



***Philippinozercon*, a new genus of Heterozerconidae (Parasitiformes: Mesostigmata), with description of all active instars**

BEVERLY S. GERDEMAN¹, RUFINO C. GARCIA², ANDREW HERCZAK³ & HANS KLOMPEN⁴

¹ Washington State University NWREC, 16650 State Route 536, Mount Vernon, Washington 98273-4768, U.S.A. E-mail: bgerdeman@wsu.edu

² Ecology Laboratory, Crop Protection Cluster, College of Agriculture and Museum of Natural History, University of the Philippines Los Baños, College, Laguna, Philippines. E-mail prostigman7@hotmail.com

³ Undergraduate Biology Program, Ohio State University, Columbus, Ohio, U.S.A. E-mail: herczak.1@buckeyemail.osu.edu

⁴ Ohio State University, 1315 Kinnear Rd., Columbus, Ohio 43212, U.S.A. E-mail: klompen.1@osu.edu

Abstract

The generic classification of millipede associated Heterozerconidae in the Oriental region is revised. The genus *Allozercon* Vitzthum is re-diagnosed and *Asioheterozercon* Fain is designated as a subjective junior synonym of *Allozercon*. *Philippinozercon* gen. nov., with the type species *P. makilingensis* sp. nov., is described for all instars. This genus may be endemic for the Philippines, but is quite widespread in that country. All immature instars are described, making this the second species of Heterozerconidae known for all instars. The morphology of the immatures is compared with that of immatures of the temperate species *Narceoheterozercon ohioensis* and unnamed species from Brazil and Thailand. All immatures were collected from millipede frass and litter, never from millipedes. Adults are associated with millipedes in the family Trigonulidae (Spirobolida).

Key words: heteromorphic development, Diplopoda, Oriental region, classification

Introduction

Heterozerconidae are primarily associates of large millipedes with the exception of adults of *Amheterozercon* Fain which are parasitic on snakes or worm lizards (Amphisbaenidae). The family has been reported from the Neotropical, Afrotropical, Oriental, and Nearctic faunal regions (so far not from the Palearctic or Australian faunal regions) and may be quite diverse, but the total number of described species (20) is still quite small.

The most poorly documented fauna of Heterozerconidae today is the Oriental one, even though some of the earliest descriptions of Heterozerconidae concerned specimens from this region: *Heterozercon audax* Berlese from “*Scolopendra*” and “*Spirostreptus*” spp. from Java (Berlese, 1910) (the record from *Scolopendra* is suspect because Heterozerconidae are otherwise never found associated with centipedes. It may be a contaminant or a transcription error), *Heterozercon elapsus* Vitzthum from *Thyropygus* sp. (Spirostreptidae) from Sumatra (Vitzthum, 1926), and *Allozercon fecundissimus* Vitzthum from litter in Java (Vitzthum, 1926). Vitzthum (1925) subsequently synonymized *H. elapsus* with *H. audax*, although Fain (1989) suggested that *H. elapsus* might be valid. Finally, Fain (1989) created a new genus, *Asioheterozercon* Fain, for *H. audax*, but did not appear to have considered *Allozercon* Vitzthum as an available generic name.

Heterozerconidae are relatively common on large millipedes in the Oriental region, with specimens of numerous species collected in mainland S.E. Asia, Indonesia, and especially the Philippines. Most of these agree broadly with the generic concept of *Allozercon*, but some specimens from the Philippines are strikingly different. Specimens of this type were collected from Luzon, Leyte, Negros, Panay, and Samar islands (with the exception of Luzon, all of these islands are in the central Visayas region of the country). These specimens are all highly similar, although specimens from Negros island may represent a second species. The biology of these mites has been discussed by Gerdeman and Garcia (2009) who referred to this species as *Allozercon* sp.

A second issue concerns immatures. Nearly all studies on Heterozerconidae have been restricted to adults,

which are often found on their hosts. Immatures generally occur off-host, are less easy to collect, and, perhaps most importantly, are heteromorphic relative to adults. Immatures have been described for only two species, one named, *Narceoheterozercon ohioensis* Gerdeman & Klompen (Gerdeman & Klompen, 2003), the other, known for nymphs only, was not named (Krantz & De Moraes, 2011).

The goal of this study is to provide an updated diagnosis of *Allozercon* and a description of a new genus for the divergent Philippine specimens. The new genus is based on the species from Luzon island, which was previously discussed by Gerdeman and Garcia (2009). Inclusion of data on the immatures of this species also allows some comparative observations for immature Heterozerconidae.

Material and Methods

All specimens were collected by BSG and RCG in 2000, and RCG in 2001. They were studied as both temporary mounts in cavity slides and permanent slide mounts in Hoyer's medium (Walter & Krantz 2009). For more detailed study, adult specimens were dissected, with the gnathosoma and chelicera under one coverslip, the split dorsum and venter under another. Specimens were studied using Nikon Eclipse 90i and Zeiss Axioskop compound microscopes equipped with, respectively, DIC and phase contrast illumination. The structure of the spermatodactyl was imaged using a Nikon FV3000 confocal laser scanning microscope at the Ohio State University Campus Microscopy & Imaging Facility. Specimens were imaged employing the automatic Z-stack feature in the NIS-Elements microscope imaging software (Nikon Instruments Inc., Melville, NY). Digital drawings were prepared in Adobe Illustrator CC (Adobe Systems Inc., San Jose, CA), using a Wacom Cintiq 21UX (Wacom, Vancouver, WA) drawing tablet, with stacked images as templates.

Terminology for the palp sensilla follows Evans (1963b) and for the legs Evans (1963a), both as modified by Gerdeman & Klompen (2003). Measurements were taken using NIS-Elements, are presented in micrometers (μm), and are summarized in Table 1.

Specimen depository abbreviations: UPLB: arthropod collection of the University of the Philippines at Los Baños, the Philippines; FMNH: Field Museum of Natural History, Chicago U.S.A.; OSAL: Ohio State University Acarology Collection, Columbus, U.S.A.

TABLE 1. *Philippinozercon makilingensis* sp. nov. comparative measurements for the active instars.

	L (N=2)		PN (N=4)		DN (N=5)		M (N=4)		F (N=3)	
	Av.	SD	Av.	SD	Av.	SD	Av.	SD	Av.	SD
chelicera, length fixed digit	104	1	127	2	175	3			110	3
---, length movable digit	50	1	65	4	88	4	121	4	108	4
palp, total length	269	15	337	26	471	17	217	21	237	1
---, width at femur	32	3	33	4	35	4	45	8	55	2
---, length/width ratio	9	1	10	0	14	2	5	1	4	0
idiosoma, length	378	4	387	32	647	40	761	27	775	70
---, width	347	3	384	23	567	28	695	14	701	4
setal bundle, longest seta / Z5	288	13	239	28	293	39	89	NA		
long anterior seta (LAS)			158	27	275	49	9	2	9	1
short anterior seta (SAS)			54	12	74	4				
seta <i>stl</i>	64	1	58	1	82	4	22	3	38	1
seta <i>pa</i>	87	5	85	5	80	10	46	4	51	10
seta <i>po</i>	156	10	34	3	40	2	16	3	16	1
sucker cavity, max. width							164	8	170	3

.....continued on the next page

TABLE 1. (Continued)

	L (N=2)		PN (N=4)		DN (N=5)		M (N=4)		F (N=3)	
leg I, length	568	20	719	6	1022	28	996	39	1065	37
leg II, length	323	6	405	16	560	22	548	14	609	50
leg III, length	342	8	399	24	575	41	549	22	614	36
leg IV, length			435	54	616	20	578	37	706	23
femur I, seta <i>al1</i>							88	7	53	1
---, seta <i>v1</i>							104	7	117	3
---, seta <i>al2</i>							79	11	104	4
---, seta <i>v2</i>							55	6	42	2
genu I, <i>ad1</i> (L), <i>al1</i> (PN, DN)	154	8	227	36	286	35	116	1	136	6
---, <i>pl1</i>	219	22	320	10	344	57				
---, <i>av1</i>	236	21	248	18	344	40				
tibia I, <i>av1</i> (L), <i>al1</i> (PN, DN)	292	4	318	14	403	27				
tarsus I, median long seta	292	51	313	19	390	20				
---, distal long seta	170	NA	168	4	227	17				

Av.: Average; SD: Standard deviation; NA: not applicable, only 1 specimen measured

Taxonomic section

Heterozzerconidae Berlese 1892

Allozercon Vitzthum 1926

Allozercon Vitzthum 1926: 104

Asioheterozzercon Fain 1989: 146; syn. nov.

Type species: *Allozercon fecundissimus* Vitzthum 1926, by monotypy.

Updated diagnosis (based on adults). With the following combination of characters: adults lacking spine-like setae latero-ventrally on the idiosoma; metapodal shields with rounded postero-lateral margins; setae *Jv5* inserted posterior to the fusion line of the ventral and anal shields; with one pair of greatly elongated setae inserted on the postero-marginal shield. Females with sternal setae *st2* and *st3* inserted on soft cuticle; lacking a strip-like sclerite between the geniti-ventral and the endopodal-sternal shield remnants. Males with a well sclerotized, rounded, axial extension of the palp trochanter (unique); sternal setae *st3* inserted on soft cuticle between the geniti-ventral and endopodal-sternal shield remnants.

Other described species included in *Allozercon*:

Heterozzercon audax Berlese 1910 (= *Heterozzercon elapsus* Vitzthum 1926, synonymy Vitzthum (1925).

Geographic range: Specimens belonging to this genus have been reported from Indonesia (Berlese, 1910; Vitzthum, 1925), Malaysia (Womersley, 1958), India (Rangaswamy & Channa Basavanna, 1973), and the Philippines (Gerdeman & Garcia, 2009), with additional records from Thailand and Laos (OSAL collection).

Comparison with related taxa: *Allozercon* can be differentiated from all other genera by the presence of a well sclerotized, rounded, axial extension on the palp trochanter of the males (vs. extension absent (*Afroheterozzercon* Fain) or membranous (*Amheterozzercon*, *Heterozzercon* Berlese, *Maracazercon* Fain, *Narceoheterozzercon*, *Philippinozercon* gen. nov.). The diagnostic character that the tarsus and tibia of legs I are distinctly narrower than the remaining segments of this leg, listed by Fain (1989), is rejected. The difference in relative thickness in *Allozercon* species vs. other heterozzerconid genera is not always distinct.

