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## Two new species of *Petrobunus* from China (Opiliones: Laniatores: Petrobunidae)

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### Abstract

Two new species of *Petrobunus* Sharma & Giribet, 2011, (Petrobunidae) are described: *P. chongqing* sp. nov. (♀♂) and *P. hebei* sp. nov. (♀♂). *Petrobunus chongqing* sp. nov. is similar to *P. spinifer* Sharma & Giribet, 2011, in having two large spines on the male sternite 7. However, the new species can be distinguished from *P. spinifer* by the absence of a ventral tubercle on the male femur IV, as well as the presence of three pairs of enlarged tubercles on the lateral margin of area V and free tergites I–II. *Petrobunus hebei* sp. nov. and *P. torosus* Sharma & Giribet, 2011 closely resemble each other. They are distinguished by the morphology of the ocularium, in that *P. torosus* has a median tubercle whereas the ocularium of *P. hebei* sp. nov. is unarmed. The discovery and descriptions of these species greatly expand the known range of the genus *Petrobunus*.

**Key words:** Arachnida, harvestmen, taxonomy, genitalia

### Introduction

Petrobunidae was recently erected by Sharma & Giribet (2011). The family includes two genera, *Petrobunus* Sharma & Giribet, 2011, and *Zalmoxida* Roewer, 1912. The type genus *Petrobunus* is remarkable in having a greatly incrassate coxa and trochanter of male leg IV, with the trochanter IV appearing sub-rectangular in lateral aspect. This genus was described based on three species, *P. schwendingeri* Sharma & Giribet, 2011 (the type species), *P. spinifer* Sharma & Giribet, 2011, and *P. torosus* Sharma & Giribet, 2011. These previously described species are restricted to the Philippine islands of Palawan and Panay (Sharma & Giribet 2011).

Herein, two new species of *Petrobunus* are described: *P. chongqing* sp. nov. and *P. hebei* sp. nov. The description of these species broadens the known distribution of *Petrobunus* significantly. The description of *P. hebei* sp. nov. additionally constitutes the northernmost locality of Chinese Laniatores to date.

### Materials and methods

Specimens were preserved in 75% ethanol, and examined and drawn under a Leica M205A stereomicroscope equipped with a drawing tube. Photographs were taken using a DFC450 CCD camera coupled to the stereomicroscope. Male genitalia were initially placed in hot lactic acid, followed by distilled water, to expand those parts for observation (Schwendinger & Martens 2002). The terminology of genitalic structures follows Macías-Ordóñez *et al.* (2010). The type specimens were deposited in the Museum of Hebei University, Baoding, China (MHBU). All measurements are given in mm.

## Taxonomy

### Petrobunidae Sharma and Giribet, 2011

Petrobunidae Sharma & Giribet, 2011: 111.

**Type genus:** *Petrobunus* Sharma and Giribet, 2011.

**Genera included:** *Petrobunus* Sharma and Giribet, 2011; *Zalmoxida* Roewer, 1912 [familial assignment by Sharma & Giribet (2011)].

### *Petrobunus* Sharma and Giribet, 2011

*Petrobunus* Sharma & Giribet, 2011: 112.

Type species: *Petrobunus schwendingeri* Sharma and Giribet, 2011, by original designation.

**Distribution** (Fig. 52). China (Chongqing, Hebei, Taiwan), Philippine (Palawan, Panay),

**Expansion of Penis** (Figs. 37–45). Due the hydraulic pressure the glans exhibit a mix of two movements: The capsula externa have an erection movement changing the position (90–100 degrees) respect to the truncus axis and the capsula interna is everted. As result of the capsula interna movement the parastylar lobes are completely everted and folded against the capsula externa and the stylus fully exposed.

