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DESCRIPTION OF IMMATURE STAGES OF *PRASADISEIUS COCYTES* (PRASAD, 1970) (ACARI: OTOPHEIDOMENIDAE)

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ABSTRACT — Immature stages of *Prasadiseius cocytes* (Prasad, 1970) (Acari: Otopheidomenidae) are described for the first time based on live material collected from sphingid moths (Lepidoptera: Sphingidae) during an expedition to Peru in August 2010. Different idiosomal structures, setal patterns and some details of the gnathosoma using photos are provided.

KEYWORDS — Otopheidomeninae; immature stages; description; setal pattern

INTRODUCTION

Three genera of ectoparasitic otopheidomenid mites from moths (Lepidoptera) are known that comprise the subfamily Otopheidomeninae Treat. These are: *Noctuiseius* Prasad, 1968 and *Otopheidomenis* Treat 1955, both from noctuid moths (Noctuidae), and *Prasadiseius* Wainstein 1972, from sphingid or hawk moths (Sphingidae). Of the three genera, immature stages have only been described of *N. treati* Prasad 1968 (Prasad 1969) and *O. zalelestes* Treat 1955. Although Prasad (1970 – 1973) reported the presence of immature stages of several species of the genus *Prasadiseius* from museum-preserved hawk moths over 40 years ago, until now, they have not been described.

The species of *Prasadiseius* are ectoparasites that are only known to occur on sphingid moths (Lepidoptera: Sphingidae) and are reported mostly from equatorial countries of the world (Prasad 1976). They are of scientific interest as they closely resemble phytoseiids, an important group of predatory mites, but have a much more reduced structures and complement of setae. The two families are considered to be within the same sister group, having a close evolutionary relationship, with otopheidomenids being more highly derived than the phytoseiids (Chant and McMurtry 2007). Prasad (1970a, b, 1972, 1973, 1987) reported seven species of *Prasadiseius* from museum-preserved hawk moths collected in different countries, including *Prasadiseius cocytes* (Prasad 1970a). Recently, this mite was found to heavily infest a sphingid moth, *Manduca rustica* (Fab.), in Ecuador (Prasad, 2011b) and to have a widespread distribution in neotropical countries including Brazil, Ecuador, Guatemala, and Peru (Prasad 2011d).

A new species, *Prasadiseius incanus* Prasad and Guanilo 2011, has also been described recently from Peru (Prasad *et al.* 2011) bringing the number of known species in this genus to eight.

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It is not known if the immature stages of the different species of *Prasadiseius* resemble or are different from each other and how closely they resemble the adults. These mites had never been seen alive until August 2010 when they were seen for the first time by the author during an international expedition conducted by him along with three other members in the Amazon Forest of Peru. Live adults of *P. cocytes* were collected on live sphingid moths and redescribed (Prasad 2011e). The immature stages of this species from the same collections are described herein. It is hoped that more studies on the immature stages of these and other species of Otopheidomenidae will be published in the future to gain a better understanding of the morphology and evolutionary relationships between these and other species of Gamasina, especially the Phytoseiidae.

The idiosomal chaetotaxy is based on the system of Lindquist and Evans (1965) as adapted for the family Phytoseiidae by Rowell *et al.* (1978). The dorsal and ventral setal pattern notation follows Chant and Yoshida-Shaul (1989, 1991, 1992) and Chant and McMurtry (2007) indicating fixed and variable setae. This system was adapted for Otopheidomenidae by Prasad (2011a, c) and is used herein.

Materials and methods

The details of the materials and methods are given in Prasad *et al.* (2011). In brief, a permit was obtained to collect and study sphingid moths in Peru. Mites were brought to USA, mounted in Hoyer's medium on glass microscope slides, dried, the edges of the cover slip sealed with Glyptal, and labeled with appropriate collection data. The author identified the mites using an Accu-Scope 3000 phase-contrast microscope (Accu-Scope, New York, USA) with a 400x magnification. Occasionally, a 1000x magnification was needed to see the structural and setal details under the oil immersion lens. Many photographs of the mites, using the mounted Micrometrics^{TM} camera on the microscope, were taken and saved in Photoshop CS2. As most dorsal and some ventral idiosomal setae were minute (usually less than 10 μm), a series of pictures at a 400x magnification were taken and included in this study to present these with clarity.

All measurements were taken from slide-mounted specimens and given in micrometers (μm) with the average in brackets. These were taken, unless otherwise mentioned, at the longest and widest points of the structure. The length of each seta was measured from the base to the tip and the distance between two setae was measured from the inner base of one seta to the inner base of the other seta.

Abbreviations used in the explanation of Figures

These are as follows: ALINV = anterolateral invagination, AOPS = anterior opisthonotal shield, AS = anal shield, BE = broad end of egg, CO = corniculi, CS = connecting shield, DE = denticles, E = egg, F = female, FDCH = fixed digit of chelicera, GN = gnathosoma, HY1-3 = hypostomal setae 1-3, HYPS = hypostome, ID = idiosoma, JV 1 = ventral seta located posterior to sternal shield and anterior to anal shield, L = larva, LAV = lateral anal valves, LC I-IV = left coxae I-IV, LCH = left chelicera, LCONC = lateral concavity, LCONC-1 = anterior lateral concavity, LCONC-2 = posterior lateral concavity, LCONV = lateral convexity, LLI-LLIV = left legs I-IV, LOPS = left opisthonotal shield, LP = left palp, LPPOL = left posterior podonotal lobe, LVINV = left vertical invagination in between LPPOL and MPPOL, MAV = membranous anal valves, MDCH = movable digit of chelicera, MM = muscle marks, MPPOL = middle posterior podonotal lobe, MS = hawk moth scale, NE = narrow end of egg, OP = opisthosoma, OPS = opisthonotal shield, PA = paraanal setae, PCONC = posteromedial concavity, PE = peritreme, PLINV = posterolateral invagination, PMCONC = posteromedial concavity, POPS = posterior opisthonotal shield, POS = podonotal shield, PST = postanal seta, RC I-IV = right coxae I-IV, RCH = right chelicera, RLI to RLIV = right legs I-IV, ROPS = right opisthonotal shield, RP = right palp, RPPOL = right posterior podonotal lobe, RVINV = right vertical invagination in between MPPOL and RPPOL, SS = sternal shield, ST1-ST3 = sternal setae ST1-ST3, ST5 = genital or sternogenital seta, TE = tectum.

Prasadiseius cocytes (Prasad, 1970) (Figures 1-33)

Otopheidomenis cocytes Prasad, 1970a: 29.
Prasadiseius cocytes (Prasad); Wainstein, 1972: 453.

Material examined — Seven eggs (VP10-38, VP10-39), four larvae (VP10-36, VP10-42, VP10-43), five protonymphs (VP10-36), and five deutonymphs (VP10-36), collection data:

1. VP10-36, moth #275, Morro Leguia, 2300m, 13°08′35.3"S, 71°35′08.1"W, Cusco Department, Peru, 13.VIII.2010, moth coll. Alberto D. Guanilo, Juan Grados, Vikram Prasad, and Indira Prasad, moth host – *Xylophanes nabuchondonosor* Oberthür;
2. VP10-38, moth #281, coll. data as VP10-36;
3. VP10-39, moth #286, coll. data as VP10-36;
4. VP10-42, moth #253, Alfamayo, 2625m, 13°03′56.3"S, 72°23′47.3"W, Urubamba, Cusco Department, Peru, 15.VIII.2010, moth coll. Alberto D. Guanilo and Juan Grados, moth host – *Adhemarius sexoculata* (Grote);
5. VP10-43, moth #260, coll. data as VP10-42 but moth host – *Xylophanes nabuchondonosor* Oberthür.

The voucher specimens will be deposited in the Natural History Museum (MUSM, Universidad Nacional Mayor de San Marcos), Lima, Peru; Museum of Biodiversity, The Ohio State University, 1315 Kinnear Road, Columbus, OH 43212, USA; US National Museum, Washington, DC, USA, and the author's collection.

Description of immature stages

Egg (n = 7) (Figs. 1, 2)

Single egg in each gravid female (Fig. 1); oval with one end of egg slightly broader than other end, narrow end facing anteriorly towards genital opening while broad end facing posteriorly indicating release of egg facing narrow end first during oviposition (Fig. 1). Eggs inside gravid female and some eggs laid on host without developing larva inside. However, some eggs laid on host clearly with developing larva having three pairs of legs and gnathosoma facing broad end of egg while opisthosoma and anal region facing narrow end of egg (Fig. 2). Eggs white, laid singly attached to moth hairs, 340 – 398 (377) long, 250 – 307 (277) wide (with and without larva).

Larva (n = 4) (Figs. 3-11)

Very small, whitish, slightly larger than egg, found in same area with other stages. Idiosoma 382 – 395 (388) long, 321 – 327 (324) wide, roughly oval, with round opisthosoma and three pairs of legs.

Dorsum (Figs. 3, 4, 11A) — Two shields present on idiosoma: a large podonotal shield and a small opisthonotal shield.

Podonotal shield (Figs. 3, 4, 11A) — Anterior margin more smoothly rounded than lateral margins showing a lateral concavity and lateral convexity in a few areas. Posterior margin divided in three divisions or lobes: left posterior podonotal lobe, middle posterior podonotal lobe, and right posterior podonotal lobe. Three lobes separated by two partial vertical invaginations (26 long): a left vertical invagination between left posterior podonotal lobe and middle posterior podonotal lobe and a right vertical invagination between middle posterior podonotal lobe and right posterior podonotal lobe. Middle posterior podonotal lobe much wider (102) than lateral two lobes (62, 64) and with or without small posteromedial concavity between setae j6. Entire podonotal shield with variously shaped polygonal reticulation pattern. Muscle marks not developed. Podonotal shield 238 – 245 (242) long and 226 – 250 (238) wide. Width of posterior three lobes of podonotal shield: left lobe = 56 – 70 (62), middle lobe = 98 – 110 (102), and right lobe = 58 – 70 (64). Length of left vertical invagination = 25 – 28 (26) and right vertical invagination = 22 – 30 (26).

Podonotal setae — Podonotal shield with eight pairs of tiny setae (j3, j4, j5, j6, z2, z4, z5, s4; j1 absent) (Figs. 3, 4, 11A). Seta r3 absent on lateral integument.

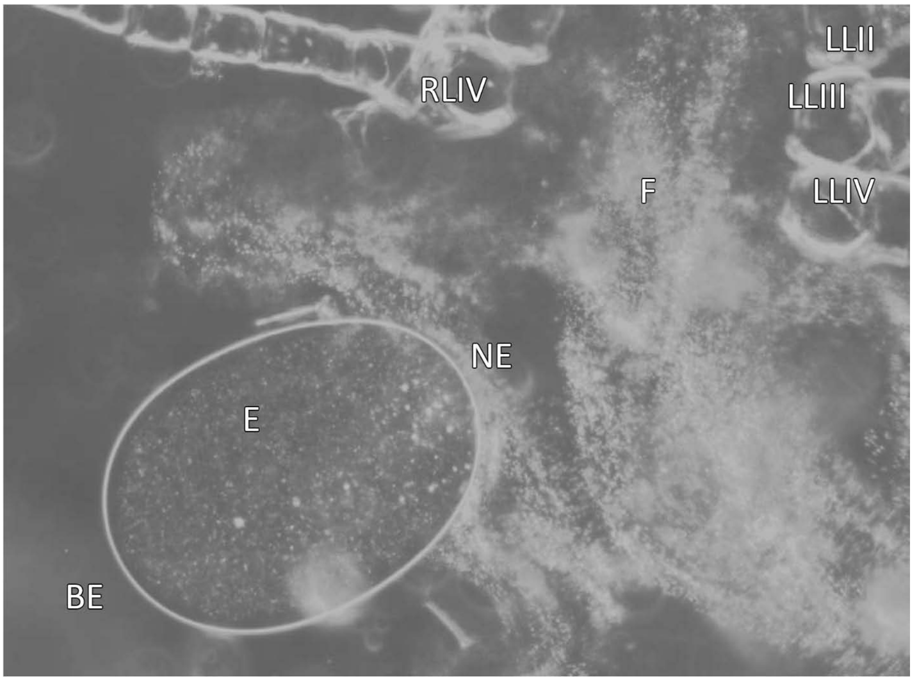

FIGURE 1: *Prasadiseius cocytes* (egg) — Opisthosoma (OP) of a female (F) with an egg (E) the narrow end (NE) which is facing anteriorly toward the genital opening or left leg IV (LLIV) and right leg IV (RLIV), while the broad end (BE) of the egg is facing posteriorly (opisthosoma is broken and anal area is not seen) (VP10-38-33, 100x).

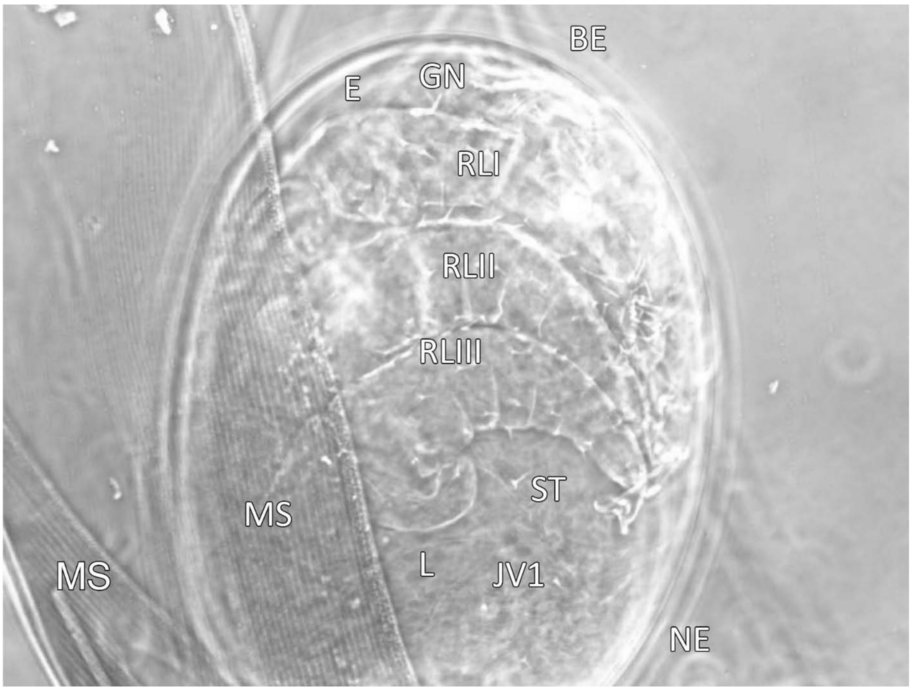

FIGURE 2: *Prasadiseius cocytes* (egg) — Attached to hawk moth scale (MS) an egg (E) with a developing larva (L) showing 3 pairs of right legs I-III (RLI-RLIII), gnathosoma (GN) on top toward the broad end of the egg (BE), sternal setae (ST3) and JV1 (VP10-39-8, 200x).

