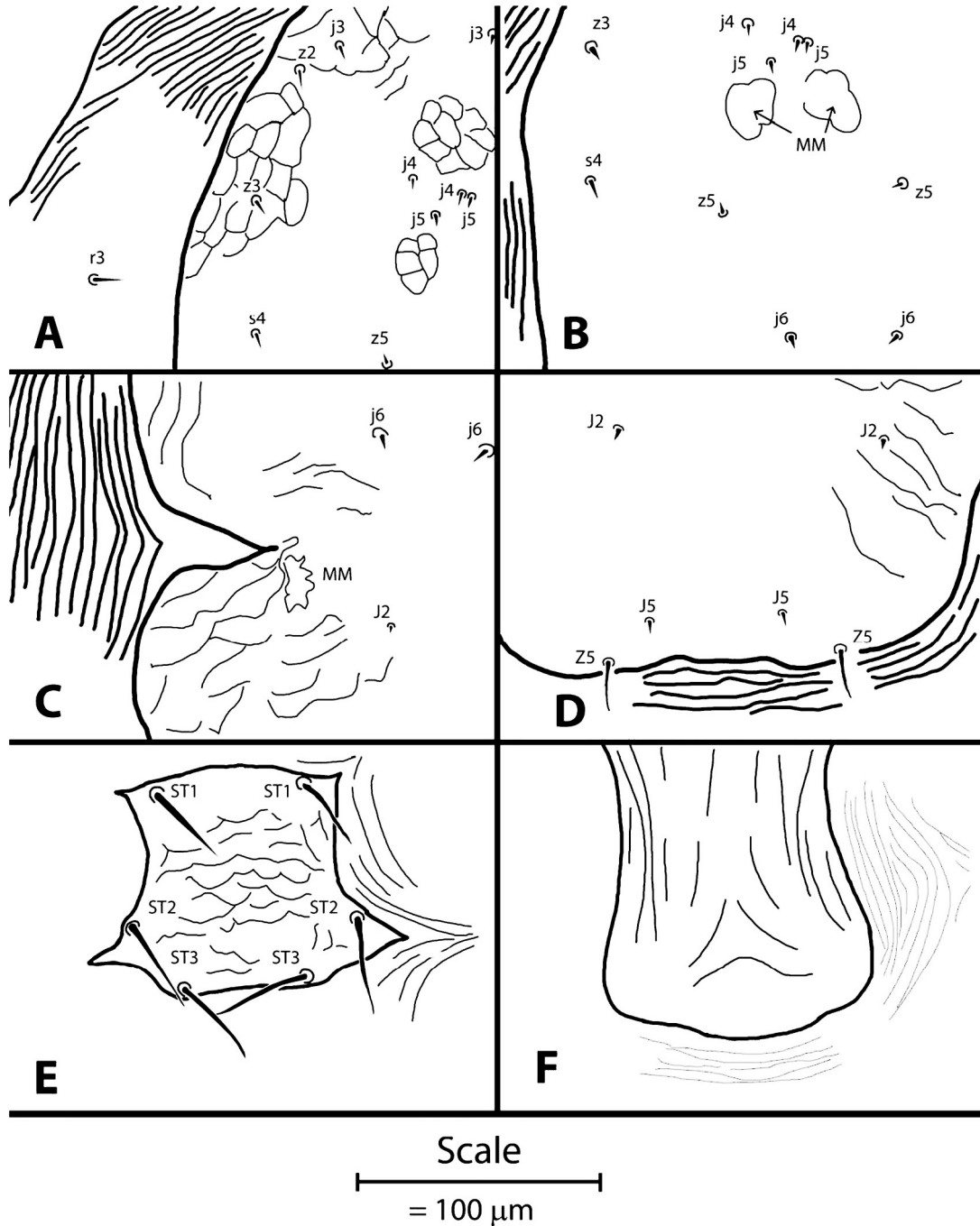


FIGURE 21: *Prasadiseius incanus* Prasad and Guanilo, **n. sp.** (Female). A – Part of left anterolateral podonotal shield showing setae j3, j4, j5, z2, z3, z5, and s4 (drawn from Fig. 1); B – Part of left and midanterior podonotal shield showing setae j4, j5, j6, z3, z5, and s4 (drawn from Fig. 2); C – Part of left and midlateral podonotal and opisthonotal shield showing left lateral invagination, setae j6, J2, and muscle mark (MM) (drawn from Figs. 3, 4); D – Part of opisthonotal shield showing setae J2, J5 and Z5 (drawn from Fig. 4); E – Sternal shield with sternal setae (drawn from Fig. 5); F – Genital shield (drawn from Fig. 6).