### Key to species of *Petrobunus*

1	Ocularium armed with a median tubercle (Sharma & Giribet, 2011:119, fig. 11b) . . . . .	<i>P. torosus</i>
-	Ocularium unarmed. . . . .	2
2	Free tergites with conspicuous tubercles (Sharma & Giribet, 2011:116, fig. 7a; 118, fig. 10a) . . . . .	<i>P. spinifer</i>
-	Free tergites with granules or unarmed. . . . .	3
3	Dorsal scutum or Opisthosomal sternite unarmed in male . . . . .	<i>P. hebei</i> sp. nov.
-	Dorsal scutum or Opisthosomal sternite armed tubercles (Fig. 1) or spines (Sharma & Giribet, 2011:112, fig. 4b) in male . . . . .	4
4	Scutal area V and free tergites I and II of male armed with paired enlarged lateral tubercles, opisthosomal sternite 7 of male with two large setose spines . . . . .	<i>P. chongqing</i> sp. nov.
-	Dorsal scutum unarmed that of tubercles, opisthosomal sternite 7 of male with four large setose spines . . . . .	<i>P. schwendingeri</i>

### *Petrobunus chongqing* sp. nov.

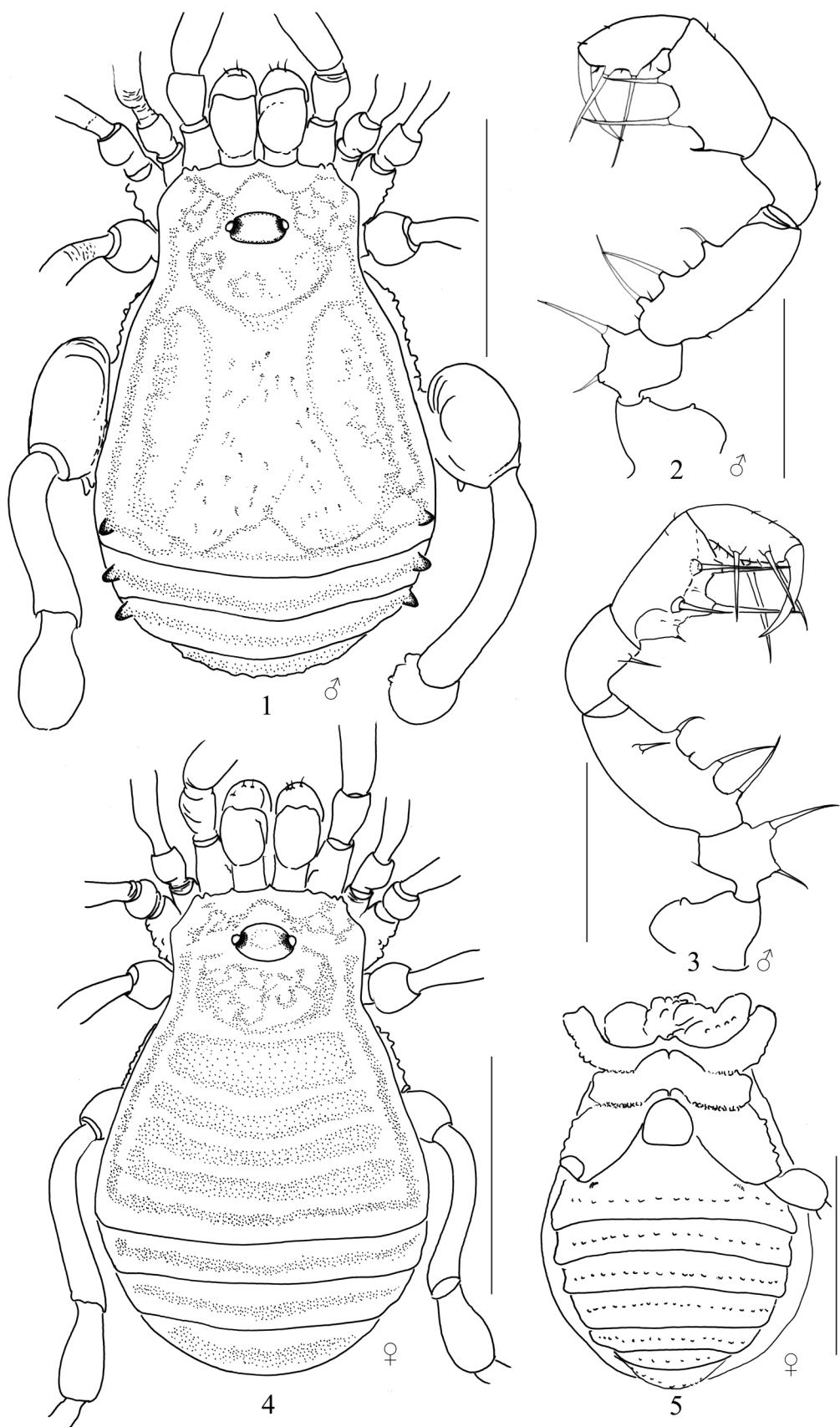
(Figs. 1–22, 37–40)