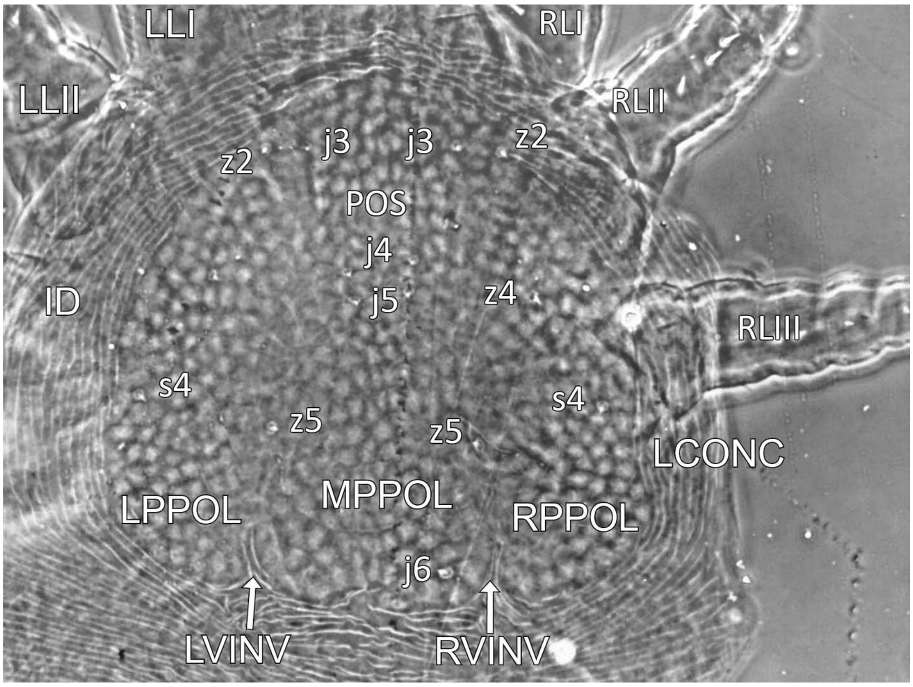

FIGURE 3: *Prasadiseius cocytes* (larva) — Dorsal view of anterior idiosoma (ID) showing parts of 3 pairs of right legs (RLI-RLIII), 2 pairs of left legs (LLI-LLII), podonotal shield (POS) with lateral concavity (LCONC), left posterior podonotal lobe (LPPOL), middle posterior podonotal lobe (MPPOL), right posterior podonotal lobe (RPPOL), left vertical invagination (LVINV) in between LPPOL and MPPOL, right vertical invagination (RVINV) in between MPPOL and RPPOL, and 8 pairs of podonotal setae (j3, j4, j5, j6, z2, z4, z5, s4). Note MPPOL having a small posteromedial invagination and setae j6 near it (VP10-43-3, 200x).

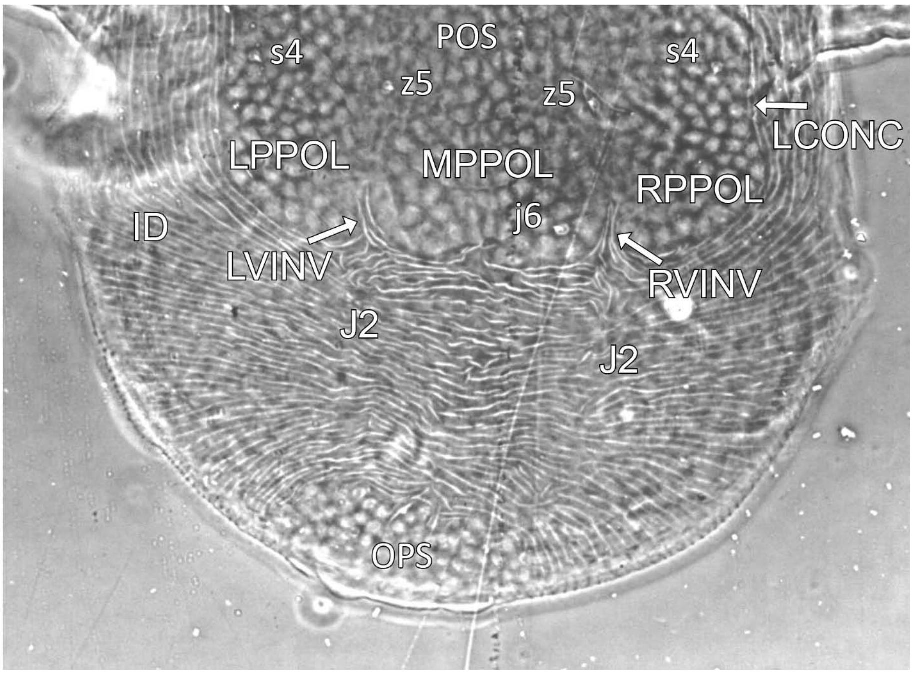

FIGURE 4: *Prasadiseius cocytes* (larva) — Dorsal view of posterior idiosoma (ID) showing posterior podonotal shield (POS) with LCONC, LPPOL, MPPOL, RPPOL, LVINV, RVINV, setae j6, z5, s4, most of opisthonotal shield (OPS), and setae J2 on soft integument in between POS and OPS (VP10-43-4, 200x).

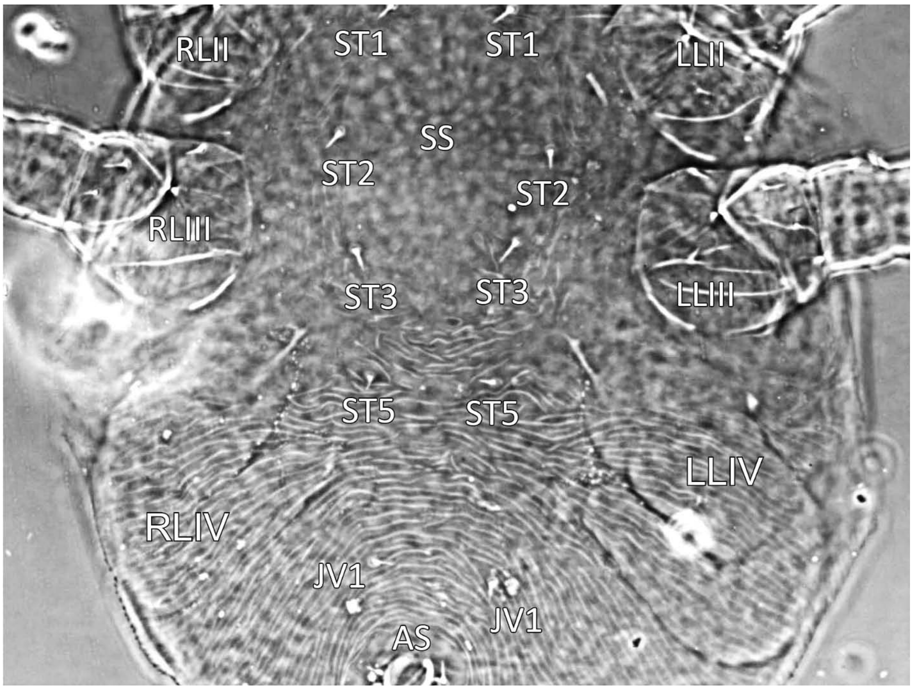

FIGURE 5: *Prasadiseius cocytes* (larva) — Ventral view showing sternal shield (SS) in between left legs II-III (LLII-LLIII) and right legs II-III (RLII-RLIII) with setae ST1, ST2, ST3 on sternal shield, ST5 on soft integument, anal shield (AS), and setae JV1 on soft integument in between ST5 and AS. Note left and right legs IV (LLIV, RLIV) developing inside indicating development of protonymph inside this larva (VP10-43-2, 200x).

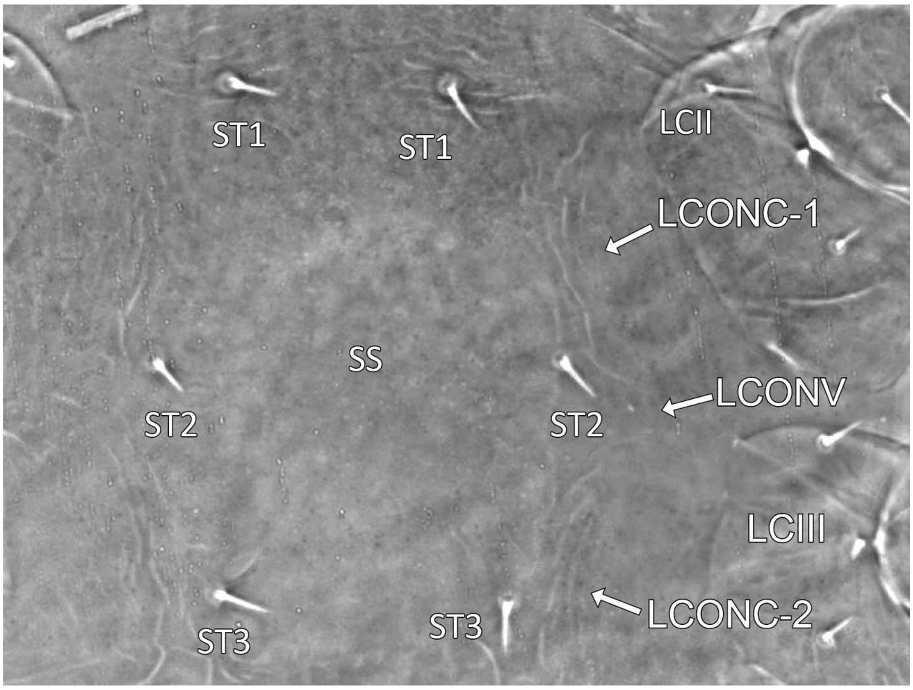

FIGURE 6: *Prasadiseius cocytes* (larva) — Ventral view showing sternal shield (SS) in between left coxae II-III (LCII-LCIII) and right coxae II-III (barely seen) with setae ST1, ST2, and ST3 located marginally on the shield, anterior lateral concavity (LCONC-1) in between ST1-ST2, posterior lateral concavity (LCONC-2) near ST3, and lateral convexity (LCONV) near ST2 (VP10-36-160, 400x).

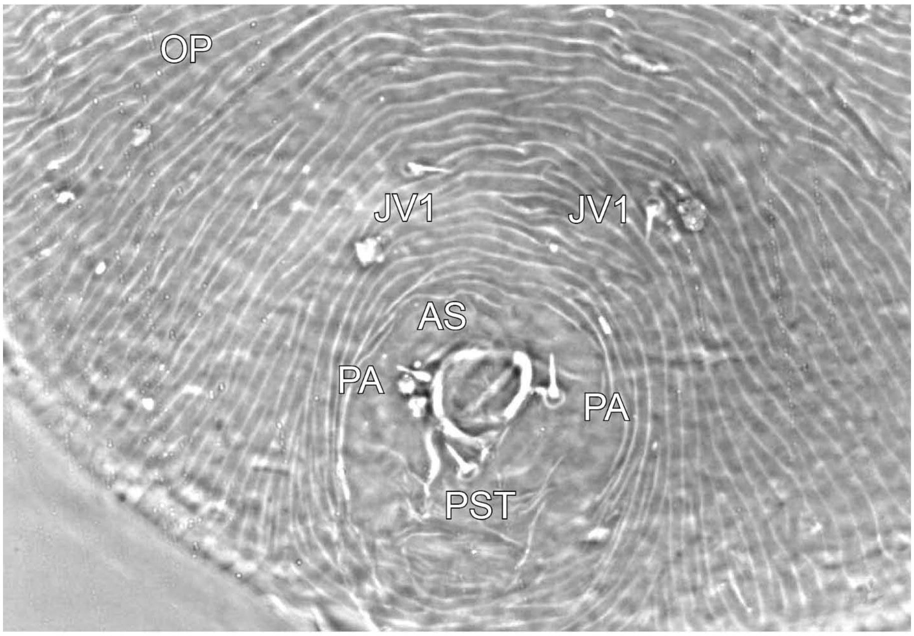

FIGURE 7: *Prasadiseius cocytes* (larva) — Ventral view of opisthosoma (OP) showing anal shield (AS) with paraanal setae (PA) and postanal seta (PST) and ventral setae JV1 on soft integument anterior to AS (VP10-43-5, 400x).

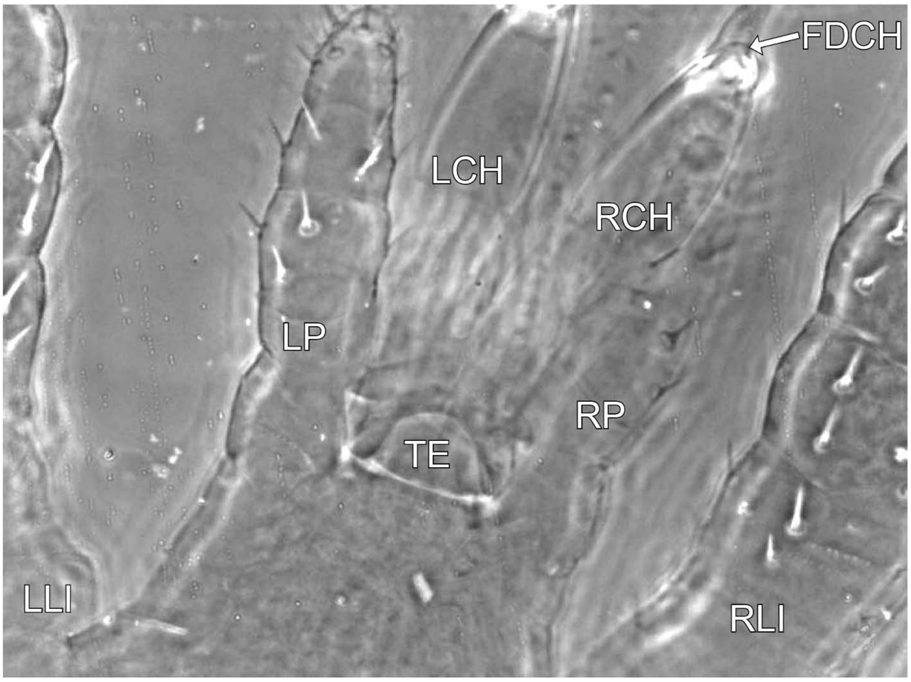

FIGURE 8: *Prasadiseius cocytes* (larva) — Dorsal view of gnathosoma (GN) in between left leg I (LLI) and right leg I (RL1) with tectum (TE), left palp (LP), right palp (RP), left chelicera (LCH), right chelicera (RCH), and tiny fixed digit of chelicera (FDCH, right) (VP10-43-1, 400x).