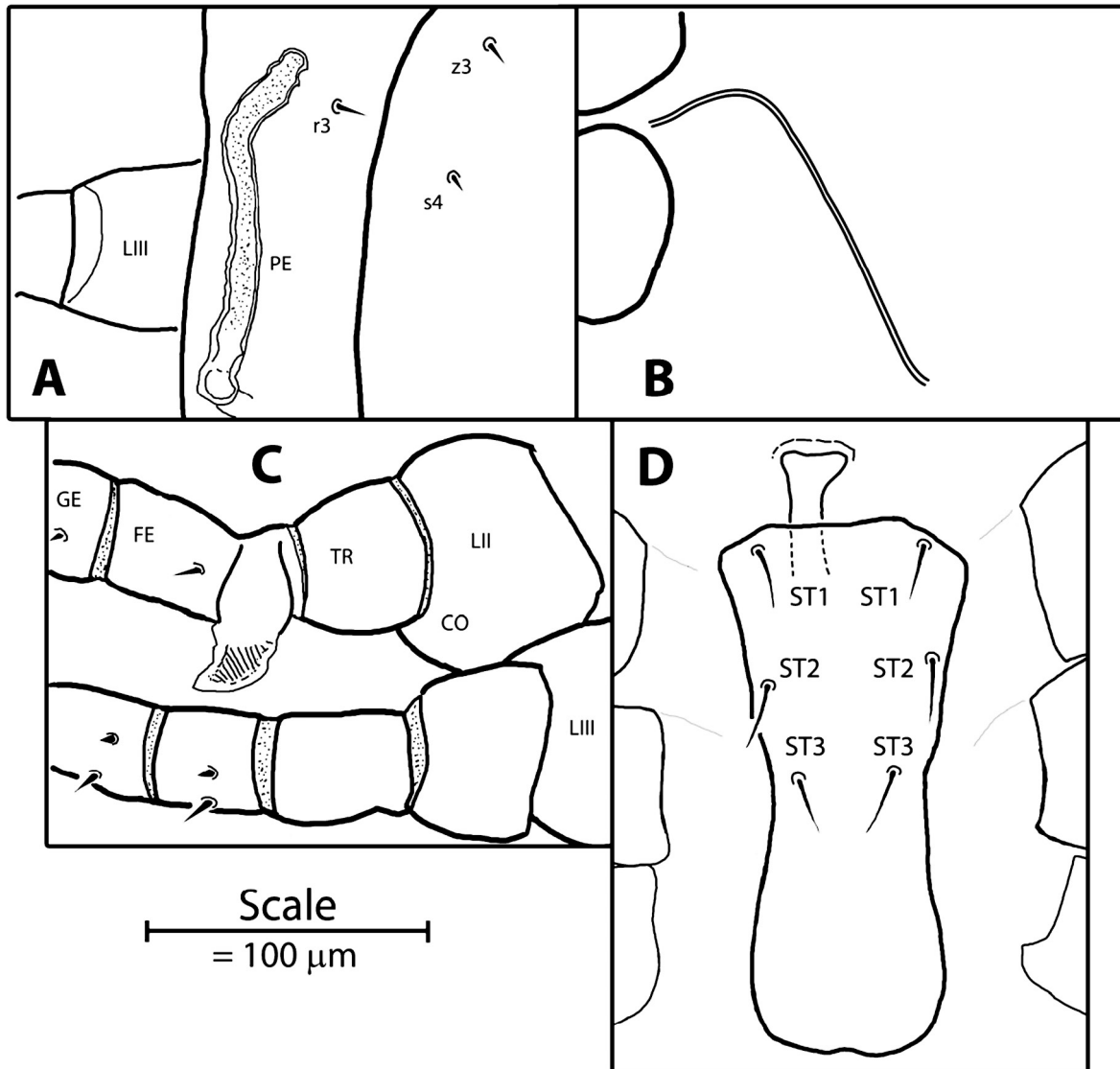


FIGURE 22: *Prasadiseius incanus* Prasad and Guanilo, **n. sp.** (A, B: Female; C, D: Male). A – Left peritreme (PE) beside podonotal shield (showing z3 and s4) and r3 (drawn from Fig. 9; LIII = Leg III); B – Tubular spermatheca (drawn from Fig. 10); C – Leg II (LII) showing large spur on ventral basifemur (drawn from Fig. 20; CO = coxa, TR = trochanter, FE = femur, GE = genu); D – Sternogenital shield with sternal setae (drawn from Figs. 16, 17).