**Type material.** Male holotype, China: Chongqing City, Jinshan Town, Shiti Cave [N 28°56', E 107°05'], alt. 850m, May 27, 2016, C. Zhang leg. (MHBU-Opi-16ZC1122). One female, paratype (MHBU-Opi-16ZC1123), same collecting data as holotype.

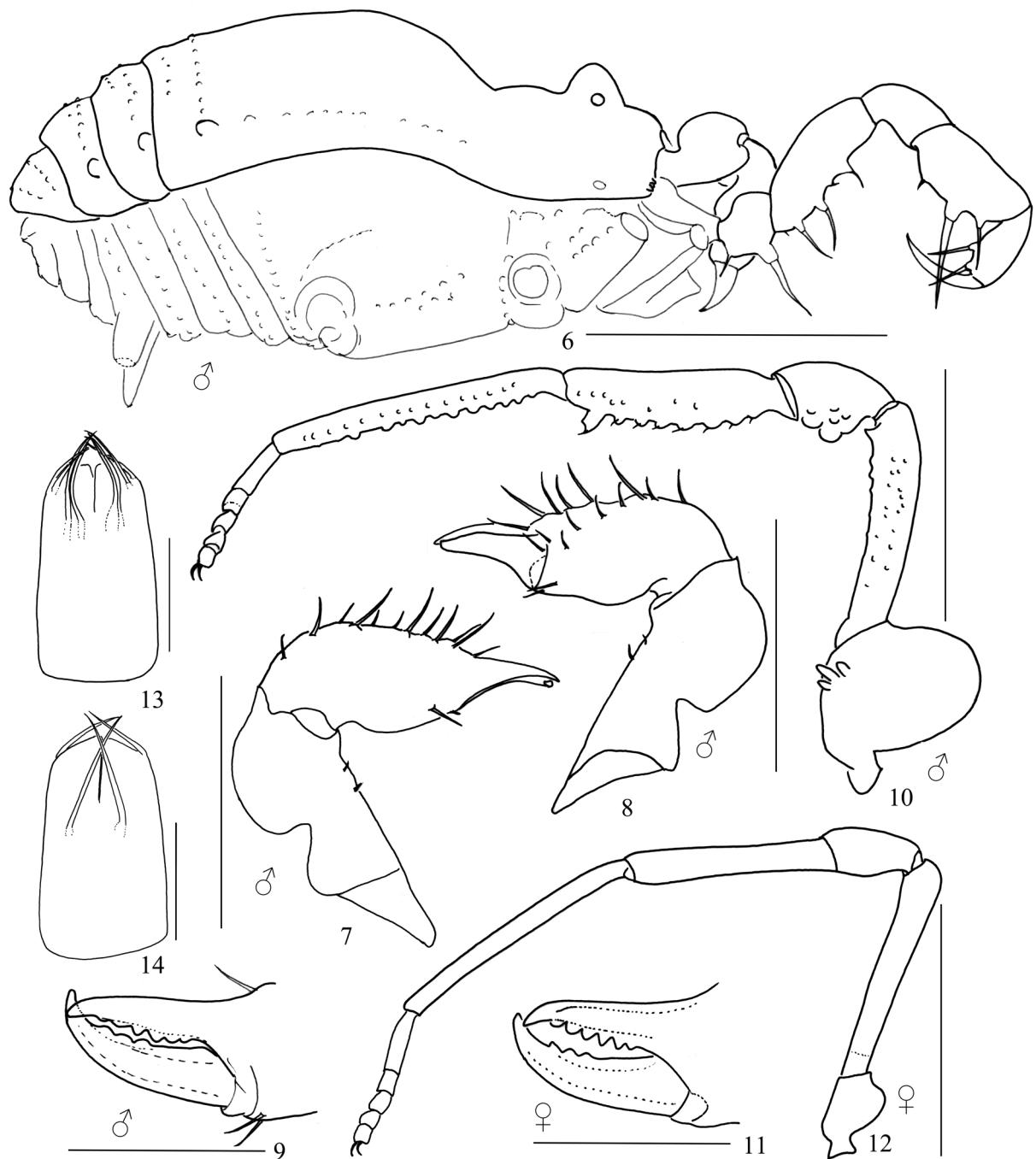
**Diagnosis.** Large size (body length > 2 mm); scutal area V, free tergites I and II of male each with a pair of lateral enlarged tubercles; opisthosomal sternite 7 of male with two large setose spines; trochanter IV of male with three mesoventral tubercles; the distal end of ventral plate of arrowhead shape (dorsal view); stylus slender and curved.