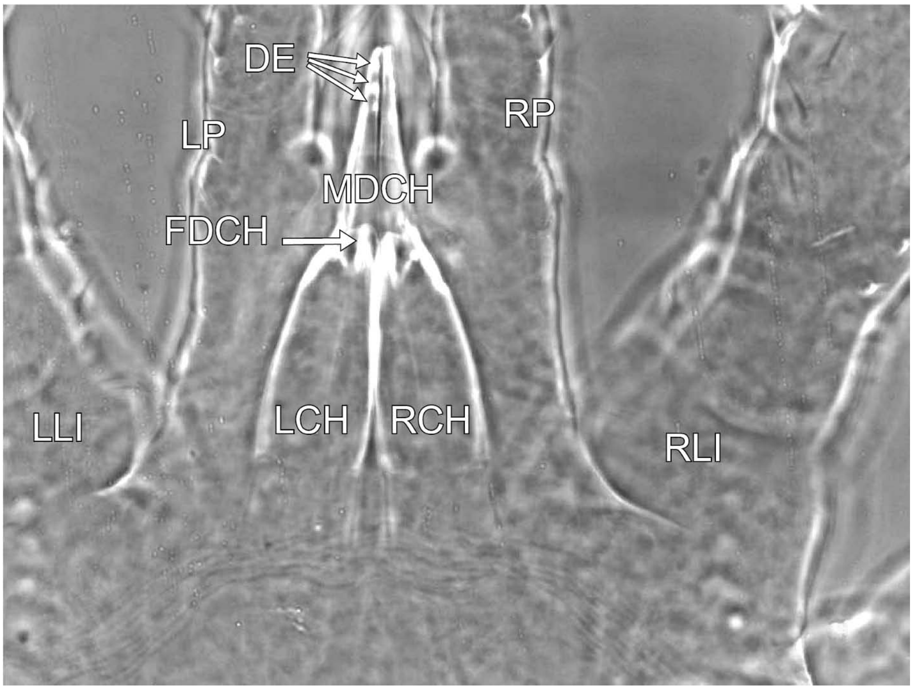

FIGURE 9: *Prasadiseius cocytes* (larva) — Dorsal view of gnathosoma (GN) in between left leg I (LLI) and right leg I (RL1) with left chelicera (LCH), right chelicera (RCH), tiny fixed digit of chelicera (FDCH, left), elongate movable digit of chelicera (MDCH, left and right) with denticles (DE), left palp (LP), and right palp (RP) (VP10-42-7, 400x).

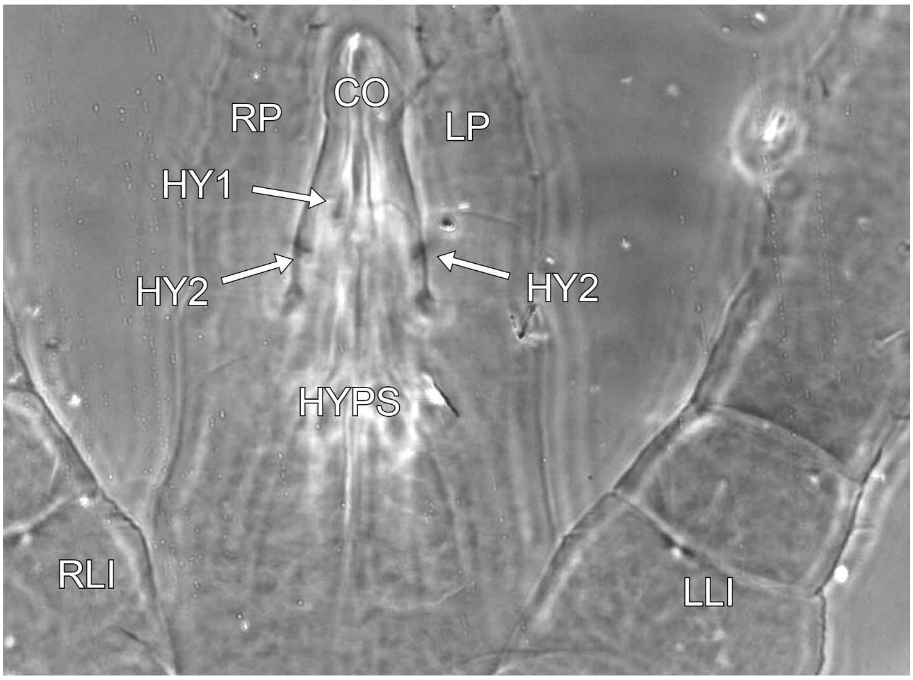

FIGURE 10: *Prasadiseius cocytes* (larva) — Ventral view of gnathosoma (GN) in between left leg I (LLI) and right leg I (RL1) showing hypostome (HYPS) with barely visible hypostomal setae (HY1 and HY2, HY3 absent in larva), corniculi (CO), left palp (LP), and right palp (RP) (VP10-42-8, 400x).

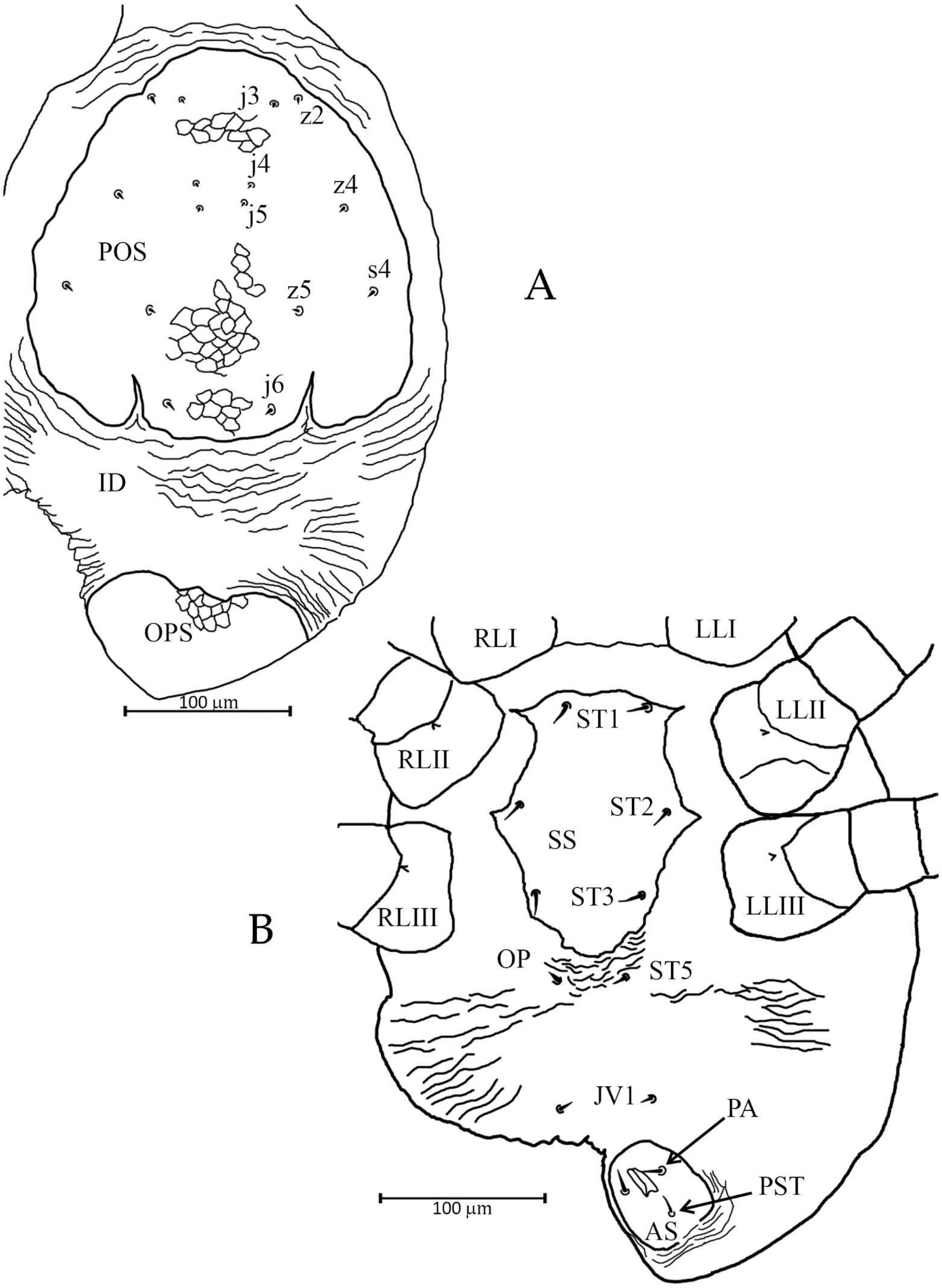

FIGURE 11: *Prasadiseius cocytes* (larva, line drawing): A – dorsal view; B – ventral view (both drawn from composite of Figs. 3 – 7 showing same abbreviations) (VP10-36).

Podonotal setae located as follows: z2 lateral to and in a transverse line with j3; z4 posterolateral to z2 and in a transverse line with j4, j5; s4 posterolateral to z4 and anterolateral to z5; and j6 on middle posterior podonotal lobe located closer to each other than to z5 pair of setae (Figs. 3, 4, 11A). Setae j5 and j6 form a hexagonal Fig. with z5. All these setae 4-7 long, finely pointed and without serrations. Measurements of different setae: j3 = 4 – 5 (4), j4 = 4 – 5 (5), j5 = 4 – 5 (5), j6 = 5 – 7 (6), z2 = 5 – 6 (6), z4 = 4 – 6 (5), z5 = 5 – 6 (6), and s4 = 6 – 7 (6). Measurements between setal pairs: j3-j3 = 54 – 55 (55), j4-j4 = 32 – 36 (34), j5-j5 = 23 – 25 (24), j6-j6 = 60 – 63 (62), z2-z2 = 86 – 92 (89), z4-z4 = 132 – 138 (135), z5-z5 = 88 – 92 (90), and s4-s4 = 181 – 190 (185). Measurements between other setal bases: j3-j4 = 45 – 50 (48), j4-j5 = 12 – 15 (14), j5-j6 = 114 – 125 (121), j3-z2 = 16 – 20 (18), j3-z5 = 110 – 132 (124), j5-z5 = 65 – 72 (68), j6-z5 = 57 – 64 (60), j6-s4 = 90 – 96 (93), z2-z4 = 60 – 64 (62), z2-z5 = 112 – 133 (117), z4-z5 = 62 – 71 (68), z4-s4 = 44 – 62 (53), and z5-s4 = 45 – 52 (48).

Remark — Seta z4 referred above was called z3 by this author in his previous publications (Prasad, 2011a, c, Prasad *et al.*, 2011).

Opisthonotal shield (Figs. 4, 31) — Much smaller than podonotal shield, almost twice as wide (128) as long (67), concave anteromedially and roughly rounded laterally, 63 – 70 (67) long, 120 – 133 (128) wide, with reticulation pattern similar to that of podonotal shield.

Opisthonotal setae — Seta J2, 2 – 3 long, barely visible, on soft integument in between podonotal shield and opisthonotal shield. Setae J5 and Z5 observed on opisthonotal shield at a 1000x magnification but difficult to see and draw at lower magnification (up to 400x) and, thus, not measured or shown in Figs. 4 and 11A.

Venter (Figs. 5-7, 11B) — Anteriorly, lightly sclerotized sternal shield mostly in between coxae II-III, and an anal shield posterior to coxae III at terminal end. Sternal shield with light polygonal reticulation pattern, much longer than wide, 145 – 177 (165) long, 102 – 130 (115) wide near ST2, widest in middle having widest lateral convexity near ST2 in between coxae II-III (Fig. 6), lateral concavity in between ST1-ST2 and near ST3, slightly concave anteromedially in between ST1-ST1 and gradually tapering to a triangular end medially posterior to ST3 (Fig. 5). Seta ST5 shorter (8) than ST3 (13) and located on soft integument (Figs. 5, 11B). Serrations of setae ST1, ST2, ST3 and ST5 not evident at 400x magnification. Distance between ST1-ST1 shorter (47) than ST2-ST2 (83) or ST3-ST3 (64). Setae ST5 on soft integument, very small, pointed and of about same length (8) as JV1 (8). Measurements of various setae: ST1 = 13 – 14 (13), ST2 = 12 – 14 (13), ST3 = 12 – 14 (13), ST5 = 7 – 10 (8) , JV1 = 7 – 10 (8). Distance between setal pairs: ST1-ST1 = 43 – 51 (47), ST2-ST2 = 70 – 90 (83), ST3-ST3 = 58 – 69 (64), ST5-ST5 = 36 – 55 (43), JV1-JV1 = 47 – 56 (50), ST1-ST2 = 62 – 65 (64), ST2-ST3 = 50 – 55 (53), ST3-ST5 = 51 – 65 (58), and ST5-JV1 = 60 – 86 (71). Distance between ST1-ST3 in vertical line = 102 – 114 (107) and in diagonal line = 116 – 130 (122). Anal shield (Fig. 7) 69 – 72 (71) long, 60 – 64 (62) wide. Pair of paraanal setae (PA) and single postanal seta (PST) present around anus, PA = 14 – 16 (15), PST = 14 – 15 (14). Distance between PA-PA = 25 – 31 (27) and PA-PST = 25 – 26 (26).

Peritreme — Peritreme and stigmata absent.

Gnathosoma (Figs. 8-10) — Tectum small, round anteriorly (Fig. 8), 15 – 20 (17) long, 26 – 35 (30) wide. Palp length = 76 – 97 (85). Pair of chelicerae present (Figs. 8, 9). Fixed digit very small and reduced to small protuberance, 9 – 12 (10) long. Movable digit of chelicera narrowly elongate, 43 – 51 (47) long, with 3 – 4 teeth (Fig. 9). Hypostome with two pairs of barely visible hypostomal setae (Fig. 10). Corniculi short but well-developed (Fig. 10). A detailed study of gnathosomal structures for all motile immature stages may be necessary to understand details at a much higher magnification such as that of a scanning electron microscope.

Legs — Leg I longer (304) than II or III (284, 278), latter two more or less of same length. Each tarsus with a pretarsus having two tiny claws and a pulvillus. Measurements of legs (including pretarsus): I = 291 – 313 (304), II = 275 – 294 (284), and III = 272 – 284 (278). Detailed study of the leg chaetotaxy of the larva and other motile stages is currently being conducted and will be presented by the author at a future date.

Protonymph (n = 5, Figs. 12-20)

With four pairs of legs. Body longer (529) than larva (388) but smaller than deutonymph (578); easily distinguishable from larva in having four pairs of legs and from deutonymph in lacking a T-shaped dorsal shield (Figs. 25, 26, 33A). Idiosoma 488 – 568 (529) long, 371 – 400 (390) wide.