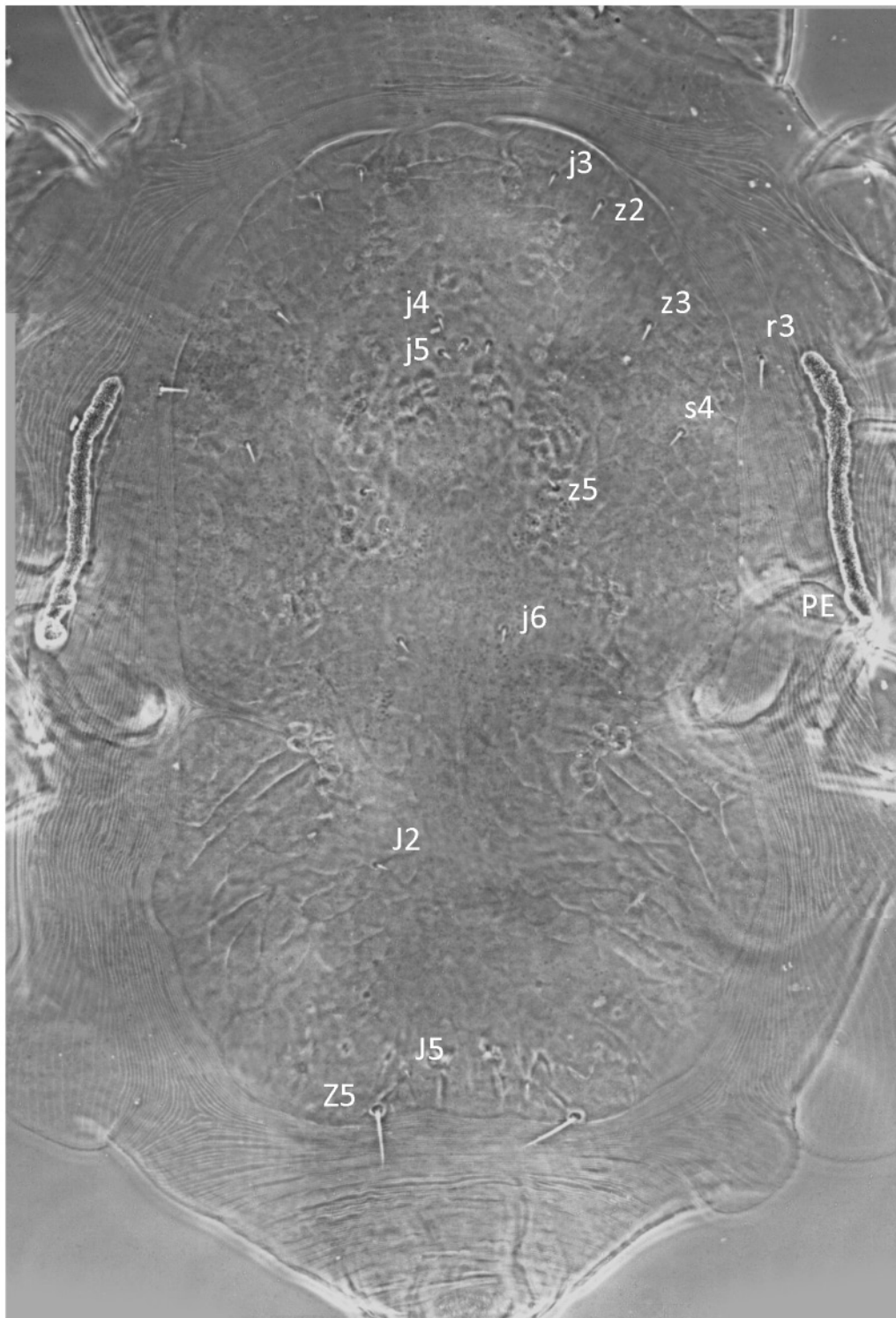


FIGURE 23: *Prasadiseius incanus* Prasad and Guanilo, **n. sp.** (Female). Photo of idiosoma in dorsal view (note absence of seta J2 on one side in this female).