Note 1: The diagnosis of *Asioheterozzercon* does not provide any distinguishing characters between that genus

and *Allozercon*. This is consistent with observations on specimens in the OSAL collection which represent multiple species, but which are all very similar. To avoid retaining two generic concepts that appear to cover the same group of mites and that cannot be distinguished, we propose *Asioheterozercon* Fain as a subjective junior synonym of *Allozercon* Vitzthum.

Note 2: The continued recognition of *Allozercon* Vitzthum (Heterozerconidae) could raise a nomenclatural problem as the same name was subsequently proposed for a genus of Zerconidae (Błaszak, 1984). This issue was addressed by Koçak & Kemal (Koçak & Kemal, 2008; Kemal & Koçak, 2009) who proposed the replacement name *Błaszakzercon* Kemal & Koçak for the zerconid genus.

***Philippinozercon* Gerdeman, Garcia, Herczak & Klompen gen. nov.**

Type species: *Philippinozercon makilingensis* Gerdeman, Garcia, Herczak & Klompen sp. nov.

Diagnosis (based on adults). With the following combination of characters: adults with only three setae on the palp genu (unique); lacking series of spine-like setae latero-ventrally on the idiosoma; metapodal shields with acute postero-lateral angles (unique); setae *Jv5* inserted posterior to the fusion line of the ventral and anal shields; with one pair of greatly elongated setae inserted on the postero-marginal shield. Female with a strip-like sclerite between the geniti-ventral and the endopodal-sternal shield remnants; sternal setae *st3* inserted on soft cuticle. Male with sternal setae *st3* on endopodal-sternal shield remnants (unique); seta *p11* on femora II hook-like and spinose.

Comparisons with related taxa (adults). Based on literature data and the collections of Heterozerconidae at the OSAL, there are at least two genera of Heterozerconidae in S.E. Asia. *Allozercon* is found throughout the region, while *Philippinozercon* so far has only been found in the Philippines. The two genera can, and occasionally do, co-occur on a single host individual. They are probably closely related, sharing a number of characters relative to Heterozerconidae from Africa or the New World:

1. setae *st3* in the female on shieldlets that are not fused to the geniti-ventral shield (vs. inserted on the geniti-ventral shield).
2. setae *st1* in the male on a contiguous endopodal shield (vs. on separate shieldlets with lyrifissure *iv1* only (*Amheterozercon*, *Narceoheterozercon*, *Heterozercon*)).
3. setae *st2* in the male on distinct endopodal shield (shared with *Amheterozercon*), vs. free (*Heterozercon*) or on the sterniti-ventral shield (*Narceoheterozercon*).
Note: Characters 2–3 cannot be coded for *Maracazercon* and *Afroheterozercon* which have fused endopodal and sterniti-ventral shields.
4. lateral opisthosomal setae not modified (vs. distinctly modified in *Amheterozercon*, *Maracazercon*, *Heterozercon*, *Afroheterozercon*).
5. setae *Jv5* inserted posterior to fusion line of the ventral and anal shields (vs. anterior to that line).
6. seta *pv1* on genua and tibiae II of male spinose (vs. setiform). Males of *Heterozercon* have a spinose ventral seta on genu and tibiae II, but this appears to be *av1*, not *pv1*.
7. both genera may share tocospermous, rather than podospermous, mating systems (Di Palma *et al.*, 2015), despite the presence of a spermatodactyl in the males. This characteristic is tentative, it has only been examined in detail in one Asian and two American species. It clearly needs to be studied in more taxa.

Philippinozercon can be differentiated from *Allozercon* species by:

1. the presence of a strip-like sclerite between the geniti-ventral and the endopodal-sternal shield remnants in the females (absent in *Allozercon*).
2. the acute postero-lateral angle of the metapodal shields (rounded in *Allozercon*), unique.
3. the reduction in setal complement of the palp genu in the adults from 6 to 3, unique.
4. the shape of seta *p11* on femora II of the male: hook-like and spinose (vs. a straight spine or setiform).

Comparison with related taxa (immatures):

This comparison is limited to immatures of *Narceoheterozercon*, the unnamed nymphs from Brazil (Krantz & De Moraes, 2011) and, for a few characters, immatures of an undescribed species of *Allozercon* from Thailand:

1. deutonymphs do not add a sixth seta on the palp genu and the adults lose two setae on the palp genu relative to the deutonymph, vs. sixth seta added in deutonymph, and setal complement in deutonymph and adult identical (*Narceoheterozercon*, nymphs from Brazil [in part], and *Allozercon* from Thailand).
2. palp tibiotsarsus without bilobed setae, vs. bilobed setae present in *Narceoheterozercon* (may be unique for *Narceoheterozercon*).
3. five (vs. three) setae added on palp tibiotsarsus in transition from proto- to deutonymph
4. gnathotectum in all immature instars with distinct central or central plus lateral points, vs. points absent in *Narceoheterozercon*, the nymphs from Brazil and *Allozercon* from Thailand.
5. hypertrichy of dorsal setae in the nymphs in the form of posterolateral setal bundles (absent in *Narceoheterozercon*, the nymphs from Brazil, and *Allozercon* from Thailand).

***Philippinozercon makilingensis* Gerdeman, Garcia, Herczak & Klompen sp. nov.**

(Figs. 1–11)

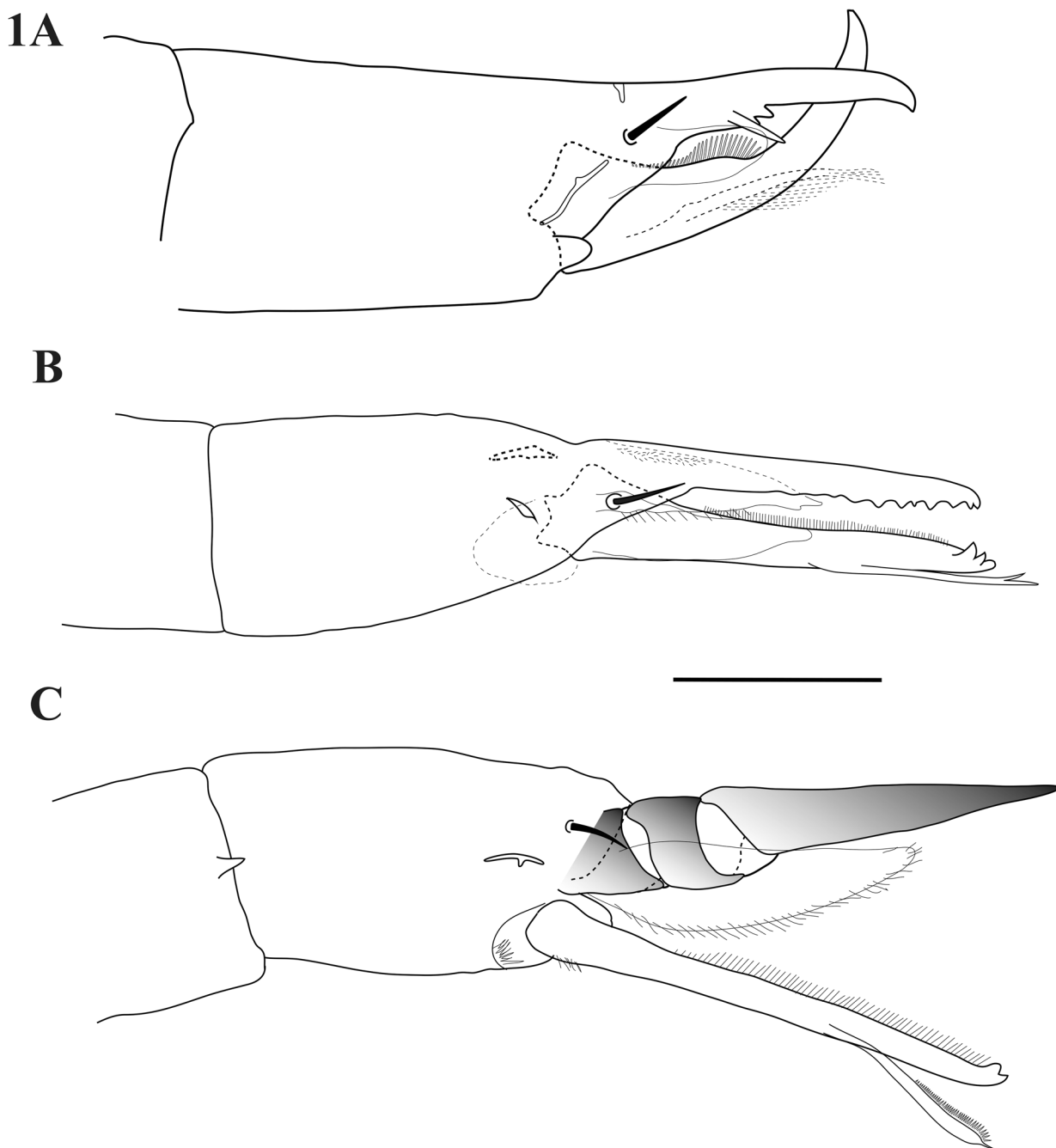


FIGURE 1. *Philippinozercon makilingensis* sp. nov., chelicera. A, Deutonymph (OSAL 0053228); B, Female (OSAL 0053222); C, Male (OSAL 0053267). Scale bar = 50 μ m.