Dorsum (Figs. 12-15, 20A) — Similar but larger and more sclerotized than larva's, with podonotal shield and opisthonotal shield.

Podonotal shield (Figs. 12,13, 15, 20A) — Length of podonotal shield about same (236 – 256, 245) as width (233 – 269, 252). Podonotal shield margin not smoothly rounded but with concavity and convexity anteriorly and laterally similar to larva's. As in larva, with three lobes or divisions posteriorly (left lobe, middle lobe and right lobe) caused by left and right vertical invaginations, but larger than in larva, and with muscle marks. Width of middle posterior podonotal lobe almost twice (117) than that of left (64) or right posterior podonotal lobe (69). Width of left lobe = 60 – 74 (64), middle lobe = 111 – 127 (117), and right lobe = 60 – 75 (69). Length of left vertical invagination same (26 – 40, 31) as right vertical invagination (26 – 38, 31). Middle posterior podonotal lobe more smoothly rounded at corners and concave posteromedially (Fig. 13) than in larva (Figs. 3, 4).

Podonotal setae (Figs. 12, 13, 15, 20A) — All eight pairs of podonotal setae (j3, j4, j5, j6, z2, z4, z5, s4) present as in larva, but, in addition, r3 on integument lateral to z4 and s4 (Figs. 12, 15, 20A). Seta r5 = 12 – 14 (13) long, considered to be variable, present in two specimens. Seta j3 located in a transverse line with z2 but may be located anteriorly, posteriorly, or in line with it. All podonotal setae minute, without any evident serrations. Setal measurements: j3 = 4 – 5 (4), j4 = 3 – 5 (5), j5 = 3 – 6 (5), j6 = 5 – 7 (6), z2 = 6 – 8 (7), z4 = 6 – 8 (7), z5 = 4 – 7 (5), s4 = 5 – 7 (6), r3 = 8 – 11 (10), r5 = 11 – 12 (12). Setae j3, j4, j5, j6, s4, and z5 very small (4 – 6), followed by z2 and z4 (7), r3 (10), and r5 (12). Distance between setal pairs: j3-j3 = 50 – 69 (62), j4-j4 = 35 – 40 (38), j5-j5 = 24 – 28 (26), j6-j6 = 68 – 84 (76), z2-z2 = 97 – 111 (105), z4-z4 = 152 – 172 (164), z5-z5 = 90 – 106 (97), and s4-s4 = 208 – 215 (212). Distance between other setal bases: j3-j4 = 40 – 54 (50), j4-j5 = 8 – 17 (15), j5-j6 = 125 – 134 (130), j3-z2 = 18 – 24 (20), j3-z5 = 110 – 141 (126), j6-s4 = 96 – 106 (100), j6-z5 = 62 – 69 (64), z2-z4 = 58 – 73 (64), z2-z5 = 114 – 128 (123), z4-z5 = 67 – 80 (74), z4-s4 = 67 – 72 (69), and z5-s4 = 62 – 66 (64).

Opisthonotal shield (Fig. 14) — Opisthonotal shield much longer (80) than in larva (67), and much wider (149) than long (80), length at maximum convexity = 74 – 84 (80), length in middle of concavity = 66 – 71 (69) and width = 140 – 156 (149). Anterior, posterior, left and right lateral margins of opisthonotal shield irregular and with concavities and convexities (Fig. 14).

Opisthonotal setae (Figs. 14, 20A) — Seta J2 on soft integument and J5, along with Z5, on shield, both J2 and J5 minute, J2 = 5 – 7 (6), and J5 = 4 – 6 (5). Seta Z5 longest pair of dorsal setae, 24 – 37 (31), with fine serrations. Distance between J2-J2 = 77 – 85 (82), J5-J5 = 48 – 51 (49), Z5-Z5 = 55 – 70 (64), j6-J2 = 98 – 108 (104), J2-J5 = 81 – 98 (91), J2-Z5 = 94 – 113 (102), and J5-Z5 = 15 – 18 (17).

Venter (Figs. 16, 17, 20B) — Sternal shield 150 – 218 (171) long, 102 – 140 (118) wide, lightly sclerotized, located mostly in between coxae II-III, similar to, but slightly longer (171), than in larva (165). Anterior, posterior and lateral margins, concavity and convexities, and reticulation patterns as in larva but more pronounced in protonymph. Setae ST1, ST2, and ST3 well developed and larger (20, 19, 23) than in larva (13, 13, 13). Fine serrations evident at higher magnifications. Seta ST5, smallest of all ventral setae (10), usually present, but absent in some specimens. Setal measurements: ST1 = 16 – 24 (20), ST2 = 16 – 21 (19), ST 3 = 21 – 25 (23), and ST5 = 7 – 12 (10). No serrations evident on ST5. Distance between setal pairs ST2-ST2 much greater (86) than between ST1-ST1 (55) or ST3-ST3 (65). Distance between ST1-ST2 slightly greater (64) than ST2-ST3 (53). Distance between setal bases: ST1-ST1 = 52 – 60 (55), ST2-ST2 = 80 – 90 (86), ST3-ST3 = 50 – 70 (65), ST5-ST5 = 54 – 66 (58), ST1-ST2 = 45 – 73 (64), ST2-ST3 = 50 – 60 (53), and ST3-ST5 = 81 – 96 (86).

Vertical distance between ST1-ST3 = 108 – 124 (114) and diagonal distance between ST1-ST3 = 121 – 140 (127). Seta JV1, located on soft integument in

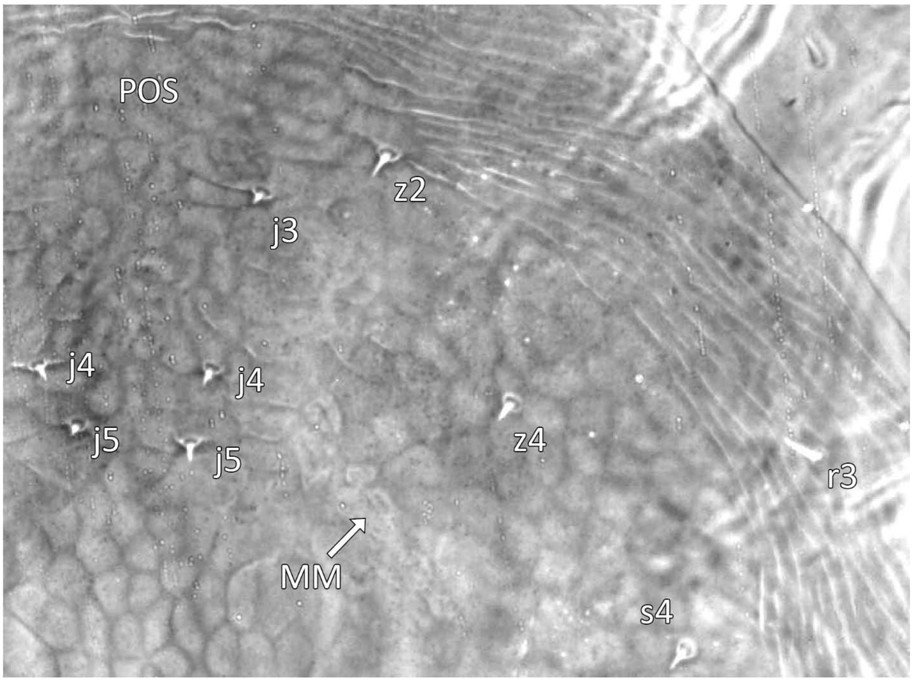

FIGURE 12: *Prasadiseius cocytes* (protonymph) — Dorsal view of anterior idiosoma (ID) showing right anterior podonotal shield (POS), muscle marks (MM, absent in larva), some podonotal setae (j3, j4, j5, z2, z4, s4), and r3 on soft integument. Note r3 longer than remaining setae (VP10-36-228, 400x).

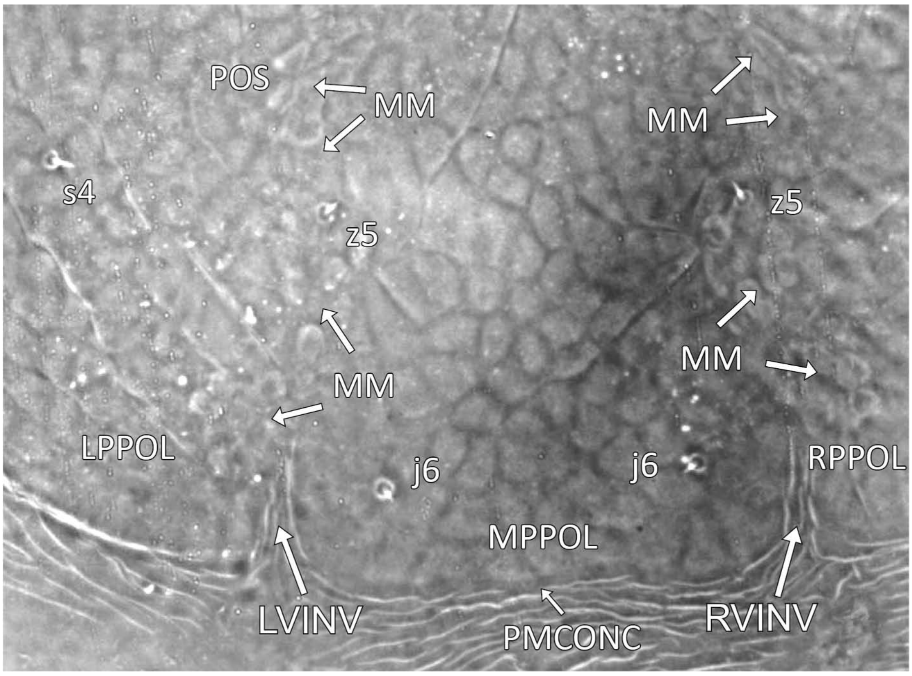

FIGURE 13: *Prasadiseius cocytes* (protonymph) — Dorsal view of mid idiosoma showing mid-posterior podonotal shield (POS) with left posterior podonotal lobe (LPPOL), middle posterior podonotal lobe (MPPOL), right posterior podonotal lobe (RPPOL), left vertical invagination (LVINV) in between LPPOL and MPPOL, right vertical invagination (RVINV) in between MPPOL and RPPOL, and some podonotal setae (j6, z5, s4). Note MPPOL having a small posteromedial concavity (PMCONC) and setae j6 in this area of the lobe (VP10-36-229, 400x).

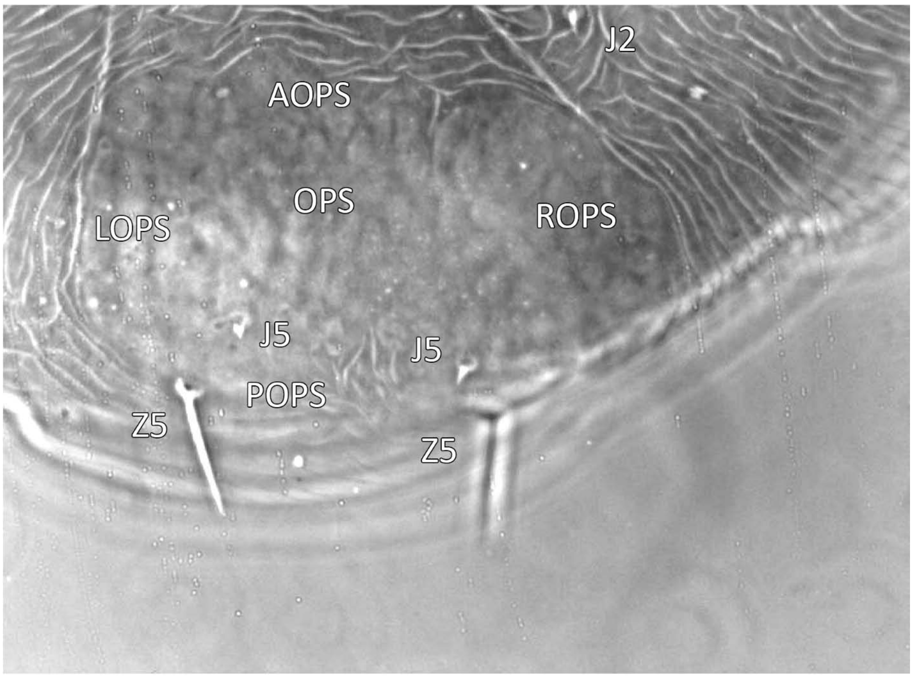

FIGURE 14: *Prasadiseius cocytes* (protonymph) — Dorsal view of posterior idiosoma (ID) showing opisthonotal shield (OPS) having concavity and convexities in anterior opisthonotal shield (AOPS), posterior opisthonotal shield (POPS), left opisthonotal shield (LOPS), and right opisthonotal shield (ROPS). Note minute right seta J2 on soft integument and setae J5 anteromedial to very long setae Z5 on opisthonotal shield (VP10-36-232, 400x).

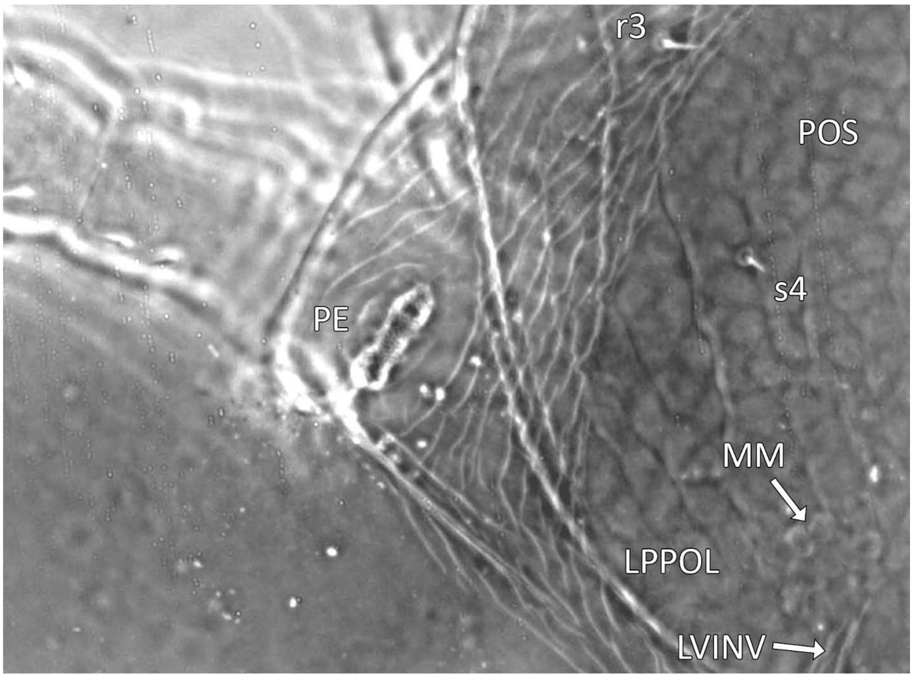

FIGURE 15: *Prasadiseius cocytes* (protonymph) — Dorsal view of left lateral idiosoma (ID) showing small left peritreme (PE) and part of left posterolateral podonotal shield (POS) with left posterior podonotal lobe (LPPOL) and s4. Note seta r3 on soft integument well anterior to the tip of peritreme and anterolateral to s4. Some part of left vertical invagination (LVINV) could also be seen (VP10-36-231, 400x).