**Etymology.** The specific epithet is a noun in apposition, referring to the type locality.

**Description.** Male (holotype) habitus as in Figs. 1, 6, 15–17, 21. Coloration (Figs. 15–17): entire body rusty yellow; carapace and ocularium with blackish brown reticulations; the opisthosomal region of scutum centrally with a upside down cordiform band of blackish brown, which the five areas; both lateral ridges of the scutum blackish brown; free tergites with transverse rows of dark brown stripes; coxae and genital operculum yellow; all free sternites with dark brown bands, somewhat lighter medially; chelicerae and pedipalpi with the same coloration as the dorsum, also with blackish brown reticulate markings dorsally; legs yellow to brown as well as basitarsus, remaining tarsomeres whitish yellow.



**FIGURES 1–5.** *Petrobunus chongqing* sp. nov. male holotype and female paratype. 1. Male body, dorsal view. 2. Male, left pedipalp, ectal view. 3. Same, medial view. 4. Female body, dorsal view. 5. Same, ventral view. Scale bars: 1 mm (1, 4, 5); 0.5 mm (2, 3).



**FIGURES 6–14.** *Petrobunus chongqing* sp. nov. male holotype and female paratype. 6. Male body, lateral view. 7. Male, left chelicera, medial view. 8. Same, ectal view. 9. Male, cheliceral fingers, frontal view. 10. Male, left leg IV, retrolateral view. 11. Female, cheliceral fingers, frontal view. 12. Female, left leg IV, retrolateral view. 13. Ovipositor, dorsal view. 14. Same, ventral view. Scale bars: 1 mm (6, 10, 12); 0.5 mm (7, 8); 0.25 mm (9, 11, 13, 14).

Dorsum (Figs. 1, 15). Dorsal scutum granular and pyriform in shape, widest portion of body at scutal area V. Carapace with two blunt pegs on each side of anterior margin of carapace located near antero-lateral corners. Ocularium unarmed. Scutal sulci of mesotergum indistinct. Scutal area V with a single lateral enlarged tubercle on each side as well as free tergites I and II (Figs. 1, 6). Anal operculum with numerous scattered granules.

Venter (Fig. 16). Surface of all coxae granulated. Coxa II with a few setose tubercles retrolaterally. Coxa III with prolateral and retrolateral tubercular bridges to adjacent coxae. Coxa IV greatly enlarged, with setose

tubercles on anterior margin. Genital operculum sub-triangular. Spiracles not concealed. Opisthosomal sternites 3–6 each with belt of small regular tubercles. Opisthosomal sternite 7 with two large setose spines directly posteroventrally.

Chelicera (Figs. 7–9). Proximal article with a prominent bulla, but without any conspicuous armament. Second article unarmed, with scattered setae mainly on the prodorsal surface. Fingers relatively short, dentition as illustrated (Fig. 9); movable finger with three teeth; fixed finger with six teeth.