119

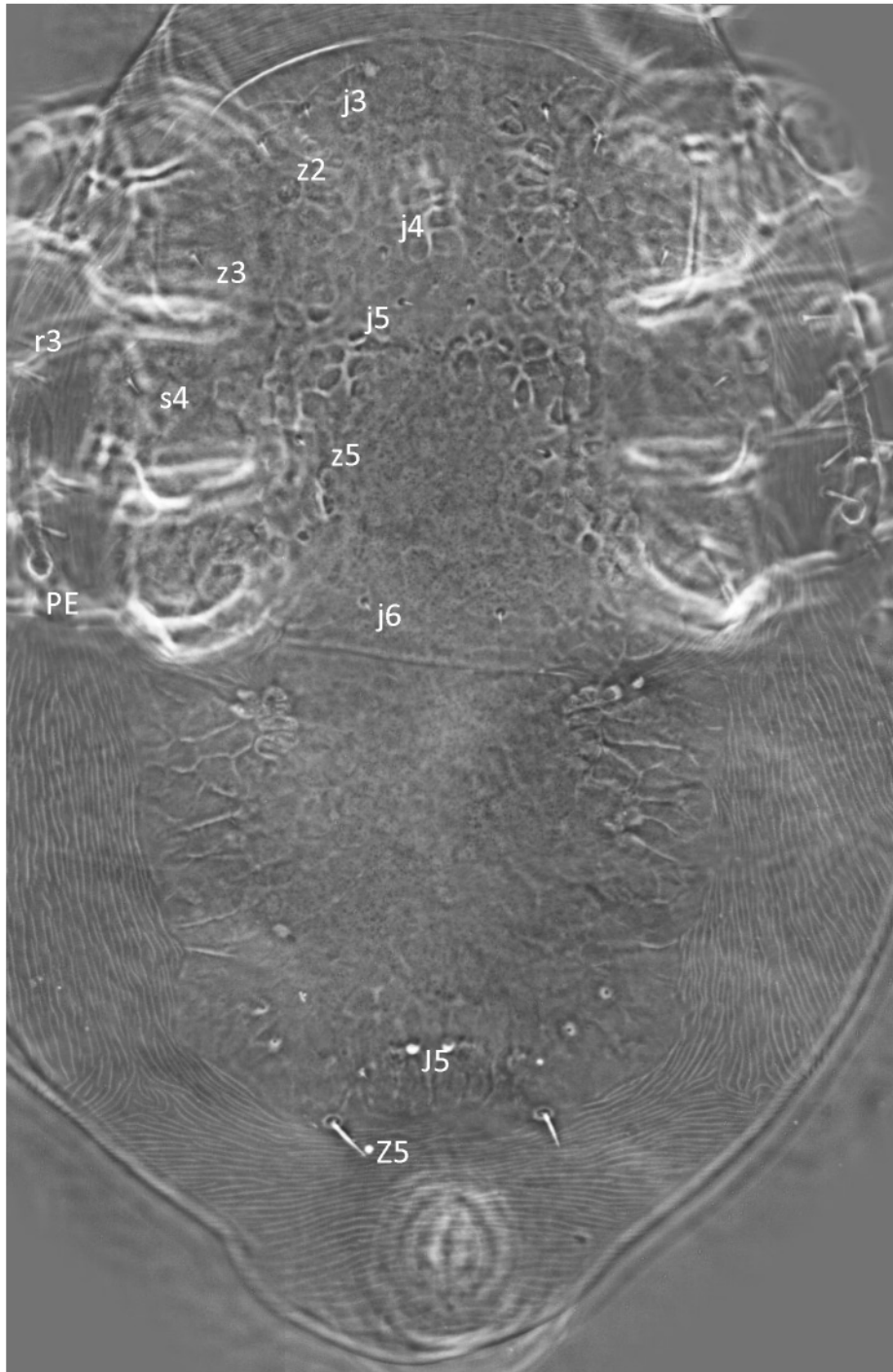


FIGURE 25: *Prasadiseius incanus* Prasad and Guanilo, **n. sp.** (Male). Photo of idiosoma in dorsal view (setae J2 not evident, note shorter peritreme and setae Z5 than in female).