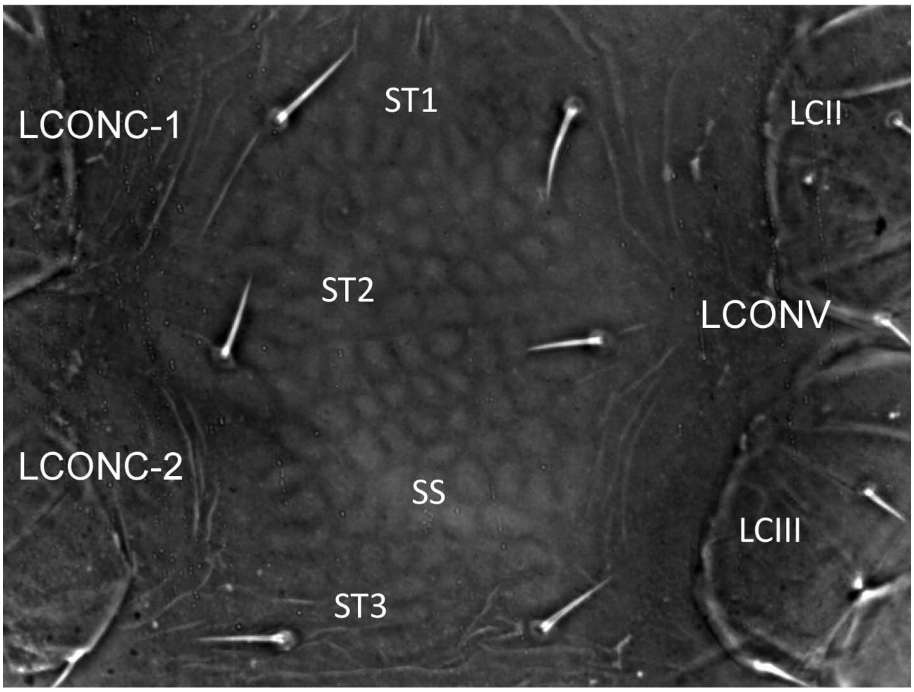

FIGURE 16: *Prasadiseius cocytes* (protonymph) — Ventral view of anterior idiosoma showing sternal shield (SS) in between left coxae II-III (LCII-LCIII) and right coxae II-III (barely seen) with setae ST1, ST2, and ST3 located marginally on the shield, anterior lateral concavity (LCONC-1) near coxa II (LCII) in between ST1-ST2, posterior lateral concavity (LCONC-2) near coxa III (LCIII) in between ST2-ST3, and lateral convexity (LCONV) in between LCII-LCIII near ST2 (VP10-36-234, 400x).

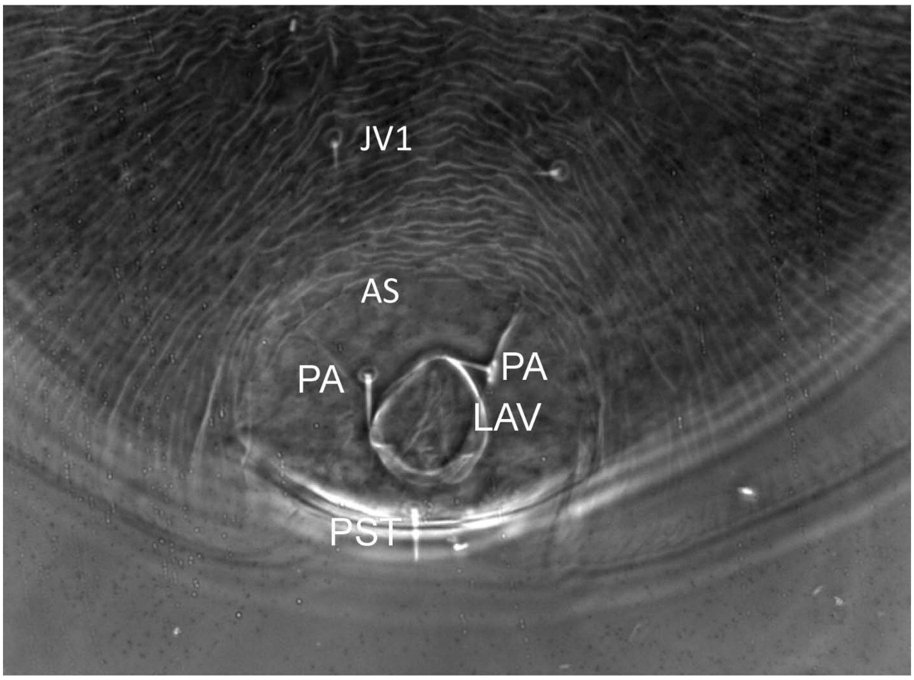

FIGURE 17: *Prasadiseius cocytes* (protonymph) — Ventral view of posterior opisthosoma (OP) showing anal shield (AS) with paraanal setae (PA), postanal seta (PST), lateral anal valves (LAV), and ventral setae JV1 on soft integument anterior to AS (VP10-36-224, 400x).

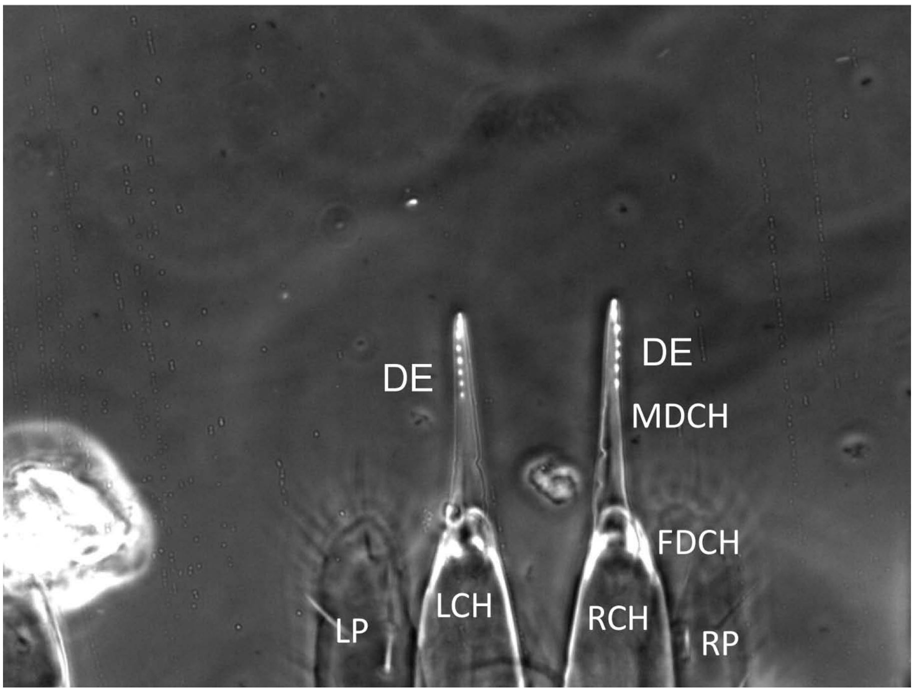

FIGURE 18: *Prasadiseius cocytes* (protonymph) — Dorsal view of gnathosoma (in part) with left chelicera (LCH), right chelicera (RCH), tiny fixed digit of chelicera (FDCH), elongate movable digit of chelicera (MDCH) with denticles (DE), left palp (LP), and right palp (RP). Note movable digit of chelicera much longer and having more denticles than shown for larva in Fig. 9 (VP10-36-206, 400x).

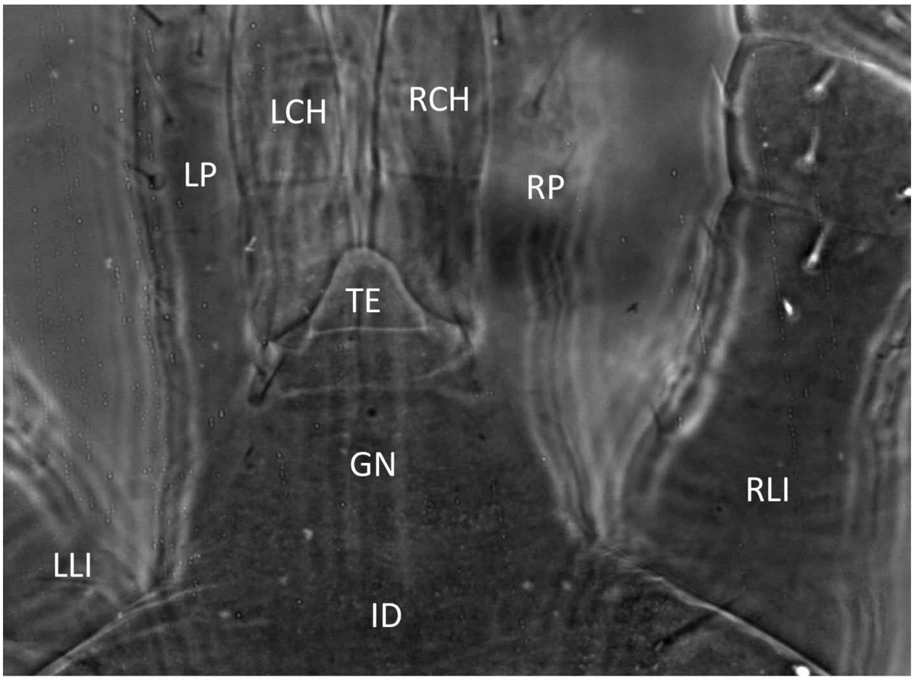

FIGURE 19: *Prasadiseius cocytes* (protonymph) — Midanterior dorsal idiosoma (ID) showing gnathosoma (GN) with tectum (TE), left palp (LP), right palp (RP), left chelicera (LCH), and right chelicera (RCH) in between left leg I (LLI) and right leg I (RL1). Note tectum being narrow anteriorly here than shown for larva in Fig. 8 (VP10-36-205, 400x).

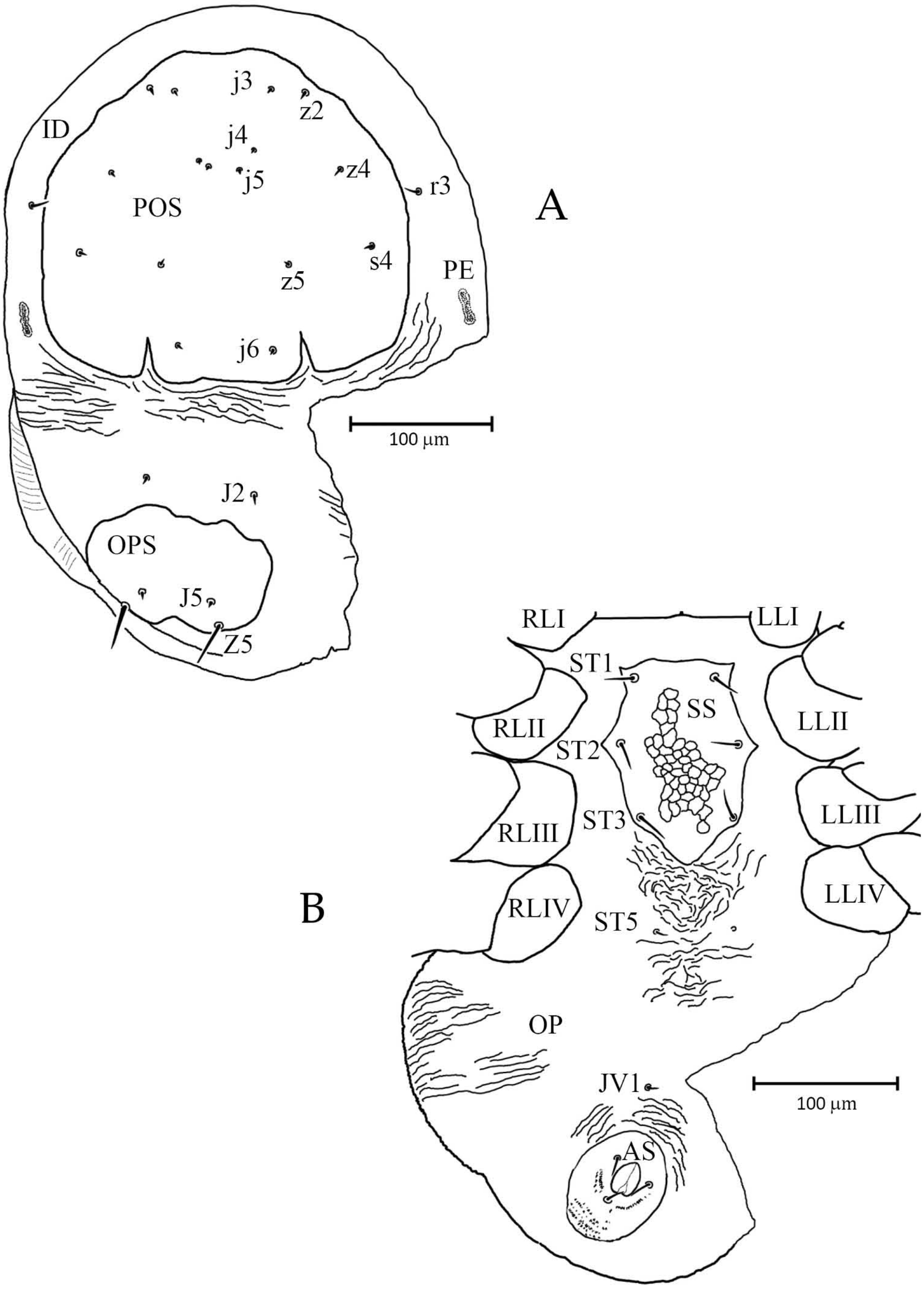

FIGURE 20: *Prasadiseius cocytes* (protonymph, line drawing): A – dorsal view; B – ventral view (both drawn from composite of Figs. 11 – 16 showing same abbreviations) (VP10-36).

between coxae IV and anal shield short, 7 – 12 (9) long. Anal shield (AS) (Figs. 17, 20B) located posteriorly, at terminal end of opisthosoma, 86 – 88 (87) long, 68 – 80 (75) wide, roughly round anteriorly and laterally. Three anal valves, two lateral and one posterior, similar to but larger than those in larva. Anterior paraanal setae (PA) = 14 – 22 (17) and postanal seta (PST) = 12 – 16 (15). Distance between PA-PA = 27 – 31 (29) and PA-PST = 30 – 38 (33).