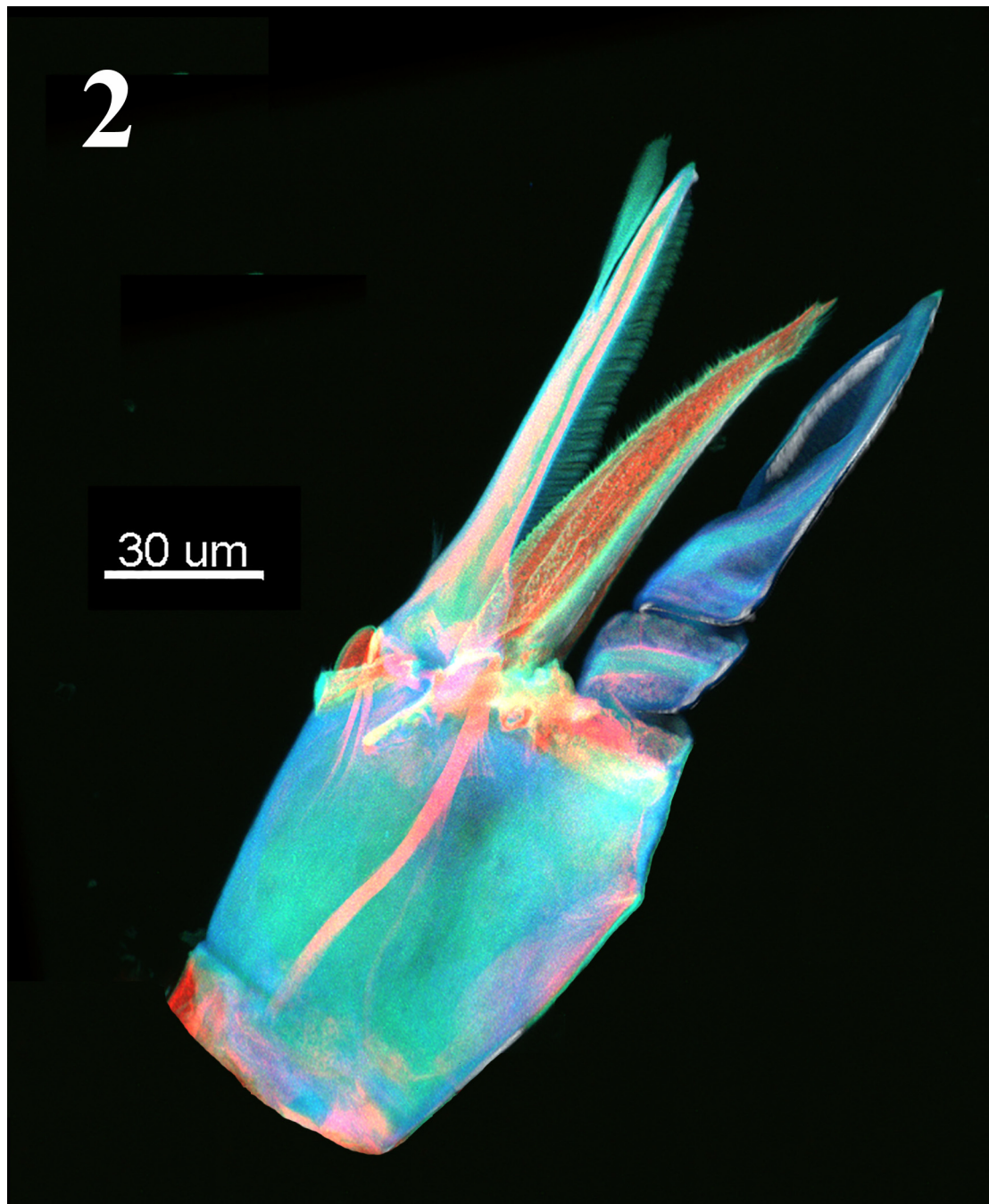


FIGURE 2. *Philippinozercon makilingensis* sp. nov., chelicera male, confocal microscopy, maximum intensity projection.

Diagnosis: with characteristics of the genus.

Description. Available specimens. Slide mounted: 6 females, 6 males, 4 larvae, 6 protonymphs, 6 deutonymphs; in fluid (75% ethanol): 11 larvae, 25 nymphs.

Gnathosoma

Chelicera (Fig. 1). Immatures (Fig. 1A). Basic morphology in larva, protonymph and deutonymph identical. Movable digit without teeth but with basal “comb-like process” (Gerdeman & Klompen 2003) composed of densely packed extensions; ventrally with a finger-like excrescence with a bifid tip (larva) or extensive barbs (deutonymph). Fixed digit with two small teeth and prominent pilus dentilis. With a single rounded interdigital membranous excrescence. Cheliceral seta well developed; dorsal and axial lyrifissures present.

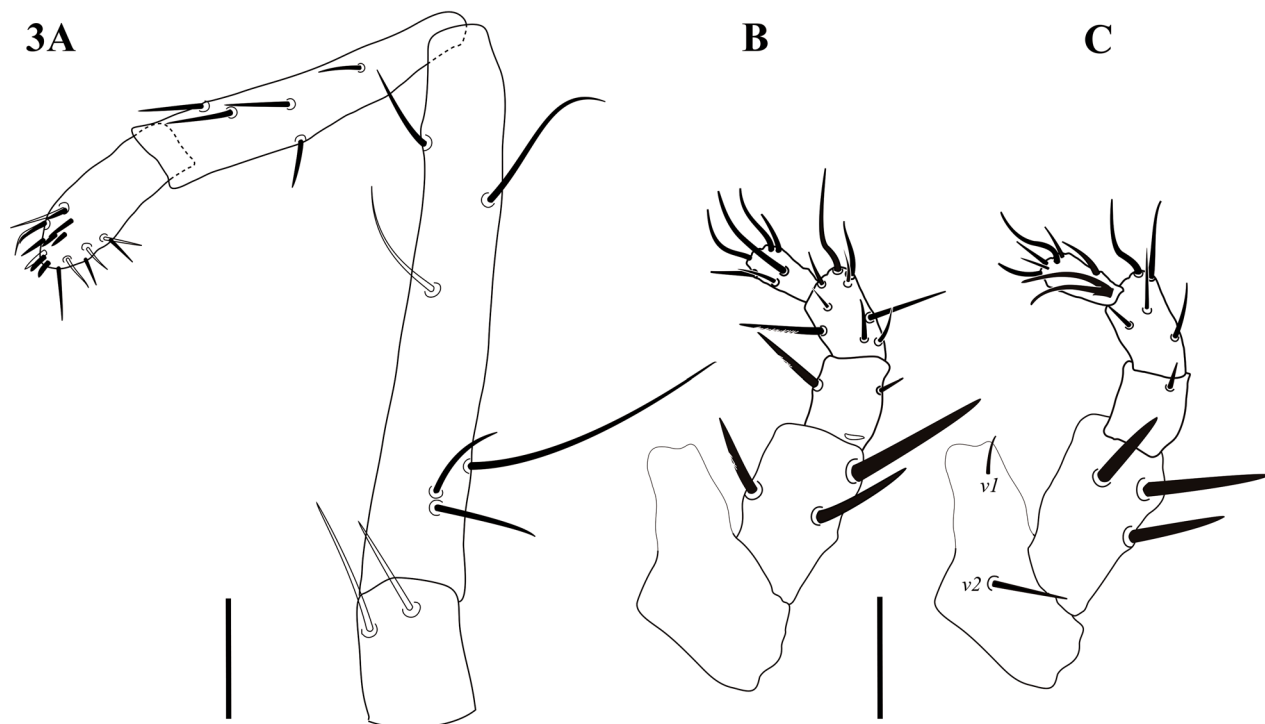


FIGURE 3. *Philippinozercon makilingensis* sp. nov., palp. A, Deutonymph (OSAL 0053262), dorsal view; B-C, Male (OSAL 0053267), separate dorsal (B) and ventral (C) views. Scale bars = 50 μ m.

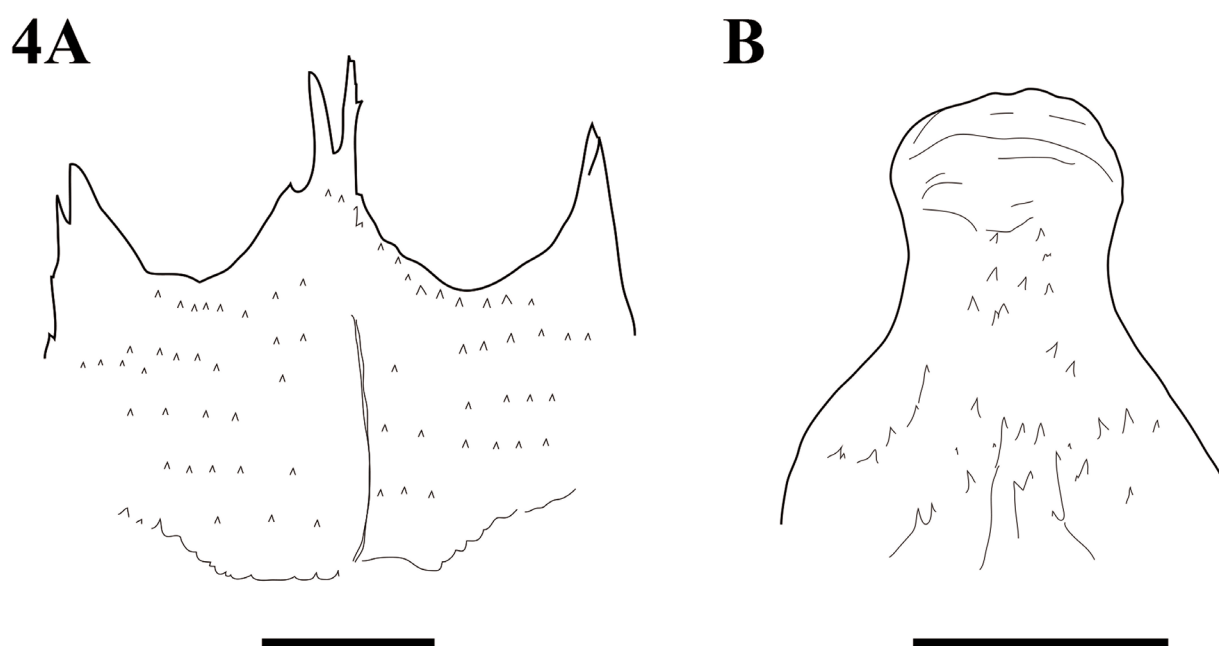


FIGURE 4. *Philippinozercon makilingensis* sp. nov., gnathotectum. A, Deutonymph (OSAL 0053262); B, Female (OSAL 0053269). Scale bars = 50 μ m.

Adults. Female (Fig. 1B): movable and fixed digits thin (width 8–12; Table 1), elongate (length/width ratio 11:1). Movable digit with 2 small teeth near tip and a dense fimbriate comb along entire dorsal margin; ventrally with finger-like excrescence terminating in bifid tip. Fixed digit with about 6 small teeth in distal half; pilus dentilis not observed. With two interdigital membranous excrescences. Cheliceral seta short; both cheliceral lyrifissures

present. Male (Figs. 1C, 2): Movable digit as in female (width 10–12), ventral finger-like excrescence barbed. Fixed digit strongly reduced; spermatodactyl on fixed digit massive (length 119–130), with two basal twists, terminating in an elongate point. Only one interdigital membranous excrescence observed. Cheliceral seta and lateral lyrifissure present, dorsal lyrifissure not observed.

Palp (Fig. 3). Immatures (Fig. 3A). Thin and elongate (length/width ratio in larva 8.7, in protonymph 10.1, in deutonymph 13.7; Table 1), femur and genu at least 5x as long as wide; palps often flexed at femur-genu joint. Tibia and tarsus fused, pretarsal apotele strongly reduced. No axial extensions on trochanter. All setae smooth, setiform; chaetotaxy in larva 0-4-5-10, in protonymph 1-6-5-10, in deutonymph 2-6-5-15.