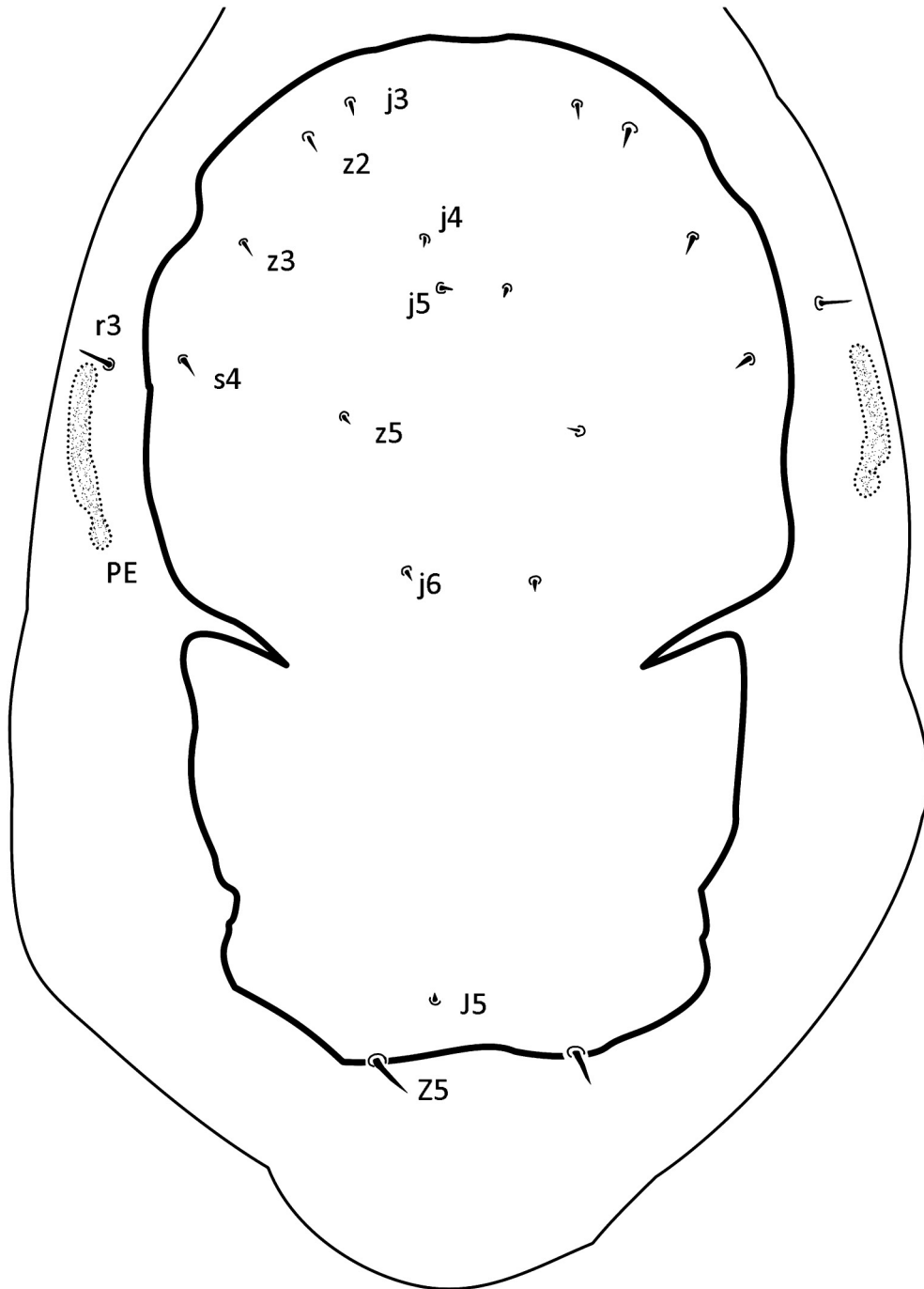


FIGURE 26: *Prasadiseius incanus* Prasad and Guanilo, n. sp. (Male). Line drawing of idiosoma in dorsal view (setae J2 not evident, note shorter peritreme and setae Z5 than in female).