Pedipalp (Figs. 2, 3). Coxa dorsally with two small blunt tubercles. Trochanter ventrally with one short proximal and one long distal setiferous tubercle. Femur ventrally with a row of four setiferous tubercles, two proximal ones being the longest, the medial one being the shortest; on the medial distal side with one setiferous tubercle. Patella with one setiferous tubercle disto-medially. Tibia with two setiferous tubercles mesally; ectally with one short proximal and two long setiferous tubercles. Tarsus with two setiferous tubercles on both sides of ventral surface. Tarsal claw curved and smooth approximately the same length as the tarsus.

Legs (Figs. 10, 15–17). All segments finely granulated. Trochanter III enlarged. Trochanter IV greatly enlarged, oval in lateral aspect, with three mesoventral tubercles (Fig 10). Femora III–IV curved, especially femur IV. Femur IV with slightly enlarged granules on ventral surface. Patella IV conspicuously incrassated. Patella IV, tibia IV and metatarsus IV ventrally with enlarged tubercles, one near the distal end forming a spine on the tibia IV. Tarsi III–IV with bare double claws, without scopulae. Tarsal claws smooth. Tarsal formula, 3 (2): 5 (3): 5: 5.

Penis (Figs. 37–40) slender, sides nearly parallel along its shaft. Pars distalis well-defined, wider than pars basalis. Distal end of the ventral plate shaped like an arrowhead (dorsal region, not inflatable). Ventral plate with seven pairs of setae on lateral margins. Glans free in apical part, with parastylar lobe extending proximally (not inflatable). Capsula externa cylindrical. Capsula interna small, irregular ovate. The parastylar lobes including one triangular ventral lobe and one bifurcate dorsal lobe. Stylus elongate tubular, and curved.

Female. (Figs. 4, 5, 11, 12, 18–20, 22). In general appearance similar to the male, but lacking lateral enlarged tubercles on scutal area V and on free tergites I and II, and lacking the large setose spines on opisthosomal sternite 7 (Figs. 4, 5, 18–20, 22). Leg IV not enlarged and lacking tubercles on coxa through metatarsus (Fig. 12). Cheliceral dentition as illustrated (Fig. 11).

Ovipositor (Figs. 13, 14) composed of two apical lobes, each bearing two dorsal setae, one ventral seta, and two apical setae.

**Measurements.** Male holotype (female paratype): body 2.24 (2.01) long, prosoma 0.82 (0.80) wide, opisthosoma 1.40 (1.39) wide; length-to-width ratio 1.60 (1.45). Ocularium 0.15 (0.16) long, 0.25 (0.28) wide. Pedipalp claw 0.29 (0.27) long. Penis 1.23 long. Measurements of pedipalp and legs as in Tables 1, 2.

**Habitat.** The specimens were collected by hand by turning rocks in a small cave about ten meters long.

**Distribution.** Known only from the type locality (Fig. 52).

**TABLE 1.** Pedipalp and legs measurements of *Petrobunus chongqing* sp. nov. holotype, length/width

	Trochanter	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
Pedipalp	0.17/0.20	0.48/0.17	0.32/0.16	0.36/0.20		0.32/0.14	1.65
Leg I	0.20/0.17	0.71/0.12	0.32/0.15	0.46/0.13	0.68/0.07	0.55/0.07	2.92
Leg II	0.25/0.17	0.93/0.11	0.41/0.16	0.70/0.12	0.81/0.07	0.91/0.07	4.01
Leg III	0.25/0.21	0.74/0.14	0.35/0.19	0.60/0.15	0.81/0.09	0.57/0.07	3.32
Leg IV	0.60/0.64	1.02/0.18	0.51/0.27	0.90/0.21	1.24/0.12	0.60/0.08	4.87

**TABLE 2.** Pedipalp and legs measurements of *Petrobunus chongqing* sp. nov. female paratype, length/width

	Trochanter	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
Pedipalp	0.20/0.19	0.46/0.18	0.31/0.15	0.36/0.18		0.33/0.13	1.66
Leg I	0.21/0.16	0.65/0.11	0.33/0.14	0.45/0.11	0.62/0.07	0.54/0.07	2.80
Leg II	0.25/0.17	0.88/0.11	0.38/0.13	0.63/0.11	0.74/0.07	0.96/0.07	3.84
Leg III	0.25/0.17	0.72/0.12	0.30/0.17	0.55/0.14	0.74/0.08	0.61/0.07	3.17
Leg IV	0.37/0.21	0.90/0.13	0.40/0.18	0.77/0.14	1.07/0.08	0.63/0.07	4.14