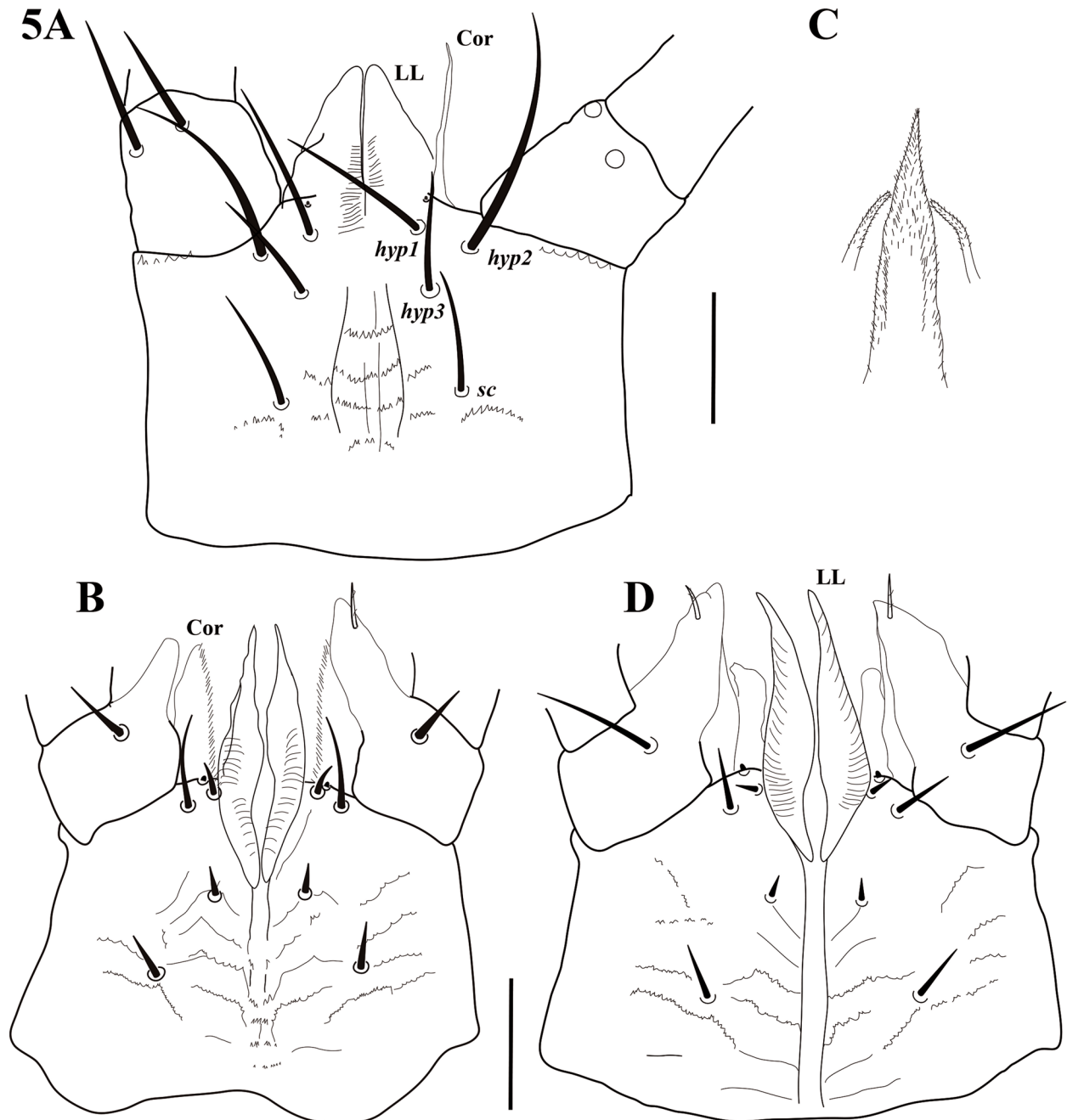


FIGURE 5. *Philippinozercon makilingensis* sp. nov., subcapitulum. A, Deutonymph (OSAL 0053262); B-C, Male (OSAL 0201161), ventral view (B), labrum and paralaciniae (C); D, Female (OSAL 0053271). Abbreviations: Cor, corniculus; LL, lateral lips. Scale bar = 50 μ m.

Adults (Fig. 3B–C). Palp relatively thick, stocky (length/width ratio 4.3–5.7). Tarsus and tibia distinct; pretarsal apotele with 2 slender tines. Femoral setae thickened into spines, elongate (59–65); some femoral, genual, and tibial setae with fine barbs; chaetotaxy 2-6-3-14-12. Trochanter with membranous axial extension in both sexes; trochanteral seta *v1* strongly reduced, inserted on axial extension; *v2* short, setiform.

Gnathotectum (Fig. 4). Immatures (Fig. 4A). Larva: gnathotectum appearing more or less rectangular but with a single, median “spike”; anterior margin dentate (see *Narceoheterozercon*). Proto- and deutonymph: with three somewhat irregular points, margin with a few denticles; central point often appearing bifid; surface covered with small denticles.

Adults (Fig. 4B): gnathotectum with a single, smooth edged, broadly rounded lobe; surface covered with small spines.

Subcapitulum (Fig. 5). Immatures. Larva: corniculi thin, membranous, indistinct; 2 pairs of hypostomal setae (*hyp1*, *hyp2*), setae smooth, setiform. Deutonymph (Fig. 5A): corniculi (Cor) long, thin, membranous, indistinct; 3 pairs of hypostomal setae (*hyp1-hyp3*) in triangular arrangement, subcapitular setae (*Sc*) medium long; all setae smooth, setiform. Deutosternal borders weakly developed, with 3–4 rows of small denticles; 2–3 small transverse rows of denticles on remaining subcapitulum. Lateral lips (LL) triangular, membranous.

Adults: corniculi fairly large, membranous, may have marginal fimbriations; setae *hyp1* and *hyp3* short, seta *hyp2* twice as long, inserted almost at level of *hyp1*; setae *Sc* medium long, all setae smooth, setiform. Deutosternum in male weakly delineated, with 3–4 rows of small denticles, in female better delineated but without distinct denticle rows; multiple largely transverse rows of denticles on remaining subcapitulum. Lateral lips well-developed, shaped into a “plow-like” structure (Fig. 5B, D); labrum simple, lanceolate in shape, fimbriate throughout; paracinae well-developed (Fig. 5C).

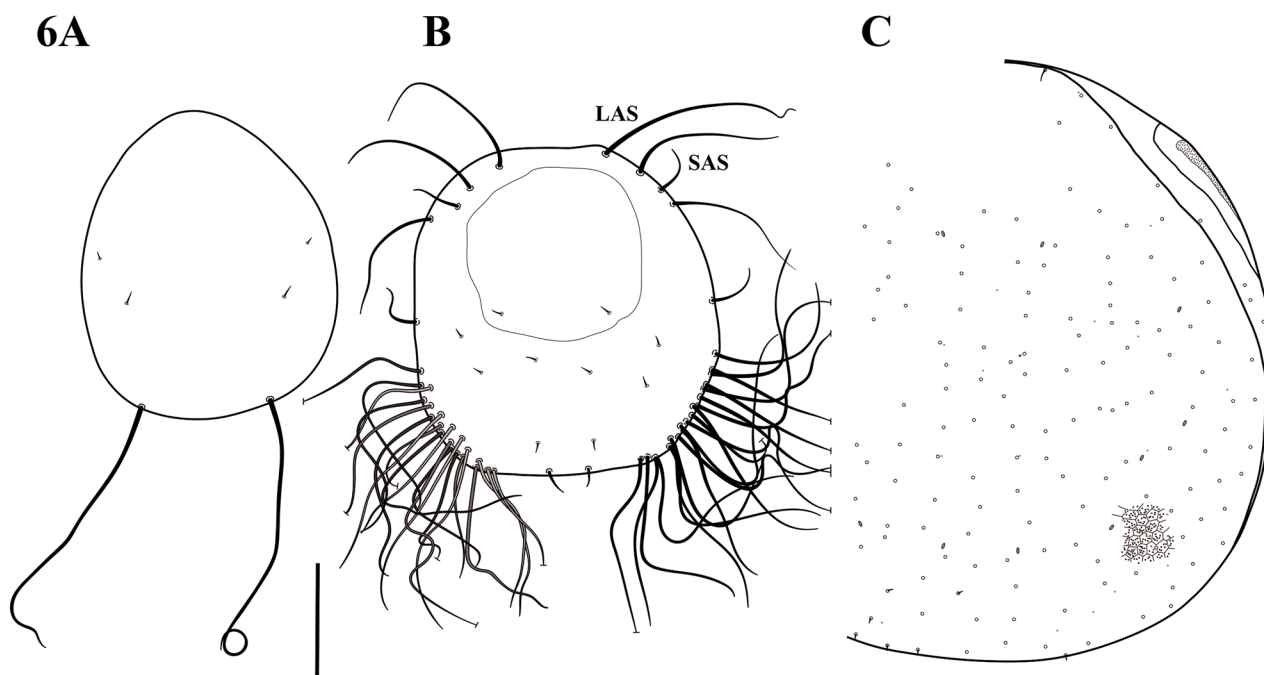


FIGURE 6. *Philippinozercon makilingensis* sp. nov., idiosoma, dorsal. A, Larva (OSAL 0118721); B, Protonymph (OSAL 0118723); C, Male (OSAL 0053267). Abbreviations: LAS, long anterior seta; SAS, short anterior seta. Scale bar A, B = 100 μ m; C = 200 μ m.

Idiosoma

Dorsum (Fig. 6). Immatures. Larva (Fig. 6A): No observable shields. Idiosomal setation reduced to 2 pairs of small setae mid-laterally, and a pair of very long setae on posterior margin (*Z5*?). Protonymph (Fig. 6B): antero-dorsal shield present, with weak reticulations, separated from anterior margin of idiosoma by band of faintly striate cuticle; shield margins very poorly defined. Setation: with 3 pairs of medium-long to long setae (LAS) and 1 pair of shorter setae (SAS) on anterior margin, 4 pairs of short setae central, 1 pair of medium length setae on lateral margin,

bundles of long setae posterior lateral (average number 23, range 22–26; N=6), and 2 pairs of medium-short setae on or near posterior margin. Homology assessments for these setae were not attempted, although homologues to setae Z5 in the larva are assumed to be among the bundle setae. Deutonymph: dorsal shield more defined than in protonymph, with distinct reticulations; shield forming an oval from the anterior border of the idiosoma posterior to include the most posterior pair of short setae. Setation: similar to protonymph, but additional pairs of setae in anterior marginal (1 pair), central (1 pair), lateral marginal (1 pair) groups, and posterior margin (1 pair) groups, and an average of 36 (range 32–41; N=10) setae in postero-lateral bundles.