FIGURE 27: Moth host: A – *Xylophanes fusimacula* (R. Felder); B – *Xylophanes undata* Rothschild and Jordan.

The position of setae j4 in relation to j5 is variable. Occasionally, an additional j4 or j5 seta may be present (Figure 14) or only 1 of the j4 pair of setae may be present. Seta J2 on one side in female may be absent (Figures 23, 24). Although present in several females, pair of seta J2 and one of J5 on one side was found absent in male (Figures 25, 26). The position of z3 in relation to j4 or to j6 may also vary within the same species. Setae z3 may be located in same or transverse line with j4 – j5 (Fig. 2) or may be slightly anterior to these (Figure 14). The position of z2 in relation to j3 (anterior or posterior) appears to be of significance in defining a species.

Of all morphological characters studied, the presence of the specific type of spur on venter of femur of leg II in the male is very species specific. Males are often present among the females in populations of 8 or more mites on the host; without the males, it may be difficult to identify a species. Differences in the shape and size of spermatodactyl of different species of *Prasadiseius* spp. may prove to be useful in distinguishing the different species. It appears to be a complex structure and needs to be studied in higher magnification, along with other gnathosomal structures, including scanning electron micrographs (SEM) of all of the species.

Several questions on the development and biology of these mites remain to be answered and need to be investigated in future. Do females infest new moth host first or males, or vice versa, or both together? Are females gravid when they infest a new moth host? In case of heavy infestations, do more than one species infest the same moth? Is there any migration of these mites involved in the case of a heavy infestation? Do any species develop to a tritonymphal stage? The first author has found eggs, protonymphs, deutonymphs, and adult females and males of these mites together on same host but has not observed presence of tritonymphs. As we have seen these mites alive for the first time in Peru, it would be interesting to study these aspects in future in this and other countries where these mites have been reported infesting various sphingid moths by the first author.

**Key for the identification of adults of
Prasadiseius spp. of the world (all parasites of
adult sphingid moths)**

1. Genital setae (ST5) present 2
— Genital setae (ST5) absent 4
2. Dorsal shield of female and male entire (1 dorsal shield), broad and truncate posteriorly; sternal shield with 3 pairs of setae (ST1 – ST3) 3
— Dorsal shield of female entire, tapering posteriorly; male with 2 dorsal shields (podonotal and opisthonotal), opisthonotal shield very small, rectangular, much wider than long; sternal shield with 2 pairs of sternal setae (ST1 and ST2) on shield and third pair (ST3) on soft integument (Bolivia, Honduras) *P. pholusis* (Prasad 1970b)
3. Setae j4 present; sternal setae (ST1 – ST3) in both female and male relatively long, ST2 reaching base of ST3 in same row (Brazil, Ecuador, Guatemala, Peru) *P. cocytes* (Prasad 1970a)
— Setae j4 absent; sternal setae (ST1 – ST3) in both female and male comparatively short, ST2 not reaching base of ST3 in same row (Uganda)
..... *P. aporodes* (Prasad 1972)
4. Setae j4 present; sternal shield normal or only slightly reduced posteriorly, ST1 and ST2 on shield but ST 3 on integument 5
— Setae j4 absent; sternal shield well reduced all around; all sternal setae (ST1 – ST3) on soft integument (Guatemala, Honduras, Panama Canal Zone, Peru) *P. kayosiekerei* (Prasad 1970b)
5. Setae ST1 in female and male short, not reaching close to base of ST2 in same line; 2 pairs of setae (z2, z3) present laterally anterior to r3 and lateral to j3 (India, Peru) 6
— Setae ST1 long, reaching close to base of ST2 in same line; 3 pairs of setae (z2, z3, s4) present laterally anterior to r3 and lateral to j3 (Uganda)
..... *P. achlora* (Prasad 1972)
6. Peritreme long, extending beyond or close to base of r3 7

— Peritreme short, way short of reaching base of r3 (Peru) *P. donahuei* (Prasad 1970a)

7. Setae S2 on opisthonotal shield present; peritreme long, extending well beyond base of r3 and z3; male with 4 pairs of setae on sternogenital shield (ST1 – ST3, ST5); ventral basifemur II in male with a short spinose seta (India)

..... *P. indicus* (Prasad 1973b)