Peritreme (Figs. 15, 20A) — Present near and lateral to fourth pair of coxae, 23 – 33 (29) long, shorter than in deutonymph (48).

Gnathosoma (Figs. 18, 19) — Palp length = 94 – 120 (104). Tectum small, round anteriorly (Fig. 19), larger and more elongate than in larva, 15 – 27 (19) long, 30 – 41 (34) wide. Fixed digit of chelicera small, reduced to a small protuberance, 10 – 13 (12) long. Similar to larva's, movable digit of chelicera elongate (Fig. 18), 45 – 55 (51), slightly longer (51) than in larva (47). Each movable digit with six to seven denticles or teeth. Hypostome with three pairs of well-developed hypostomal setae. Corniculi larger than in larva.

Legs — Leg I longer (325) than II (297) or III (295), latter two more or less of same length (297, 295). Leg IV slightly longer (303) than leg II or III but much shorter than leg I. Each tarsus with a pretarsus having two tiny claws and a pulvillus. Measurements of legs (from coxal base to tip of pretarsus): I = 307 – 363 (325), II = 270 – 311 (297), III = 271 – 319 (295), and IV = 308 – 322 (314).

Deutonymph (n = 5, Figs. 21-33)

Similar to protonymph in having 4 pairs of legs but body slightly larger than in former. Idiosoma 566 – 593 (578) long, 408 – 444 (418) wide.

Dorsum (Figs. 21-26, 33A) — Unlike larva or protonymph, podonotal shield fused with opisthonotal shield forming a single, T-shaped, dorsal shield covering almost entire vertical idiosoma (Fig. 33A).

Dorsal shield (Figs. 21-26, 33A) — Podonotal shield, part of anterior dorsal shield, similar to that of protonymph in having three posterior lobes divided by left and right vertical invaginations. However, middle lobe extending posteriorly and fusing with anterior opisthonotal shield through a roughly rectangular connecting shield (Figs. 25, 26, 33A) forming T-shaped dorsal shield, an excellent morphological feature to identify deutonymph. Left and right lateral margins of connecting shield, with a short, transverse anterolateral invagination, 8 – 20 long, present posteriorly to the end of the middle podonotal lobe. A posterolateral invagination present at the end of the connecting shield posterior to J2 and anterior to the opisthonotal shield (Figs. 25, 26). Connecting shield with small, irregular, lateral concavities and convexities (Fig. 33A). Polygon-like reticulation pattern on shield more pronounced than in larva or protonymph. Entire dorsal shield (with podonotal, opisthonotal and connecting shield) 445 – 468 (459) long, 266 – 312 (292) wide. Podonotal shield part of dorsal shield 242 – 278 (265) long, 266 – 312 (292) wide. Width of left lobe = 65 – 84 (75), middle lobe = 120 – 146 (136), and right lobe = 71 – 80 (77). Length of left vertical invagination = 32 – 40 (36), right vertical invagination = 34 – 36 (35). Anterior and posterior lateral invaginations between middle podonotal lobe and connecting shield and opisthonotal and connecting shield 8 – 20 (16) long. Opisthonotal shield (Fig. 26) 75 – 94 (86) long, 162 – 178 (171) wide. Connecting shield (Fig. 25) 96 – 123 (108) long, 139 – 156 (145) wide.

Podonotal setae (Figs. 21-26, 33A) — All 8 pairs of podonotal setae (j3, j4, j5, j6, z2, z4, z5, s4), present on the separate podonotal shield of larva and protonymph, also present in deutonymph but on the anterior T-shaped dorsal shield. In addition, seta r3, similar to protonymph's, present on integument beside podonotal shield lateral to z4 and s4 (Fig. 21). Seta r5, 12 – 14 (13), considered to be a variable seta, present in two specimens (Fig. 33A). Most dorsal podosomal setae, similar to those of protonymph, very tiny, less than 10 long. Setae j5, j6 and z5 form a hexagonal Fig., as in larva and protonymph (and adult). Seta z2 may be located in line with, anterior or posterior to j3.

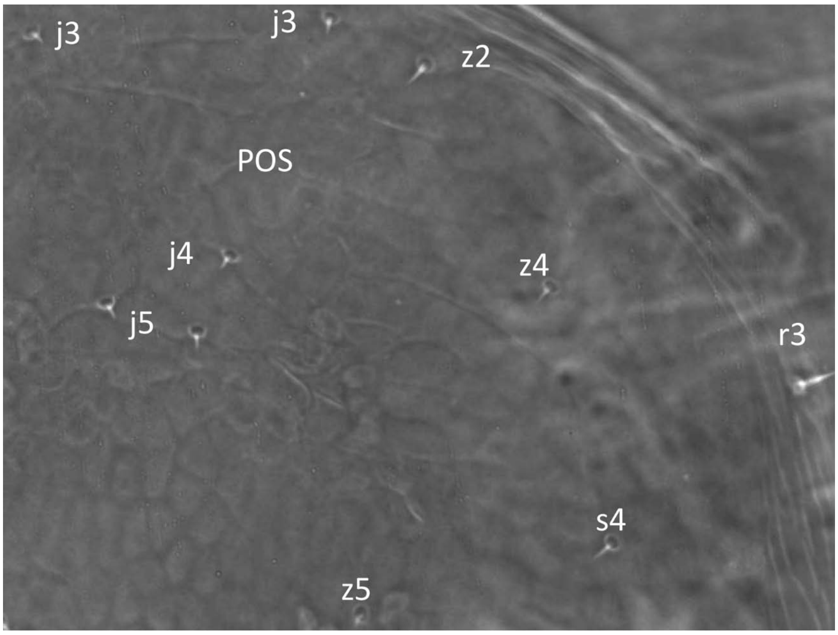

FIGURE 21: *Prasadiseius cocytes* (deutonymph) — Dorsal view of anterior idiosoma (ID) showing right anterior podonotal shield (POS) with muscle marks (MM), some podonotal setae (j3, j4, missing on left, j5, z2, z4, z5, s4) and moderately long r3 on soft integument (VP10-36-51, 400x).

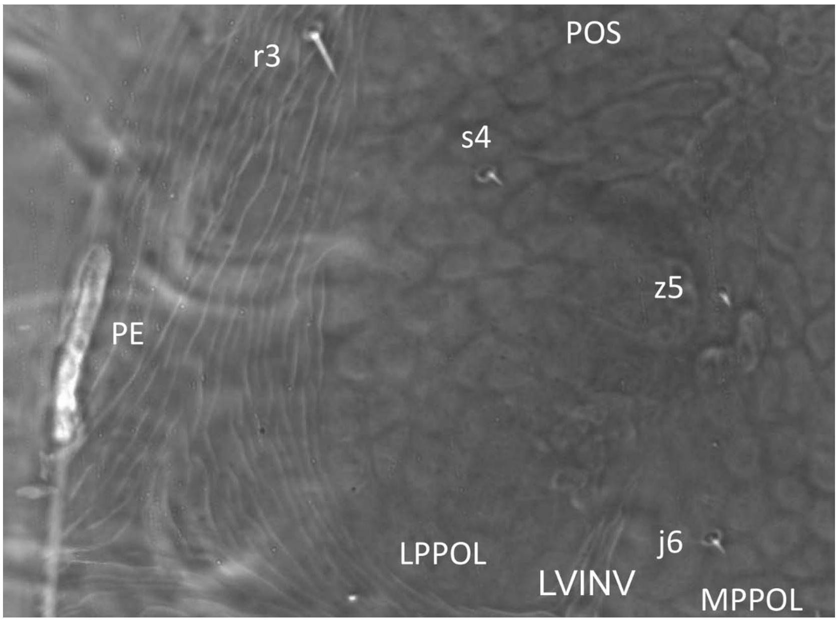

FIGURE 22: *Prasadiseius cocytes* (deutonymph) — Dorsal view of left lateral idiosoma (ID) showing left peritreme (PE) and part of left posterolateral podonotal shield (POS) with left posterior podonotal lobe (LPPOL), middle posterior podonotal lobe (MPPOL), left vertical invagination (LVINV) in between LPPOL and MPPOL, and j6, z5, s4. Note seta r3 on soft integument well anterior to the tip of peritreme and anterolateral to s4. Note also much larger peritreme and r3 than shown for protonymph in Fig. 14 (VP10-36-49, 400x).

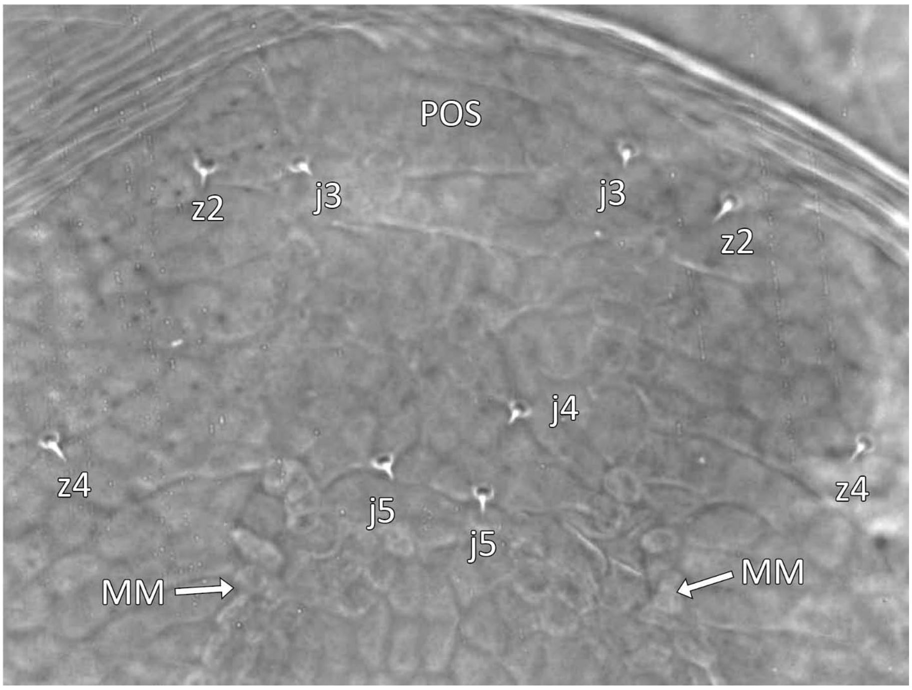

FIGURE 23: *Prasadiseius cocytes* (deutonymph) — Dorsal view of anterior idiosoma (ID) showing mid anterior podonotal shield (POS), muscle marks (MM), and some setae (j3, j4, missing on left, j5, z2, z4) (VP10-36-43, 400x).

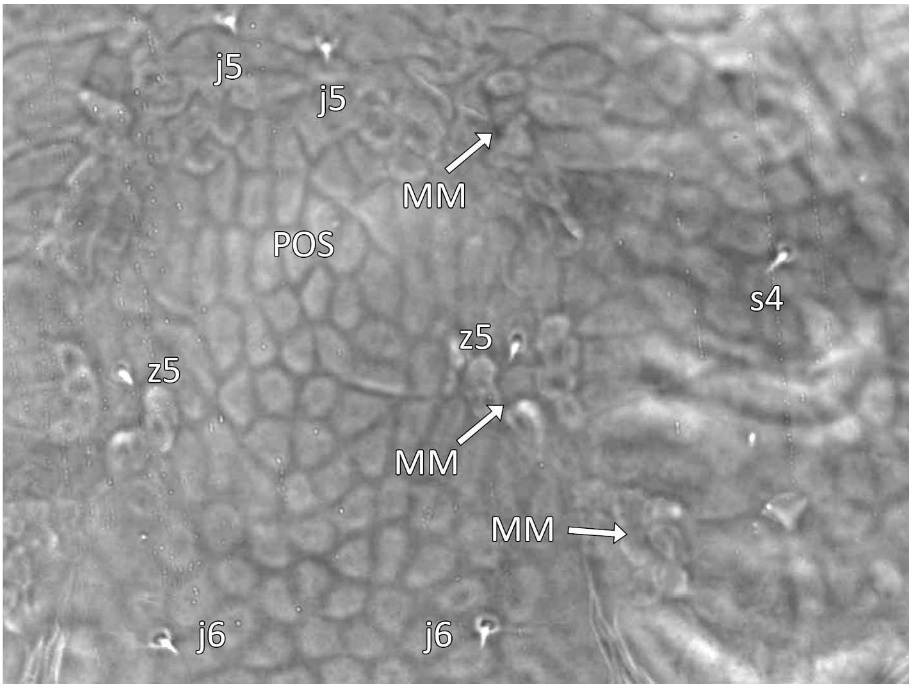

FIGURE 24: *Prasadiseius cocytes* (deutonymph) — Dorsal view of mid anterior podonotal shield (POS) showing muscle marks (MM) and some setae located posterior to j4 and z4 (j5, j6, z5, s4) (VP10-36-46, 400x).

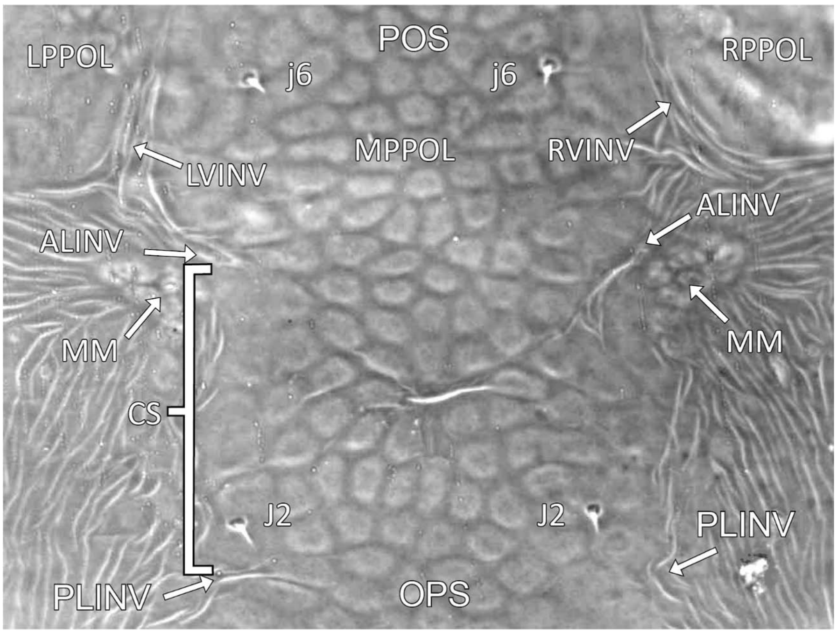

FIGURE 25: *Prasadiseius cocytes* (deutonymph) — Dorsal view of mid idiosoma (ID) showing podonotal shield (POS) having left posterior podonotal lobe (LPPOL), middle posterior podonotal lobe (MPPOL), right posterior podonotal lobe (RPPOL), left vertical invagination (LVINV) in between LPPOL and MPPOL, right vertical invagination (RVINV) in between MPPOL and RPPOL, and podonotal setae j6. Note a unique, roughly rectangular, connecting shield (CS), not present in larva or protonymph but present here in deutonymph, making connection in the podonotal shield (POS) and opisthonotal shield (OPS) with posterior MPPOL and anterior medial opisthonotal shield (AOPS, see Fig.13 to compare). Note also a short, roughly transverse, anterolateral invagination (ALINV) and another, similar, posterolateral invagination (PLINV) on left and right connecting shield. Note also the presence of setae J2 on posterior part of this connecting shield located close but to anterior part of OPS and posterior part of CS (VP10-36-47, 400x).