Adults (Fig. 6C). Well-sclerotized holodorsal shield with faint reticulate patterning (Fig. 6C, detail inset), leaving only anterolateral area unsclerotized; peritrematal shield not fused to dorsal shield. Setation: hypertrichous, nearly all setae minute (3–7), setae *jl* 12–22)

Venter (Figs. 7–8). Immatures. Larva (Fig. 7A): No shields observed. Three pairs of sternal setae (*st1-st3*; 20–39) of medium length, a pair of medium long paranal setae (*pa*) inserted distinctly anterior of anus, and a very long postanal seta (*po*). Protonymph (Fig. 7B): no shields observed; peritreme minute, without visible peritrematal shield. Cribrum pentagonal, width similar to distance between setae *pa*, depth half that distance. Relative length setae *pa* as in larva, seta *po* much shorter. In sternal region *st5* added posterior to coxae IV; one pair of setae added lateral at level of peritreme; ventral region with 3–4 pairs of ventral setae in addition to *pa* and *po*. Deutonymph: no shields observed; peritreme only slightly longer than in protonymph; cribrum shape and length of *pa* and *po* setae as in protonymph. Ventral region adding 2 pairs of setae.

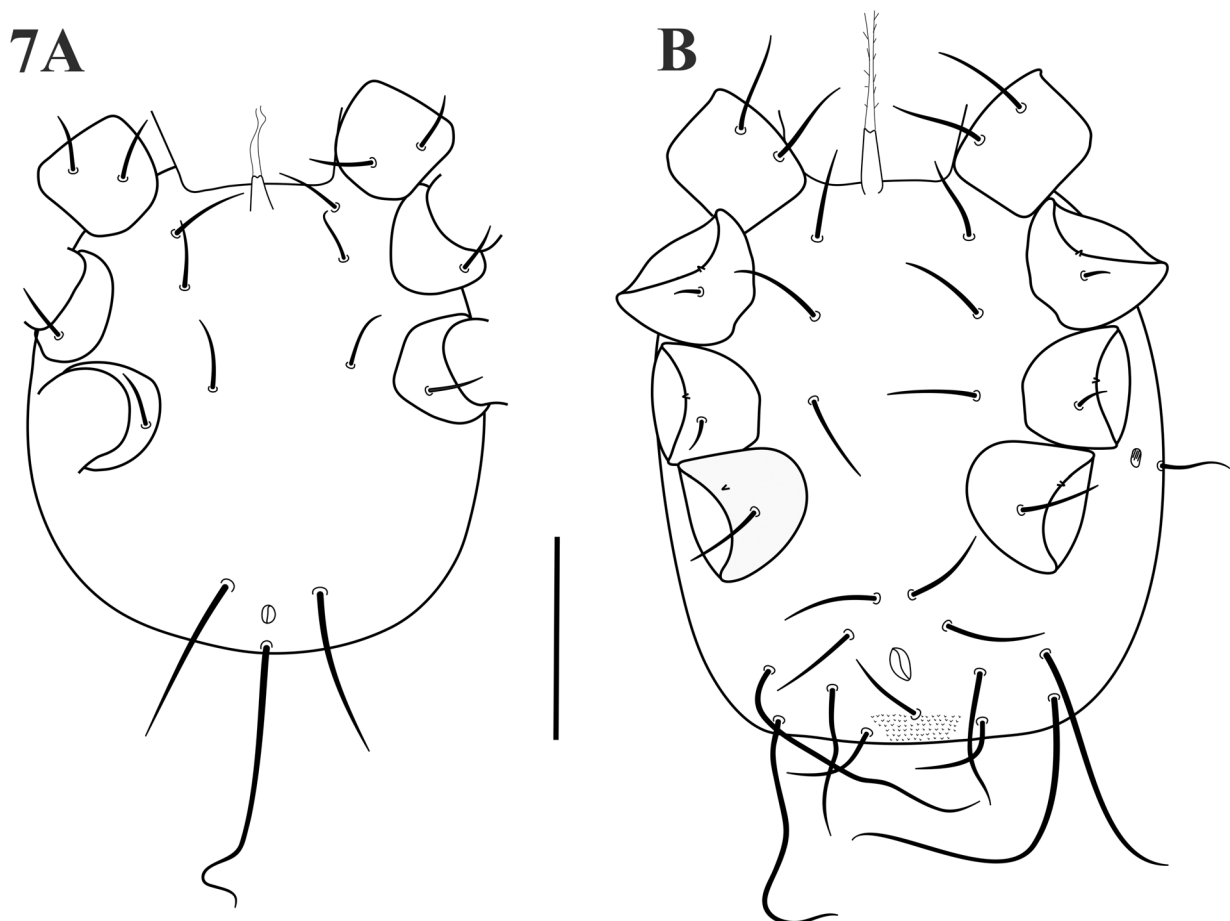


FIGURE 7. *Philippinozercon makilingensis* sp. nov., idiosoma, ventral. A. Larva (OSAL 0118721); B. Protonymph (OSAL 0118723). Scale bar = 100 μ m.

Adults. Female (Fig. 8A): tritosternal base widened basally. Setae *st1* each on separate shield with pore *iv1*; each seta *st2* with pores *iv2* and *iv3* on sternal / endopodal shield. Sternal / endopodal shield connected posterior to coxa IV with fused metapodal, exopodal and peritrematal shields; posterior lateral corner of metapodal shield

sharply angled. Peritremes extending anterior to coxae I; peritrematal / metapodal shields with about 3 lyrifissures and 5 gland openings each. Geniti-ventral shield well-developed, with faint reticulate patterning except in anterior region which is more membranous; anterior region seemingly fused with curved sclerite extending as a distinct strip between the geniti-ventral shield and the sternal shield remnants. Setae *st3* on soft cuticle between lateral arms of the sclerite and the geniti-ventral shield; setae *st5* inserted on geniti-ventral shield at base of genital portion of that shield; setae *st4* not added. Geniti-ventral shield partially fused with anal shield, separated medially by a distinct fusion line between the ventral suckers; ventral suckers well-developed, positioned in ventro-lateral corners of ventral shield. Setae *Jv1*, *Zv2* (small), *Sv2* (small) and *Sv3* inserted antero-lateral of suckers, setae *Jv2* anterior to partial fusion line, *Jv5* posterior to that line; setae *pa* inserted posterior to anus, almost in line with short seta *po*. Cribrum wide but thin, width similar to distance between setae *pa*. Narrow well sclerotized postero-marginal shield with 1 pair of long setae (*Z5*; often broken off) and numerous minute, setiform setae. Additional minute, setiform, setae on soft cuticle posterior (most) and lateral (few) to postero-marginal shield. Male (Fig. 8B): Pair of small presternal shieldlets anterior to tritosternum carrying no setae or pores. Sternal setae *st1-st3* plus pores *iv1-iv3* on pair of fused sternal / endopodal shields which are connected to fused metapodal, exopodal, and peritrematal shields (as in female). Genital shield square, presternal, partially overlapping base of tritosternum; (geniti-)ventral shield completely separating the 2 sternal / endopodal shields, adjoining the genital shield anteriorly. Setae *st5* on geniti-ventral shield at level of coxae IV. All other characteristics as in female.

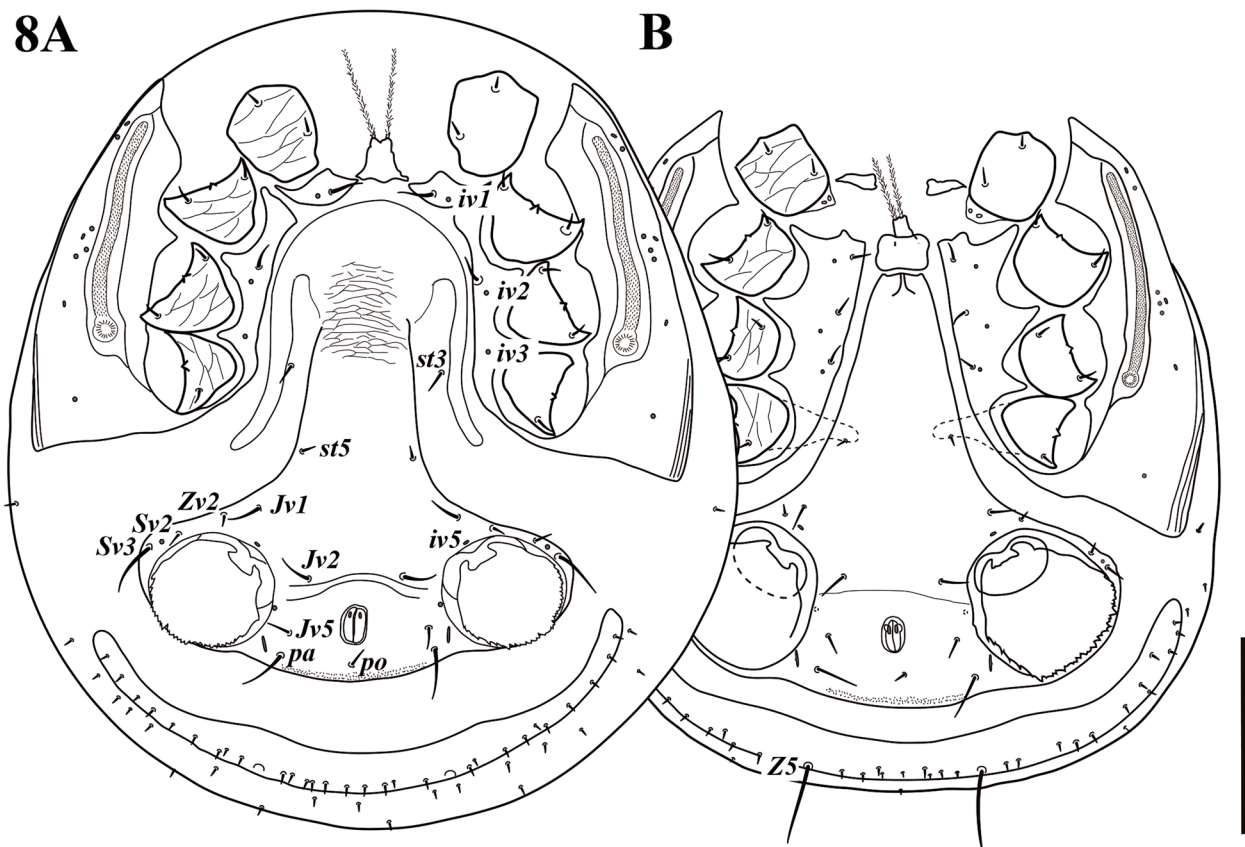


FIGURE 8. *Philippinozercon makilingensis* sp. nov., idiosoma, ventral. A, Female (OSAL 0063222); B, Male (OSAL 0053267). Scale bar = 200 μ m.