**FIGURES 15–20.** Photographs of *Petrobunus chongqing* sp. nov. male holotype and female paratype. 15. Male body and parts of appendages, dorsal view. 16. Same, ventral view. 17. Same, lateral view. 18. Female body and parts of appendages, dorsal view. 19. Same, ventral view. 20. Same, lateral view. Scale bars: 1 mm (17, 20); 0.5 mm (15, 16, 18, 19).

#### *Petrobunus hebei* sp. nov.

(Figs. 23–36, 41–49)

**Type material.** Male holotype, China: Hebei Province, Baoding City, Yi Country, Mt. Yunmeng Shan [N 39°24', E 115°15'], alt. 440m, June 12, 2012, C. Zhang leg. (MHBG-Opi-16ZC1116). One female, paratype (MHBG-Opi-16ZC1117), same collecting data as holotype.

**Diagnosis.** Unique tarsal formula (2:2:4:4); body, including ocularium and legs, unarmed; stylus short and straight.

**Etymology.** The specific epithet is a noun in apposition, referring to the type locality.

**Description.** Male habitus as in Figs. 23, 24, 28, 46–48. Coloration (Figs. 46–48): entire body yellow; carapace and ocularium with blackish brown reticulations; opisthosomal region of scutum and free tergites with transverse rows of brown stripes; coxae and genital operculum yellow; all free sternites with brown bands; legs yellow to brown as well as basitarsus, remaining tarsomeres whitish yellow.

Dorsum (Figs. 23, 46). Dorsal scutum granular and trapezoid in shape, widest portion of body at scutal area V. Carapace with two blunt pegs on each side of anterior margin of carapace near antero-lateral corners. Ocularium unarmed. Scutal sulci of mesotergum indistinct. Scutum and free tergites unarmed.

Venter (Figs. 24, 47). Surface of all coxae granulated. Coxa II with many setose tubercles retrolaterally. Coxa III with prolateral and retrolateral tubercular bridges to adjacent coxae. Coxa IV greatly enlarged, with setose tubercles on anterior margin. Genital operculum sub-triangular. Spiracles not concealed. Opisthosomal free sternites with belts of small regular tubercles.

Chelicera (Figs. 29–31). Proximal article with a prominent bulla, but without any conspicuous armament. Second article unarmed, with scattered setae on the prodorsal surface. Fingers relatively short, dentition as illustrated (Fig. 31); movable finger with three teeth; fixed finger with five teeth.

Pedipalp (Figs. 25, 26). Coxa dorsally with one small blunt tubercle. Trochanter ventrally with one short proximal and one long distal setiferous tubercle. Femur ventrally with a row of four setiferous tubercles, two proximal ones being the longest, the medial one being the shortest; on the medial distal side with one setiferous tubercle. Patella with one setiferous tubercle disto-medially. Tibia with two setiferous tubercles mesally; ectally with one short proximal and two long setiferous tubercles. Tarsus with two setiferous tubercles on both sides of ventral surface. Tarsal claw curved and smooth, approximately the same length as the tarsus.

Legs (Figs. 32, 46–48). All segments finely granulated. Trochanter III enlarged. Trochanter IV greatly enlarged, oval in lateral aspect and unarmed (Fig. 32). Femora III–IV curved, especially femur IV. Femur IV, Patella IV and tibia IV with enlarged granules (Fig. 32). Tarsi III–IV with bare double claws, without scopulae. Tarsal claws smooth. Tarsal formula, 2 (1): 2 (1): 4: 4.

Penis (Figs. 41–45). Basal portion of the shaft slender, then distended until apical portion (pars distalis). Apex of ventral plate somewhat triangular. Ventral plate with five pairs of setae on lateral margins. Glans free in apical part, with parastylar lobe extending proximally (not inflatable). Capsula externa cylindrical. Capsula interna globular. Diameter of fully inflatable Capsula interna conspicuously longer than that of the capsula externa. Parastylar lobes including one triangular ventral lobe and two square-shaped dorsal lobes. Stylus short, straight, similar in length to capsula externa.