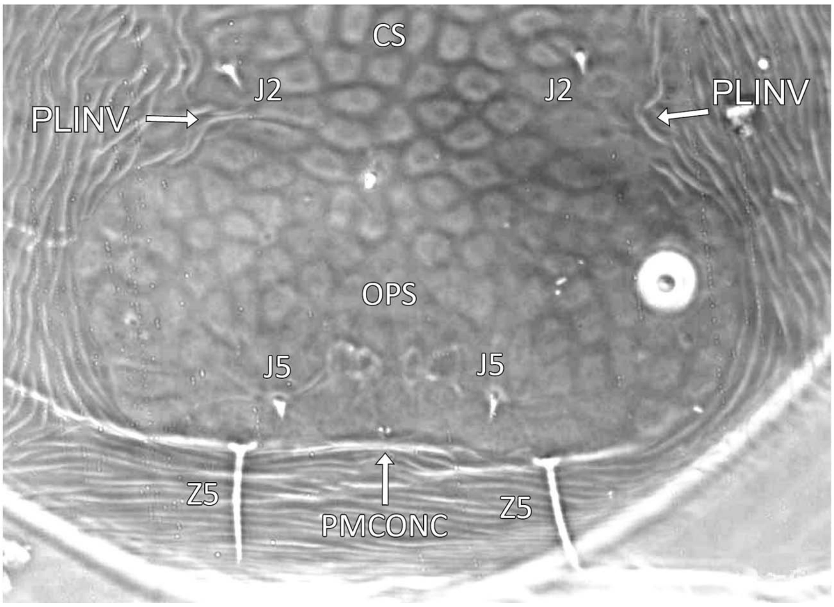

FIGURE 26: *Prasadiseius cocytes* (deutonymph) — Dorsal view of posterior idiosoma showing entire opisthonotal shield (OPS) and posterior part of connecting shield (CS), and some setae (J5, Z5) located posterior to J2. Note short posterolateral invagination (PLINV) posterior to J2, tiny J5 and very long Z5 located at mid-posterior end of OPS. A shallow posteromedial concavity (PMCONC) is also present in between Z5 (VP10-36-50, 400x).

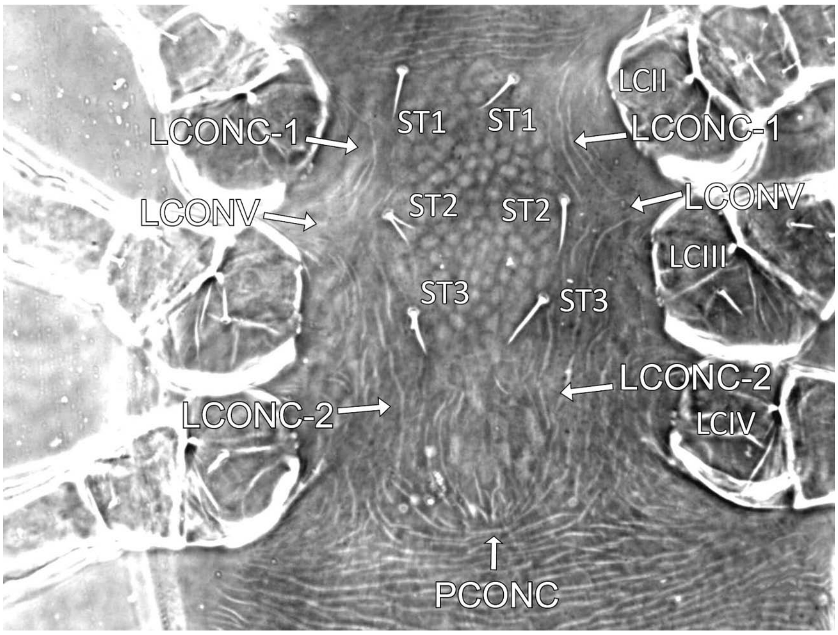

FIGURE 27: *Prasadiseius cocytes* (deutonymph) — Ventral view showing, in part, posterior three pairs of right legs, left coxae II-IV (LCII-LCIV, anterior first pair not seen) and sternal shield (SS) with setae ST1-ST3 (ST5 not visible). Note sternal shield with lateral concavity anteriorly (LCONC-1) near coxa II in between ST1-ST2 and another (LCONC-2) near coxa IV posterior to ST3. In addition, note a pronounced lateral convexity on each side (LCONV) in between LCII-LCIII and near ST2. A shallow posteromedial concavity (PCONC) could also be seen at the posterior end of SS. Distance between bases of ST2-ST2 much more than in between ST1-ST1 or ST3-ST3. Also, the distance between bases of ST1-ST2 is much larger than in between ST2-ST3 (VP10-36-10, 200x).

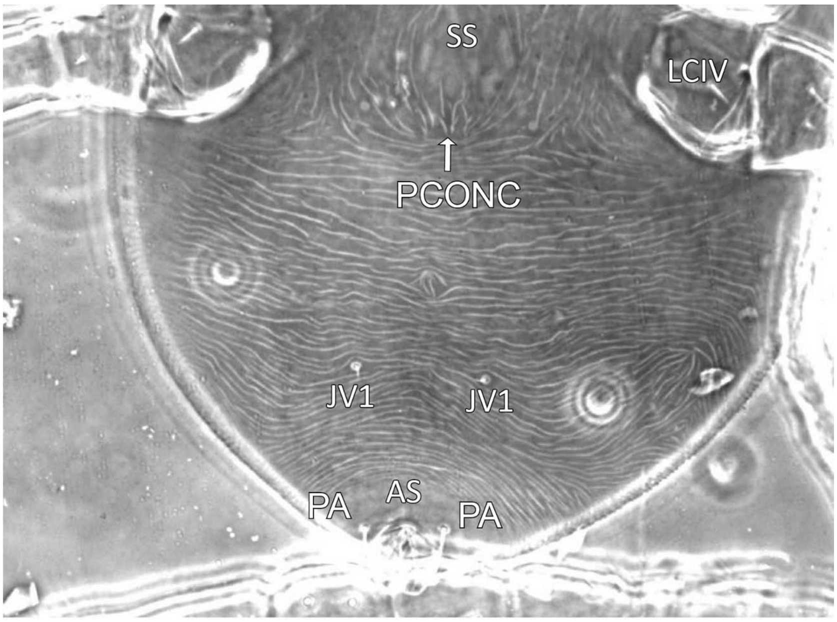

FIGURE 28: *Prasadiseius cocytes* (deutonymph) — Ventral view showing posterior sternal shield (SS), part of legs IV (LCIV), and anal shield (AS) with paraanal setae (PA). Posteromedial concavity (PCONC) could also be seen at the posterior end of SS. Setae JV1 are present on the integument (VP10-36-11, 200x).

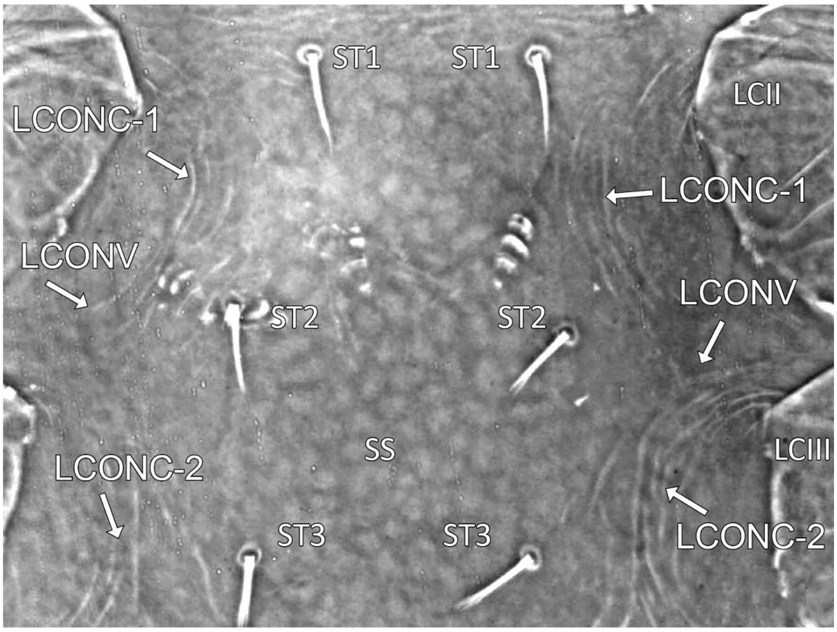

FIGURE 29: *Prasadiseius cocytes* (deutonymph) — Ventral view showing sternal shield (SS) in between coxae II-III (LCII-III and RCII-RCIII) and setae ST1-ST3, lateral concavity anteriorly (LCONC-1) in between ST1-ST2, other (LCONC-2) posterior to ST3, and a lateral convexity (LCONV) near ST2 (VP10-36-15, 400x).

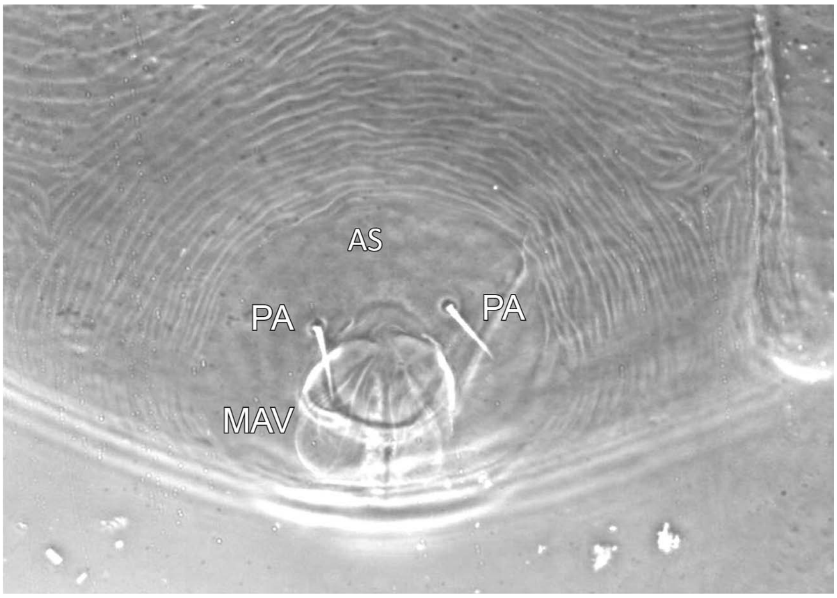

FIGURE 30: *Prasadiseius cocytes* (deutonymph) — Ventral view of posterior opisthosoma (OP) showing anal shield (AS) and pair of paraanal setae (PA), and membranous anal valves (MAV) (VP10-36-14, 400x).

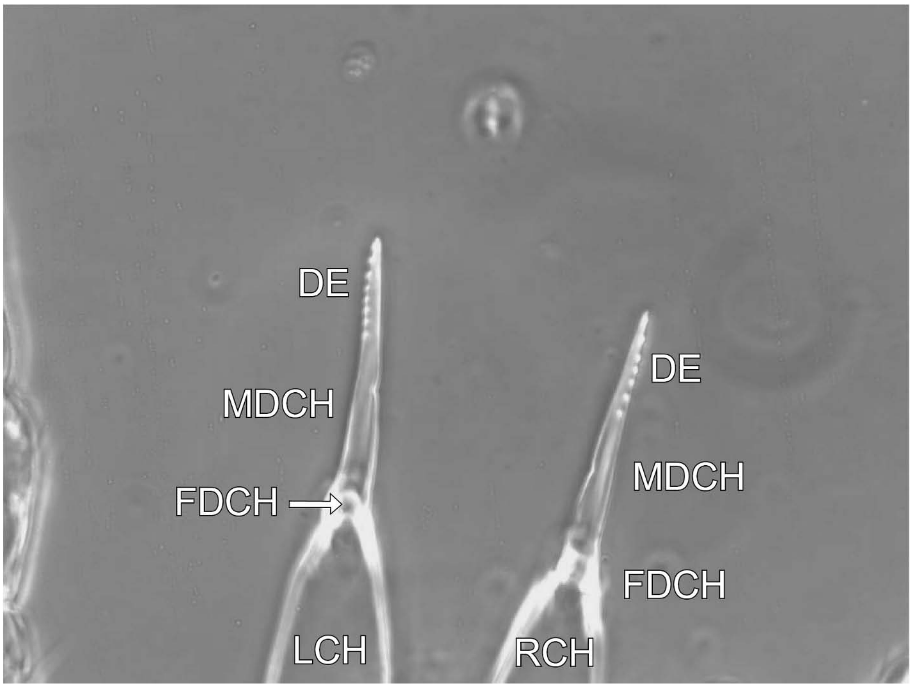

FIGURE 31: *Prasadiseius cocytes* (deutonymph) — Part of dorsal gnathosomal structures showing left chelicera (LCH), right chelicera (RCH), tiny fixed digit of chelicera (FDCH) and elongate movable digit of chelicera (MDCH) with denticles (DE). Note longer movable digit with more denticles than in protonymph (Fig. 17) (VP10-36-31, 400x).