Legs (Figs. 9–11)

Immatures. Larva (Figs. 9A, 10A, 11A): Leg I elongate, relatively thin. Chaetotaxy (legs I–III): coxae 2, 1, 1; trochanters 4, 4, 4; femora 2-2/1-2/1-2, 0-2/1-2/0-1, 0-2/1-1/0-0; genua 2-2/1-1/1-1, 1-2/0-2/0-1, 1-2/0-2/0-1; tibiae 1-1/1-2/1-1, 1-1/1-2/1-1, 1-1/1-2/1-1; tarsus I not studied, tarsi II–III 16, 16. Some setae on legs I and III unusually elongate, on leg I: tarsal, distal (170), median (292), tibial *ad1* (251), *av1* (292) and *pd1* (253) and genual *pl1* (219), *av1* (236), *ad1* (154) (Note: these setal designations are tentative. The lack of matching between long setae

on the larval leg I and the nymphal setae (see below) is unusual and somewhat disturbing); on leg III: tarsal *pd2*, *pd4*, tibial *pd1* (161), and genual *pd1* (203). Protonymph: Chaetotaxy as in larva but with addition of one seta to femora II (1-2/1-2/0 1) and one to femora III (1-2/1-1/0-0); tarsi II–IV 17 (addition *ad2/md*). Legs IV: coxae 1; trochanters 4; femora 1-2/0-0/0-1, genua 1-2/0-2/0-1, tibiae 1-1/1-2/1-1. Elongate setae restricted to legs I: tarsi, distal (168) and median (313); tibiae *al1* (318), genua *al1* (227), *av1* (248), *pl1* (320). Setae *pl1* on basitarsi, tibiae, and genua IV slightly thickened, with prominent, long barbs (Fig. 11B, inset). Deutonymph (Figs. 9B, 10B, 11B): Leg I elongate, relatively thin. Chaetotaxy (legs I–IV): coxae 2, 1, 1, 1; trochanters 6, 5, 5, 5; femora: 2-3/1-2/1-2, 2-3/1-2/1-1, 1-2/1-2/1-0, 1-2/1-1/1-1; genua 2-2/1-2/1-2, 2-2/1-2/1-1, 2-2/1 3/1-1, 2-2/1-3/1-1; tibiae 2-1/1-2/1-2, 2-1/1-2/1-1, 2-1/1-2/1-1, 2-1/1-2/1-1; tarsi II–IV 18 (addition *av3/mv*). Elongate setae as in protonymph: tarsi, distal (227), median (390); tibiae *al1* (403), genua *al1* (286), *av1* (344), *pl1* (344). Setae *pl1* on basitarsi, tibia and genua IV as in protonymph.

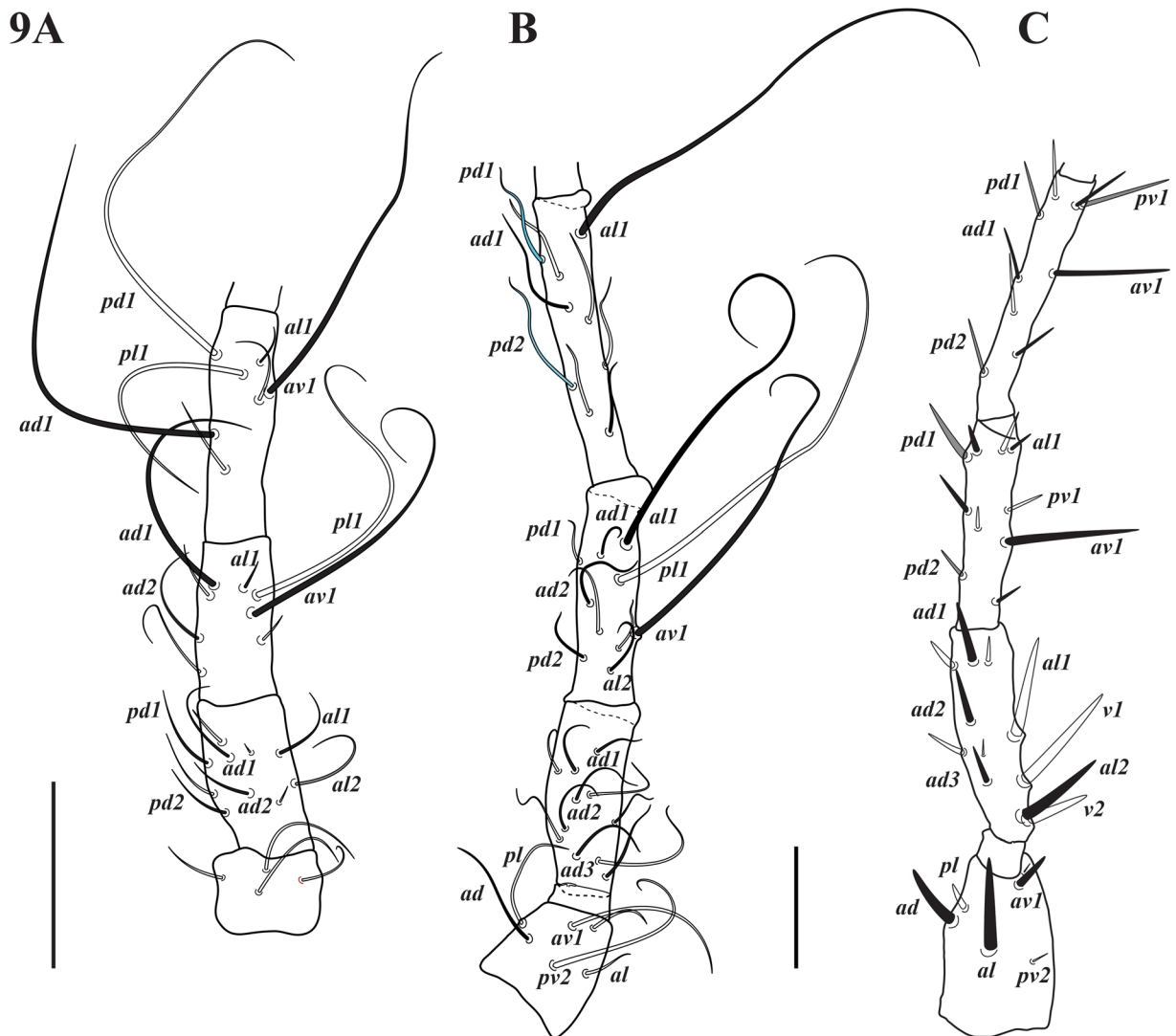


FIGURE 9. *Philippinozercon makilingensis* sp. nov., legs I. A, Larva (OSAL 0053229); B, Deutonymph (OSAL 0053259); C, Male (OSAL 0053267). Scale bars = 100 μ m.

Adults (Figs. 9C, 10C). Legs I antenniform. Chaetotaxy: coxae 2, 2, 2, 1; trochanters: 6, 5, 5, 5; femora 2-3/1-2/1-2, 2-3/1-2/1-1, 1-2/1-2/1-0, 1-2/1-2/1-0; genua 2-2/1-2/1-2, 2-2/1-2/1-1, 2-2/1-3/1-1, 2-2/1-3/1-1; tibiae 2-1/1-2/1-2, 2-1/1-2/1-1, 2-1/1-2/1-1, 2-1/1-2/1-1; tarsi II–IV 18, 18, 18. Modified setae. In male: most setae on trochanters I (exception *pv1*, *pv2*), and femora I (exception *pl1*, *pl2*) spinose, femoral setae *al1* (88), *al2* (79), *v1* (104), and *v2* (55) distinctly elongate spines with rounded tips; tibial and genual setae *av1* elongate (116), thickened, with

relatively pointed tips. Female with femora I setae *vl* (117) and *al2* (104) long spines and longer than in males, but setae *all* and *v2* shorter than in male. Setae *ad1* on femora I in both sexes about twice as long as *pd1*. Tarsal setae *ad1* and *pd1* II–IV small, somewhat leaf-like in shape. Legs II in male: femora, genua, and tibiae inflated (rel. to female). Nearly all femoral setae spinose (exception *av1* (36) which are setiform): setae *pl1* small, curved spines, *pv1* massive, blunt-tipped spines (72, basal width 18); genual and tibial setae *pv1* small, blunt spines; genual *pv1* length 16, basal width 8.