— Setae S2 on opisthonotal shield absent; peritreme long but not extending well beyond base of r3 and z3; male with 3 pairs of setae (ST1 – ST3) on sternogenital shield; ventral femur II in male with a very large and thick spur (Figs. 20, 21) (Peru)

..... *P. incanus* Prasad and Guanilo, **n. sp**

CONCLUSION

It was 1970, over 40 years ago, when two new species of the otopheidomenid mites from museum preserved sphingid moths were described by the first author from Peru. Later, after survey of preserved moths in different museums of the world in a brief period of about 3 years, he added 5 more new species from various countries to this list. These mites had never been seen alive before until August 2010 in Peru when collections were made of the new species described in this paper, which brought a total number of eight species of the genus *Prasadiseius* known from sphingid moths. Research has proved that these ectoparasitic mites are present on many sphingid hosts in various neotropical and tropical countries of the world. This work indicates the likelihood that many new species are yet to be discovered in the future and that surveys of moths housed in museums and those collected in the native countries must be conducted to learn more about these mites. It is unfortunate that the lack of research funding for such work is hampering these discoveries worldwide. As financial resources are limited due to economic crisis in many countries, authors feel that global efforts are necessary to work as team members, as done in the present work, in obtaining the necessary funding and conducting the expedition and exploration for the mite fauna in a few selected countries at a time in future.

ACKNOWLEDGEMENTS

We are grateful to the followings: Government of Peru for the permission to collect and study the live moths in Amazonian Forest of Peru; Acarology Development Foundation, USA for fellowship to Mr. J. Grados, and to International Journal of Acarology for providing Prasad Family Fellowship to the second author; Dr. Gregory A. Evans, Beltsville, Maryland, USA for valuable comments and suggestion on the manuscript; and to Dr. Hans Kloppe, Acarology Laboratory, The Ohio State University, Columbus, USA and Dr. Gerardo Lamas Müller, Director, Museo de Historia Natural, Lima, Peru for help in relation to permit for this work. Thanks also to Dr. Frank West, East Lansing, Michigan, a physician and lepidopterist, for the identification of the hawk moths, and to the owner and staff members of the Manu Paradise Lodge (www.manuparadiselodge.com) in Cusco city for the transportation and excellent facilities in their lodge in Manu National Forest area. Thanks also to Dan Papacek, Director, Bugs for Bugs, Mundubbera, QLD, Australia, for providing financial support to the second author to travel from Australia to Peru to join the expedition.

REFERENCES

- Chant, D.A. 1965 — Generic concepts in the family Phytoseiidae (Acarina: Mesostigmata) — *Can. Ent.* 97: 351-374. doi:10.4039/Ent97351-4
- Chant, D.A., McMurtry, J.A. 2007 — Illustrated Keys and Diagnoses for the Genera and Subgenera of the Phytoseiidae of the World (Acari: Mesostigmata) — Indira Publishing House, West Bloomfield, MI, USA, 220 pp.
- Chant, D.A., Yoshida-Shaul E. 1992 — Adult idiosomal setal patterns in the family Phytoseiidae (Acari: Gamasina). *Internat. J. Acarol.* — 18(3): 177-199. doi:10.1080/01647959208683949
- Evans, G.O. 1963 — Observations on the classification of the family Otopheidomenidae (Acari: Mesostigmata) with description of two new species — *Ann. Mag. Nat. Hist. ser.* 13(5), 609-620.
- Fain, A., Lukoschus, F. S. 1983 — *Katydisseius nadchatri* n. g., n. sp. (Acari: Otopheidomenidae) from the tracheae of a Malaysian katydid *Chloracris brullei* Pictet & Saussure, 1892 (Orthoptera, Pseudophyllidae). *Internat. J. Acarol.* — 9(4): 173-178. doi:10.1080/01647958308683333