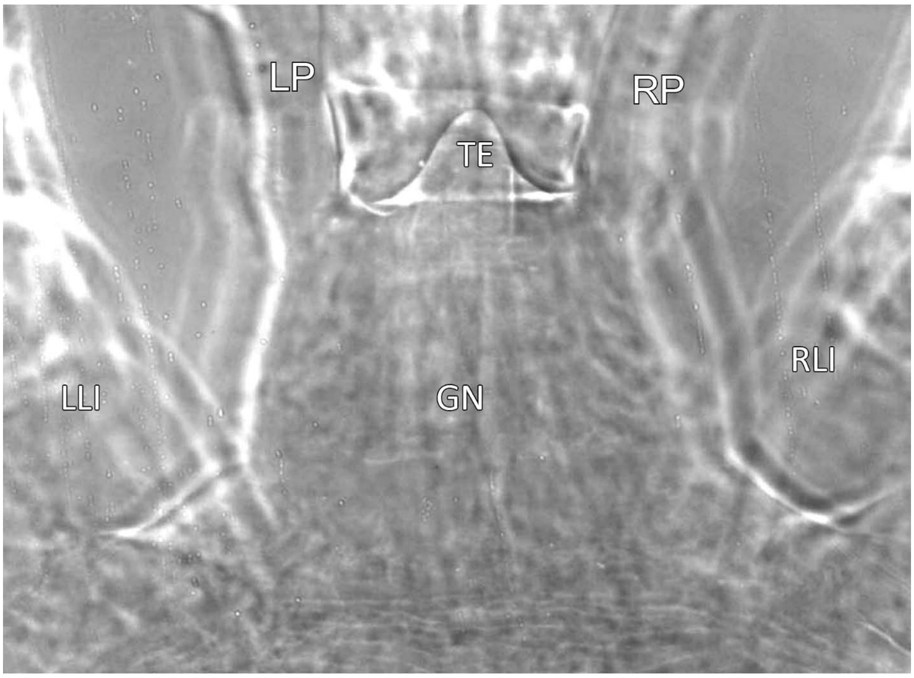

FIGURE 32: *Prasadiseius cocytes* (deutonymph) — Dorsal view of gnathosoma, in part, showing tectum (TE), left palp (LP), right palp (RP) in between left leg I (LLI) and right leg I (RLI). Note much more narrow and more elongated tectum in deutonymph than in protonymph shown in Fig.18 (VP10-36-27, 400x).

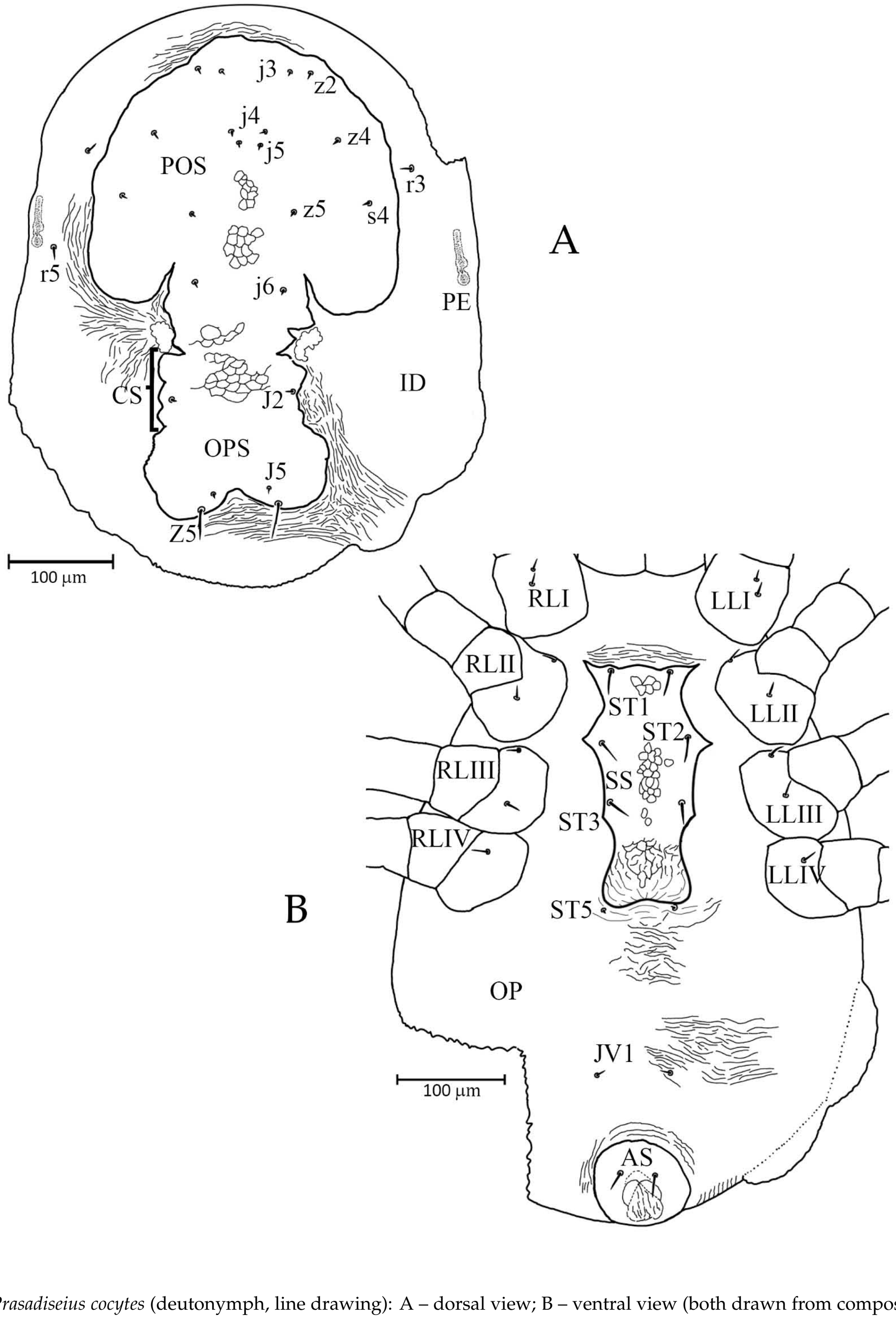

FIGURE 33: *Prasadiseius cocytes* (deutonymph, line drawing): A – dorsal view; B – ventral view (both drawn from composite of Figs. 19 – 28 showing same abbreviations) (VP10-36).

Setal measurements: j3 = 5 – 6 (6), j4 = 5 – 6 (6), j5 = 5 – 6 (6), j6 = 5 – 7 (6), z2 = 5 – 8 (7), z4 = 6 – 8 (7), z5 = 5 – 7 (6), s4 = 6 – 8 (7), r3 = 10 – 15 (13) and r5 = 13 – 17 (15). Thus, setae j4, j5, j6, and z5 smallest of all podonotal setae. Distance between setal pairs: j3-j3 = 63 – 76 (70), j4-j4 = 33 – 52 (40), j5-j5 = 19 – 33 (28), j6-j6 = 70 – 85 (78), z2-z2 = 106 – 118 (111), z4-z4 = 172 – 184 (177), z5-z5 = 86 – 104 (95), and s4-s4 = 211 – 238 (220). Vertical distance between setal bases: j3-j4 = 57 – 62 (59), j4-j5 = 11 – 22 (17), j5-j6 = 135 – 142 (138), j3-z2 = 20 – 25 (22), j3-z5 = 130 – 146 (138), j5-z5 = 73 – 80 (76), J5-Z5 = 15 – 22 (19), j6-z5 = 67 – 71 (69), j6-s4 = 110 – 114 (112), z2-z4 = 60 – 74 (68), z4-z5 = 90 – 94 (92), z4-s4 = 63 – 78 (72), and z5-s4 = 60 – 79 (68).

Opisthonotal setae (Figs. 25, 26, 33A) — Instead of being on soft integument as in protonymph, seta J2 present in the posterior part of connecting shield (Fig. 25, 33A). In addition, two pairs of opisthonotal setae (J5 and Z5), present on their normal position at the end of the small opisthonotal shield (Figs. 26, 33A). Thus, 11 pairs of dorsal setae present on single T-shaped dorsal shield and one pair (r3) present in normal position on soft integument (total: 12 pairs on dorsal idiosoma). Seta Z5 the longest of all dorsal idiosomal setae and with fine serrations. Setal measurements: J2 = 5 – 8 (7), J5 = 5 – 6 (5), Z5 = 33 – 36 (34). Distance between setal pairs: J2-J2 = 83 – 113 (94), J5-J5 = 44 – 54 (50), Z5-Z5 = 55 – 78 (70). Vertical distance between setal bases: j6-J2 = 94 – 114 (106), J2-J5 = 84 – 98 (92), and J2-Z5 = 94 – 110 (104),

Venter (Figs. 27-30, 33B) — Sternal shield as in protonymph, but more sclerotized, 236 – 250 (243) long, 117 – 130 (123) wide near ST2, located mostly in between coxae II-IV (Figs. 27, 28, 33B), with one lateral concavity on each side in between ST1-ST2 near coxa II , another lateral concavity on each side posterior to ST3 in between coxae III- IV, and one lateral convexity near ST2 (Fig. 27). It elongates posteriorly to ST3, widening bilaterally near the apex. Anterior two-thirds of sternal shield between ST1-ST1 and ST3-ST3 with polygonal reticulation pattern, while lacking it in posterior one-third posteriorly to ST3. Setae ST1, ST2 and ST3 finely serrate, longer (23, 24, 26) than in protonymph (20, 19, 23). Distance between ST1-ST1 shorter (55) than ST2-ST2 (87) or ST3-ST3 (70). Distance between ST1-ST2 longer (70) than between ST2-ST3 (49). Measurements of different setae: ST1 (may be missing on one side) = 20 – 26 (23), ST2 = 20 – 27 (24), and ST3 = 23 – 28 (26), respectively. Seta ST5 (absent on one side in one specimen) = 4 – 19 (12), on soft integument. Distance between setal pairs: ST1-ST1= 50 – 60 (55), ST2-ST2 = 70 – 96 (87), ST3-ST3 = 60 – 81 (70), ST5-ST5 = 53 – 66 (60). Distance between other setal pairs: ST1-ST2 = 60 – 76 (70), ST2-ST3 = 43 – 55 (49), ST3-ST5 = 94 – 114 (103) and ST5-JV1 = 118 – 141 (130). Vertical distance between ST1-ST3 = 110 – 120 (116) and diagonal distance between ST1-ST3 = 124 – 130 (127). Seta JV1 = 8 – 12 (10), as in larva and protonymph, located on soft integument posteriorly to ST5 and anteriorly to anal shield. Anal shield 88 – 92 (90) long, 82 – 98 (92) wide, located at terminal end of opisthosoma, three anal setae (PA, PST) similar to but longer than in protonymph (Fig. 30); PA = 20 – 22 (21), PST = 16 – 20 (18); PA-PA = 30 – 40 (36) and PA-PST = 36 – 43 (40).

Peritreme (Figs. 22, 33A) — Similar to, but longer (48) than in protonymph (29), length = 38 – 55 (48).

Gnathosoma (Figs. 31, 32) — Similar to protonymph but structures with different measurements. Palp 100 – 121 (110) long. Tectum round anteriorly (Fig. 32), longer (25) and more elongate than in protonymph (19), 20 – 30 (25) long, 45 – 58 (50) wide. Chelicerae similar but larger than in protonymph. Fixed digit small and reduced to a small protuberance, 14 – 16 (15) long. Similar to protonymph, movable digit of chelicera elongate but longer (64) than in protonymph (51), 56 – 66 (64) long. Each movable digit with seven to eight denticles or teeth (Fig. 31), which is more than in protonymph. Hypostome with three pairs of well-developed hypostomal setae. Corniculi larger than in protonymph.

Legs — Leg I (415) longest followed by Leg IV (402), Leg II (386) and Leg III (382). Each tarsus with a pretarsus having two tiny claws and a pulvillus. Measurements of legs (from coxal base to tip of pretarsus): I = 403 – 452 (415), II = 374 – 395 (386), III = 368 – 398 (382), and IV = 372 – 426 (402).

Remarks — In a few cases, a developing protonymph inside a larva (Fig. 5), a developing deutonymph inside a protonymph, and a developing adult inside a deutonymph was seen

Discussion

1. Seta r3 – This fixed seta in *P. cocytes* is present in its usual position on the soft integument of podonotal region beside podonotal shield and z4 and s4 in protonymph and deutonymph. It is absent in larva. The presence of this seta in protonymph and deutonymph and its absence in larva of *N. treati* Prasad, 1968, an otopheidomenine species, was reported (Prasad, 2011c, p 181). It was not drawn in motile immature stages of *O. zalelestes* by Treat (1955, 1975).

2. Seta r5 – Presence of this variable seta on the lateral integument beside the podonotal shield in between setae s4 and j6 (Fig. 33A) has been reported in the present study in some protonymphs and deutonymphs but not in larvae. Prasad (2011e) reported this presence in some adults of *P. cocytes* in similar position in the podonotal region. The question was: is this seta, which is similar to some otopheidomenid and phytoseiid mites' seta, R1 (located in opisthonotal region posterior to j6)? I believe it is to be r5 but a study on more immature stages of different species of *Prasadiseius* and *Otopheidomenis* is necessary before changing this conclusion.

3. Seta R1, a variable seta located in opisthonotal region on lateral integument beside opisthonotal shield laterally and in between s6 and S2 or Z1 in most Phytoseiidae, was not found in the present study. It is not reported in *N. treati* by Prasad (2011e, p 181) or drawn in *O. zalelestes* by Treat (1955, 1975) either. However, seta s6 shown in the protonymph and deutonymph in *N. treati* could be r5 or, preferably, R1.

4. Pores, poroids, and solenostomes, present on the dorsal and ventral shields in the phytoseiids, are not reported by this or other authors in *Prasadiseius* spp. Lindquist (2011, pers. comm.) believes these to be present in the otopheidomenids and suggests that they be studied and denoted in illustrations. Solenostomes and gland pores are very similar in structure but they differ notably from lyrifissures (poroids) in their form and function. These for Gamasina are discussed in detail by Alberti and Coons (1999) and need to be studied in future in the otopheidomenids.

Conclusion

Prior to the present study, details of morphology in the motile immature stages of *P. cocytes*, representing Otopheidomeninae, was not known. Finding of T-shaped dorsal shield in the deutonymph, with most dorsal and ventral idiosomal setae similar to the adults, was significant. At this time, it is not known if other species of Otopheidomenidae have similar or different morphological structures and how they resemble with those of motile immature stages of Phytoseiidae. It would be interesting to study immature stages of other otopheidomenid species in future and compare them with each other and with those of Phytoseiidae to establish the evolutionary and/or phylogenetic relationships.

Key for the identification of larva, protonymph, and deutonymph of *P. cocyteses*

1. With three pairs of legs, peritreme absent . . Larva
— With four pairs of legs, peritreme present 2

2. Both podonotal and opisthonotal shields separate from each other (Figs. 13, 14, 20A), setae J2 on soft integument, peritreme short (Figs. 15, 20A). . . . .
. . . . Protonymph
— Both podonotal and opisthonotal shields fused with each other by a rectangular connecting shield forming a T-shaped dorsal shield (Figs. 25, 26, 33A), setae J2 not on soft integument but rather on dorsal shield, peritreme longer than above (Fig. 22)... . . . . .
. . . . Deutotonymph

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