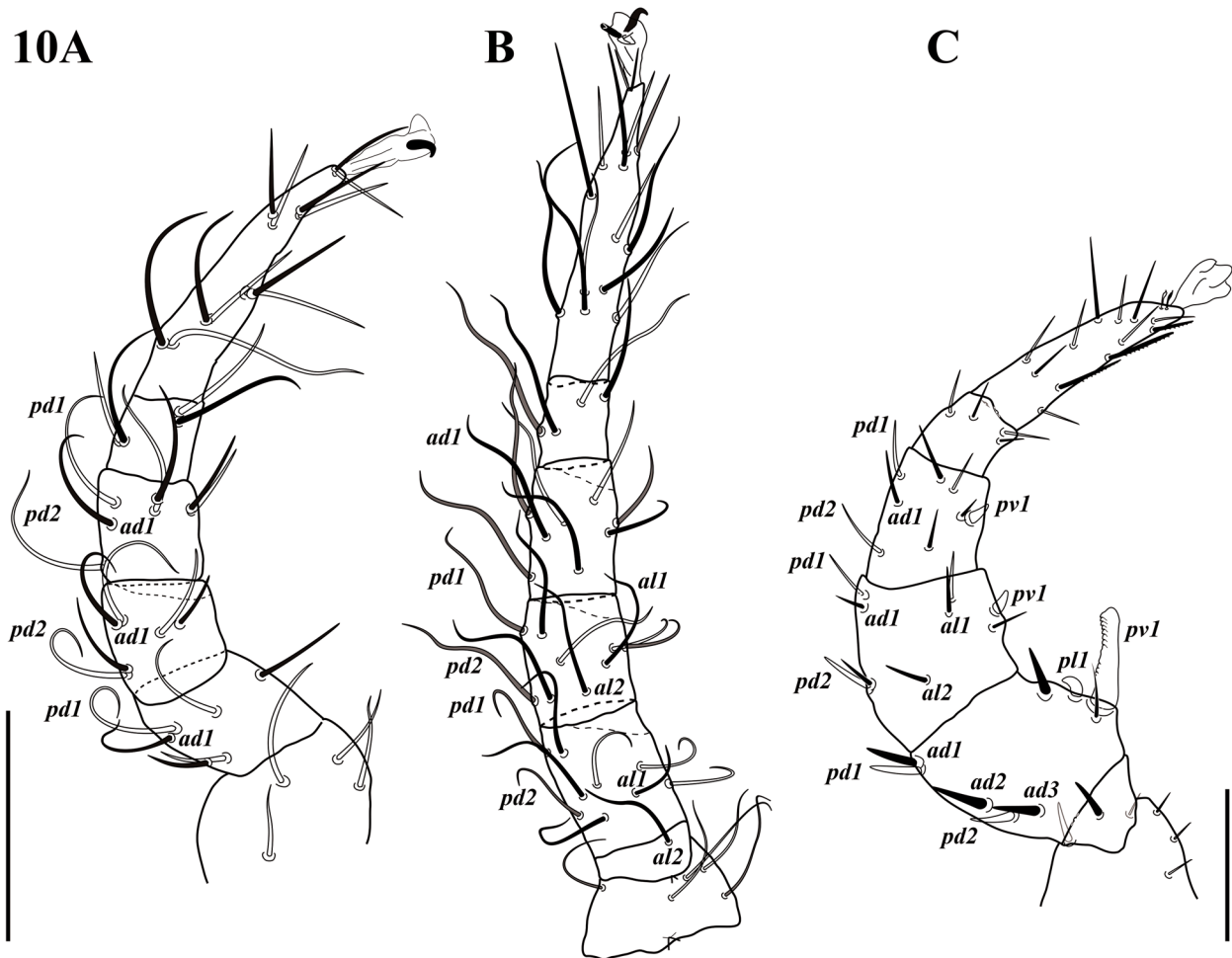


FIGURE 10. *Philippinozercon makilingensis* sp. nov., legs II. A, Larva (OSAL 0053229); B, Deutonymph (OSAL 0053265); C, Male (OSAL 0053267). Scale bars = 100 μ m.

Deposition of types. Holotype male (OSAL 0053267) and most paratypes at (UPLB); paratypes at OSAL.

Material examined (unless stated otherwise, all specimens are slide mounted). Luzon Is., Laguna prov., UPLB campus, DITRI, Los Baños, 14.1530 N 121.2458 E, 14-Jul-2001, Garcia, R. C., ex old/fresh millipede frass & fungus litter, coll. event no. 0163-E: 1-M, **OSAL 0053267 (holotype)**; 1-PN, **OSAL 0053264**; 1-DN, **OSAL 0053265**; 1-DN, **OSAL 0053266**. Same locality, 24-Jan-2000, Garcia, R C, ex downed log (tree species unknown), coll. event no. BSG 00-0124-1/2. 1-(PN), **OSAL 0053270**. Same locality, 11-Aug-2000, Garcia, R C, ex unidentified forestry millipede with yellow legs, coll. event no. BSG 00-0811-1: 1-F, **OSAL 0053269**. Same locality, 14-Jul-2001, Garcia, R C, ex old & fresh millipede frass & fungus litter, coll. event no. 0161-C: 1-DN, **OSAL 0053258**; 1-DN, **OSAL 0053259**; 1-DN, **OSAL 0053262**; 1-F, **OSAL 0053260**; 1-L, **OSAL 0053261**. UPLB campus, Hortorium, 14.1650 N 121.2378 E, 14-Mar-2000, Gerdeman, B. S., Garcia, R. C., ex coconut shell, coll. event no. BSG 00-0314-2: 1-M, **OSAL 0099469**; 1-M, **OSAL 0102161**; 1-M, **OSAL 0102162**. UPLB Forestry Campus, 14.1520 N 121.2361 E, 11-Dec-2000, Garcia, R. C., coll. event no. 0171: 2-DN (in 75% ethanol), **OSAL 0128359**. Same locality, 11-Jan-2001, Garcia, R. C., coll. event no. 0141-A: 2-L 1-N (in 75% ethanol), **OSAL 0128368**; 17-Jan-2001, Garcia, R. C., ex frass & litter, coll. event no. 0142 1/17-B: 1-L 5-N (in 75% ethanol), **OSAL 0128354**; 29-Jan-2001, Gerdeman, B.

S., Garcia, R. C., ex frass/litter with fungi, coll. event no. 0143-A: 1-L, **OSAL 0118721**; 29-Jan-2001, Gerdeman, B. S., Garcia, R. C., ex frass/litter with fungi, coll. event no. 0148-A: 1-L, **OSAL 0118722**; 1-PN, **OSAL 0118723**; 1-PN, **OSAL 0118724**; 9-Apr-2001, Garcia, R. C., ex litter mixed with millipede frass w fungus, coll. event no. 0132-B: 1-L 1-N (in 75% ethanol), **OSAL 0128360**; 7-May-2001, Garcia, R. C., ex fresh frass under decomposing log, coll. event no. 0153-A: 1-DN (in 75% ethanol), **OSAL 0128372**; 7-May-2001, Garcia, R. C., ex millipede frass & litter, coll. event no. 0154-B: 1-PN (in 75% ethanol), **OSAL 0128367**; 7-May-2001, Garcia, R. C., coll. event no. 0173-B: 2-L 2-N (in 75% ethanol), **OSAL 0128362**; 2-Jun-2001, Garcia, R. C., ex old frass with fungus & litter, coll. event no. 0155-A: 1-DN (in 75% ethanol), **OSAL 0128356**; 2-Jun-2001, Garcia, R. C., ex mix of old and new litter, coll. event no. 0157-A: 1-DN (in 75% ethanol), **OSAL 0128370**; 2-Jun-2001, Garcia, R. C., coll. event no. 0158-B: 2-N (in 75% ethanol), **OSAL 0128358**; 14-Jul-2001, Garcia, R. C., ex mix old & new frass and litter near decomposing log, coll. event no. 0142-D: 1-L 1-N (in 75% ethanol), **OSAL 0128371**; 14-Jul-2001, Garcia, R. C., ex fresh and old frass with fungus & litter near base of tree, coll. event no. 0150-C: 1-N (in 75% ethanol), **OSAL 0128365**; 14-Jul-2001, Garcia, R. C., ex mix of old and new frass with fungus & litter, coll. event no. 0159-A: 1-DN (in 75% ethanol), **OSAL 0128364**; 14-Jul-2001, Garcia, R. C., ex old frass with fungus & litter near base of tree, coll. event no. 0160-B: 1-L 2-N (in 75% ethanol), **OSAL 0128366**; 18-Aug-2001, Garcia, R. C., coll. event no. 172-A: 1-N (in 75% ethanol), **OSAL 0128355**; 18-Aug-2001, Garcia, R. C., ex mix of old and new litter, coll. event no. 0174-C: 1-N (in 75% ethanol), **OSAL 0128369**; 19-Aug-2001, Garcia, R. C., coll. event no. 0170: 3-L (in 75% ethanol), **OSAL 0128361**; 9-Feb-2009, Garcia, R. C., ex millipede frass with fungi at base tree, coll. event no. 0145-A: 1-N (in 75% ethanol), **OSAL 0128357**. College, 14.1642 N 121.2415 E, 14-Mar-2000, Garcia, R. C., ex leaf litter & fungus at base of tree, coll. event no. 0149-B: 1-DN, **OSAL 0053228**; 1-DN, **OSAL 0053227**; 1-L, **OSAL 0053229**; 1-PN, **OSAL 0053225**; 1-PN, **OSAL 0053226**. Same locality, 21-Mar-2000, Gerdeman, B. S., Garcia, R. C., ex unidentified millipede, coll. event no. BSG 00-0321-1: 1-E, **OSAL 0053224**; 1-F, **OSAL 0053221**; 1-F, **OSAL 0053222**; 1-M, **OSAL 0053223**; 2-Ad (in 75% ethanol), **OSAL 0103369**.

Luzon Is., Laguna prov., Mount Makiling, 4 km SE Los Baños, 14.1358 N 121.1901 E, 8-Mar-2000, Gerdeman, B. S., Garcia, R. C., ex unidentified millipede, coll. event no. BSG 00-0308-1: 1-F, **OSAL 0053271**.

Luzon Is., Quezon prov., nr. ranger station, Famy & Real, Quezon/Laguna Landgrant, 320m, 14.4781 N, 121.5321 E, 20-Jan-2016, Garcia, R. C., Naredo, J. C., Klompen, H., ex Trigoniulidae (Spirobolida), coll. event no. HK 16-0120-7: 1-F, **OSAL 0128336**; 1-M, **OSAL 0128337**; 4-F 5-M (in 95% EtOH), **OSAL 0129918**.

Etymology. The name is derived from the location where the specimen was collected. *Philippinozercon* refers to the country, the Republic of the Philippines, and *makilingensis* refers to Mount Makiling, the dormant volcano located on the southern border between Laguna and Batangas provinces on the island of Luzon.

Notes on distribution and hosts. As noted above, specimens that are highly similar to, and may be conspecific with, *P. makilingensis* were recovered from other islands. The specimens from Negros island showed a small, but distinct, difference in the ratio between setae *adl* and *pdl* on femora I which is much larger (4:1) in these specimens than in *P. makilingensis* (about 2:1). We present the records from these other islands to better illustrate the known geographical and host range of the genus/species. Millipede host records presented are based in part on voucher material deposited at FMNH (indicated by FMNHINS numbers).