- Halliday, R.B. 1994 — First record of the family Otopheidomenidae (Acarina: Mesostigmata) in Australia, with description of *Nabiseius melinae* sp. n. J. Aust. ent. Soc. — 33: 347-350.
- Krantz, G.W., Khot, N.S. 1962 — A review of the family Otopheidomenidae Treat 1955 (Acarina: Mesostigmata) — Acarologia 4(4): 532-542.
- Mo, C.-F. 1996 — A new genus and new species of the Otopheidomenidae (Acari: Mesostigmata) from longhorned grasshoppers — Syst. Appl. Acarol. 1: 199-204.
- Prasad, V. 1968 — *Noctuseius treati*, a new genus and species of moth mite from Hawaii and Easter Island — Ann. Ent. Soc. Amer. 61(2): 411-413.
- Prasad, V. 1970a — Two new species of *Otopheidomenis* mites from South America (Acarina: Phytoseiidae) — Acarologia 12(1): 28-33.
- Prasad, V. 1970b — Two new species of *Otopheidomenis* (Acarina: Phytoseiidae) ectoparasitic on sphingid moths with a note on *Noctuseius* — Can. Ent. 102(10): 1209-1215. doi:10.4039/Ent1021209-10
- Prasad, V. 1972 — New species of *Otopheidomenis* (Acarina: Phytoseiidae) ectoparasitic on sphingid moths from Uganda — Acarologia 14(3): 345-249.
- Prasad, V. 1973 — A new species of *Otopheidomenis* (Acarina: Otopheidomenidae) from India — Acarologia 15(2): 193-196.
- Prasad, V. 1975 (1976) — Ectoparasitic mites (Acarina: Otopheidomenidae) on sphingid moths — Acarologia 17(3): 365-383.
- Prasad, V. 1987 — A new species of otopheidomenid mite from the Philippines with comments on *Noctuseius* Prasad and *Prasadiseius* Wainstein (Acarina: Otopheidomenidae) — Internat. J. Acarol. 13(4): 245-250. doi:10.1080/01647958708683779
- Prasad, V. 2011a — Proposed nomenclature for idiosomal setae in otopheidomenid mites (Acari: Otopheidomenidae) known from sphingid moths (Lepidoptera: Sphingidae) — Internat. J. Acarol. 37(1): 11-30. doi:10.1080/01647954.2010.489055
- Prasad, V. 2011b — An unusual case of very heavy infestation of *Prasadiseius cocytes* (Prasad, 1970) (Acari: Otopheidomenidae) in *Manduca rustica* (Fab.) (Lepidoptera: Sphingidae) collected in Ecuador — Internat. J. Acarol. 37(1): 31-41. doi:10.1080/01647954.2010.491487
- Prasad, V. 2011c — Phytoseiidae and Otopheidomenidae (Acari: Mesostigmata) of the World: A Self Study Guide. Indira Publishing House, West Bloomfield, MI, USA, 208 pp.
- Prasad, V. 2011d — Rediscovery of *Prasadiseius cocytes* (Prasad, 1970) (Acari: Otopheidomenidae) in neotropical countries — Internat. J. Acarol. 37: in press.
- Prasad, V., Walker, G. 2011 — Scanning electron microscopy studies on *Prasadiseius kayosiekerei* (Prasad, 1970) (Acari: Mesostigmata: Otopheidomenidae): Idiosoma — Internat. J. Acarol. 37(1): 43-52. doi:10.1080/01647954.2010.494166
- Syed, A.R., Goff, M.L. 1983 — A new species of *Otopheidomenis* (Acari: Otopheidomenidae) ectoparasitic on *Ascalapha odorata* (Lepidoptera: Noctuidae) in the Hawaiian Islands, with a key to the species in the genus — Int. J. Entomol. 25: 316-320.
- Treat, A.E. 1955 — An ectoparasite (Acarina: Mesostigmata) from moths of the genus *Zale* — J. Parasitol. 41: 555-561. doi:10.2307/3274134
- Treat, A.E. 1975 — Mites of Moths and Butterflies — Cornell University Press, Ithaca, N.Y. and London, U.K. 362 pp.
- Wainstein, B.A. 1972 — On the system of ectoparasitic mite of the family Otopheidomenidae Treat, 1955 (Parasitiformes) — Parazit. 5: 451-456.
- Zhang, Z.-Q. 1995 — Review of the systematics and biology of the Otopheidomenidae (Acari: Mesostigmata) with a description of *Eickwortius* gen. n. from a termite (Isoptera: Termitidae) — Syst. Entomol. 20: 239-246. doi:10.1111/j.1365-3113.1995.tb00095.x

COPYRIGHT

 Prasad *et al.* Acarologia is under free license. This open-access article is distributed under the terms of the Creative Commons-BY-NC-ND which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original author and source are credited.