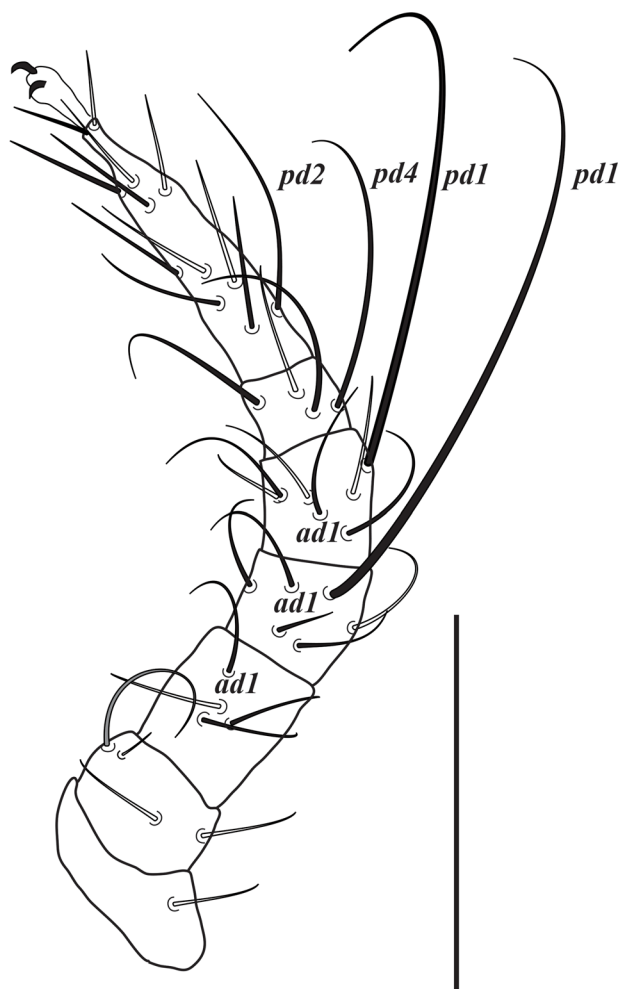
Leyte Is., Leyte, VISCA, Hubasan Creek, 10.7731 N 124.8109 E, 7-Jun-2000, Gerdeman, B. S., Garcia, R. C., ex *Trigoniulus macropygus* (Spirobolida: Trigoniulidae) (FMNHINS 0000 002 771) in litter, coll. event no. BSG 00-0607-37: 1-F, **OSAL 0053317**; 1-M, **OSAL 0053318**. Same locality, collection date, and collectors, ex unidentified millipede, coll. event no. BSG 00-0607-45: 1-F, **OSAL 0053254**; 1-F, **OSAL 0053255**; 1-F, **OSAL 0053256**; 1-F, **OSAL 0053257**; ex unidentified red, red & yellow legged millipedes millipedes, coll. event no. BSG 00-0607-45: 1-M, **OSAL 0099500**; 1-M, **OSAL 0099501**; ex *Trigoniulus macropygus* (Spirobolida: Trigoniulidae) (FMNHINS 0000 002 784) in litter, coll. event no. BSG 00-0607-47: 1-F, **OSAL 0053319**; 1-M, **OSAL 0053253**; 1-U, **OSAL 0053252**.

Panay Is., Iloilo province, Lambunao, Barangay Awarg, 11.0582 N 122.4836 E, 11-Jul-2000, Gerdeman, B. S., Garcia, R. C., ex unidentified millipede, coll. event no. BSG 00-0711-1: 1-F, **OSAL 0053295**; 1-F, **OSAL 0053296**; 1-F, **OSAL 0053297**; 1-F, **OSAL 0053298**; 1-F, **OSAL 0053299**; 1-F, **OSAL 0053300**; 1-F, **OSAL 0053301**; 1-M, **OSAL 0053291**; 1-M, **OSAL 0053292**; 1-M, **OSAL 0053293**; 1-M, **OSAL 0053294**; 1-M, **OSAL 0053302**; 1-M, **OSAL 0053303**; 1-M, **OSAL 0053304**.

Samar Is., Samar province, Basesy, Sohoton Cave, 284m, 11.4167 N 125.1500 E, 10-Jun-2000, Gerdeman, B. S., Garcia, R. C., ex Spirobolida (FMNHINS 0000 002 786) in litter, coll. event no. BSG 00-0610-1: 1-F, **OSAL**

0053310; 1-F, OSAL 0053311; 1-M, OSAL 0053307; 1-M, OSAL 0053308; 1-M, OSAL 0053309. Same locality, collecting data, collectors, ex unidentified millipede, coll. event no. BSG 00-0610-3: 1-F, OSAL 0053306; 1-M, OSAL 0053305.

11A



B

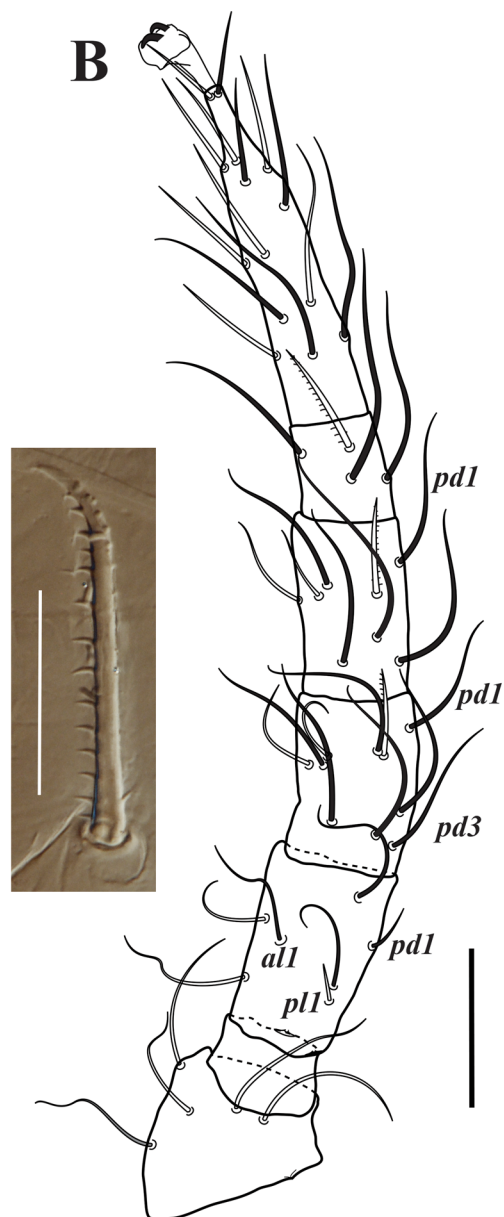


FIGURE 11. *Philippinozercon makilingensis* sp. nov., legs. A, Larva (OSAL 0052261), leg III; B, Deutonymph (OSAL 0053262), leg IV; inset: seta *pl1* on genu. Scale bars legs = 100 μ m, inset = 25 μ m.

Negros Is., Negros Oriental province, Danao lake, Barangay Danay, Mount Mahilum, 9.3504 N 123.1837 E, 1-Jul-2000, Gerdeman, B. S., Garcia, R. C., ex *Trigoniulus macropygus* (Spirobolida: Trigoniulidae) (FMNHINS 0000 002 800) in litter, coll. event no. BSG 00-0701-6: 1-F, OSAL 0053313; 1-M, OSAL 0053312; 1-M, OSAL 0053314; 1-M, OSAL 0053315; 1-M, OSAL 0053316.

Based on these records the geographical range of *Philippinozercon* includes at minimum Luzon and various islands in the Visayas region. Collections from Mindoro did not include specimens assignable to this genus, and collections from Mindanao were not available. The number of host individuals identified is small, but all that were identified are members of the family Trigoniulidae, suggesting that these millipedes may be the main hosts for *Philippinozercon*.

Acknowledgements

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References

- Berlese, A. (1910) Lista di nuove specie e nuovi generi di Acari. *Redia, Firenze*, 6 (2), 243–271.
- Błaszak, C. (1984) Three new genera of zerconid mites (Acari, Mesostigmata, Zerconidae) from the United States of America with a key to the American genera. *Polskie Pismo Entomologiczne*, 53, 587–601.
- Di Palma, A., de Moraes, G.J., Gerdeman, B.S., Huber, S., Kitajima, E.W. & Alberti, G. (2015) Ultrastructural and functional adaptations of the female reproductive system in the family Heterozerconidae (Acari, Anactinotrichida, Gamasida, Heterozerconina) and implications for the systematic position of the group. *Arthropod Structure & Development*, 44 (6, Part B), 639–655.
<https://doi.org/10.1016/j.asd.2015.09.002>
- Evans, G.O. (1963a) Observations on the chaetotaxy of the legs in free-living Gamasina (Acari: Mesostigmata). *Bulletin of the British Museum (Natural History), Zoology*, 10 (5), 277–303.
<https://doi.org/10.5962/bhl.part.20528>
- Evans, G.O. (1963b) Some observations on the chaetotaxy of the pedipalps on the Mesostigmata (Acari). *Annals and Magazine of Natural History, Series 13*, 6 (69), 513–527.
<https://doi.org/10.1080/00222936308651393>
- Fain, A. (1989) Notes on mites associated with Myriapoda. IV. New taxa in the Heterozerconidae (Acari, Mesostigmata). *Bulletin de l'Institut royal des Sciences naturelles de Belgique, Entomologie*, 59, 145–156.
- Gerdeman, B.S. & Garcia, R. (2009) Heterozerconidae: A comparison between a temperate and a tropical species. In: Sabelis, M.W. & Bruin, J. (Eds), *Trends in Acarology, Proceedings of the 12th International Congress*. Springer Science, Dordrecht, pp. 93–96. [published in 2010]
- Gerdeman, B.S. & Klompen, H. (2003) A new North American heterozerconid, *Narceoheterozercon ohioensis*, n. gen., n. sp., with first description of immatures of Heterozerconidae (Acari: Mesostigmata). *International Journal of Acarology*, 29 (4), 351–370.
<https://doi.org/10.1080/01647950308684352>
- Kemal, M. & Koçak, A.Ö. (2009) A replacement name for *Blaszakia* Koçak & Kemal, 2008 in the family Zerconidae (Acarina, Mesostigmata). *Miscellaneous Papers of the Centre for Entomological Studies Ankara*, 147–148, 10.
- Koçak, A.Ö. & Kemal, M. (2008) Nomenclatural notes on the genus group names of the order Acarina. *Miscellaneous Papers of the Centre for Entomological Studies Ankara*, 145, 1–6.
- Krantz, G.W. & De Moraes, G.J. (2011) Discovery and description of nymphal stages of a heterozerconid mite (Acari: Mesostigmata: Heterozerconidae) from coastal forest litter in southeastern São Paulo State, Brazil. In: DeMoraes, G.J. & Proctor, H. (Eds.), *Acarology XIII: Proceedings of the International Congress, 2011*, pp. 24–33.
- Rangaswamy, H.R. & Channa Basavanna, G.P. (1973) A new species of heterozerconid mite (Mesostigmata: Heterozerconidae) from India. *Mysore Journal of Agricultural Sciences*, 7 (1), 134–136.
- Vitzthum, H. (1925) Fauna sumatrensis (Beitrag No. 5) Acarina. *Supplementa Entomologica*, 11, 37–48. [published in 1926]
- Vitzthum, H. (1926) Malayische Acari. *Treubia, Buitenzorg*, 8, 1–198.
- Womersley, H. (1958) Some new or little known Mesostigmata (Acarina) from Australia, New Zealand and Malaya. *Transactions of the Royal Society of South Australia*, 81, 115–130.