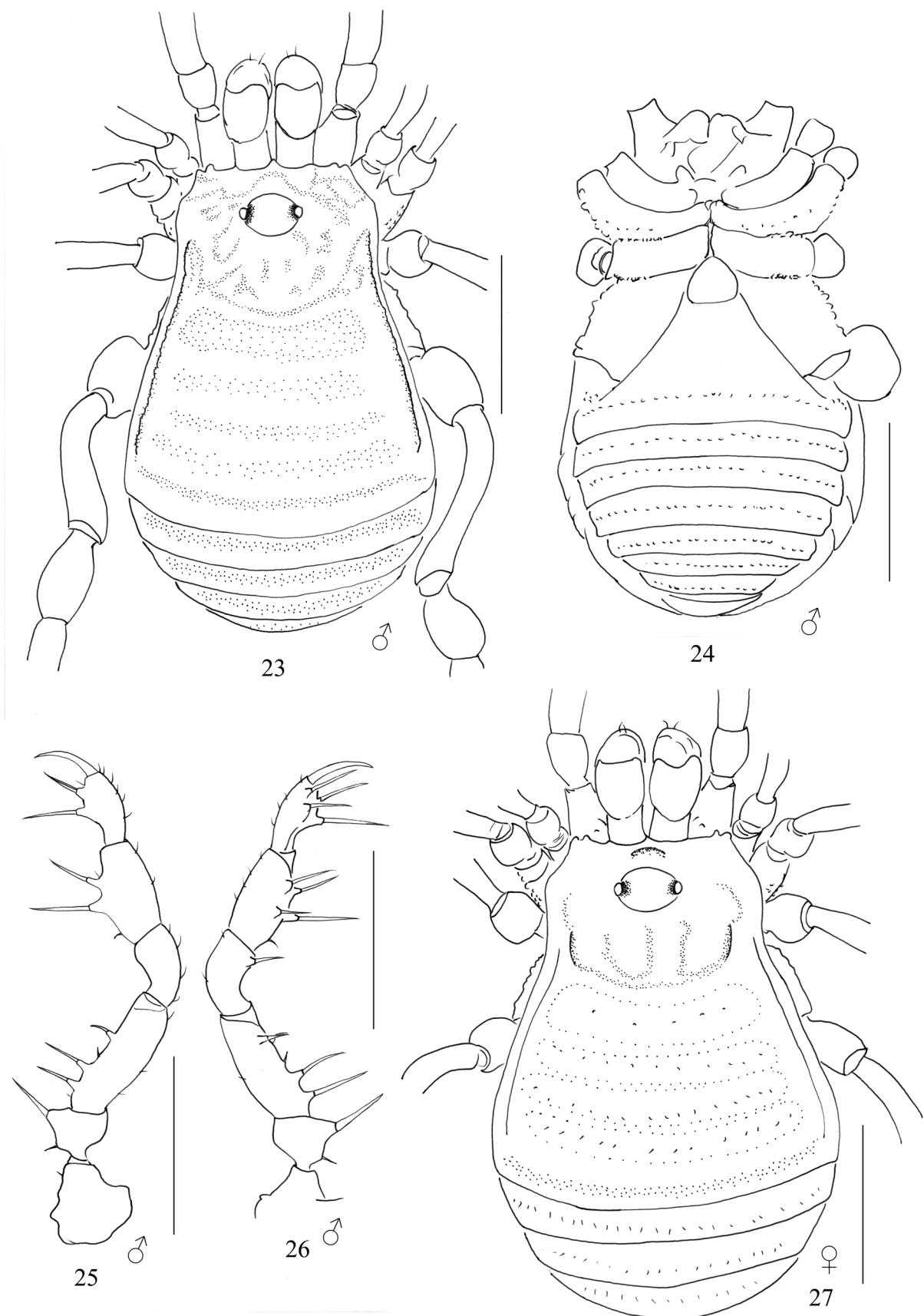


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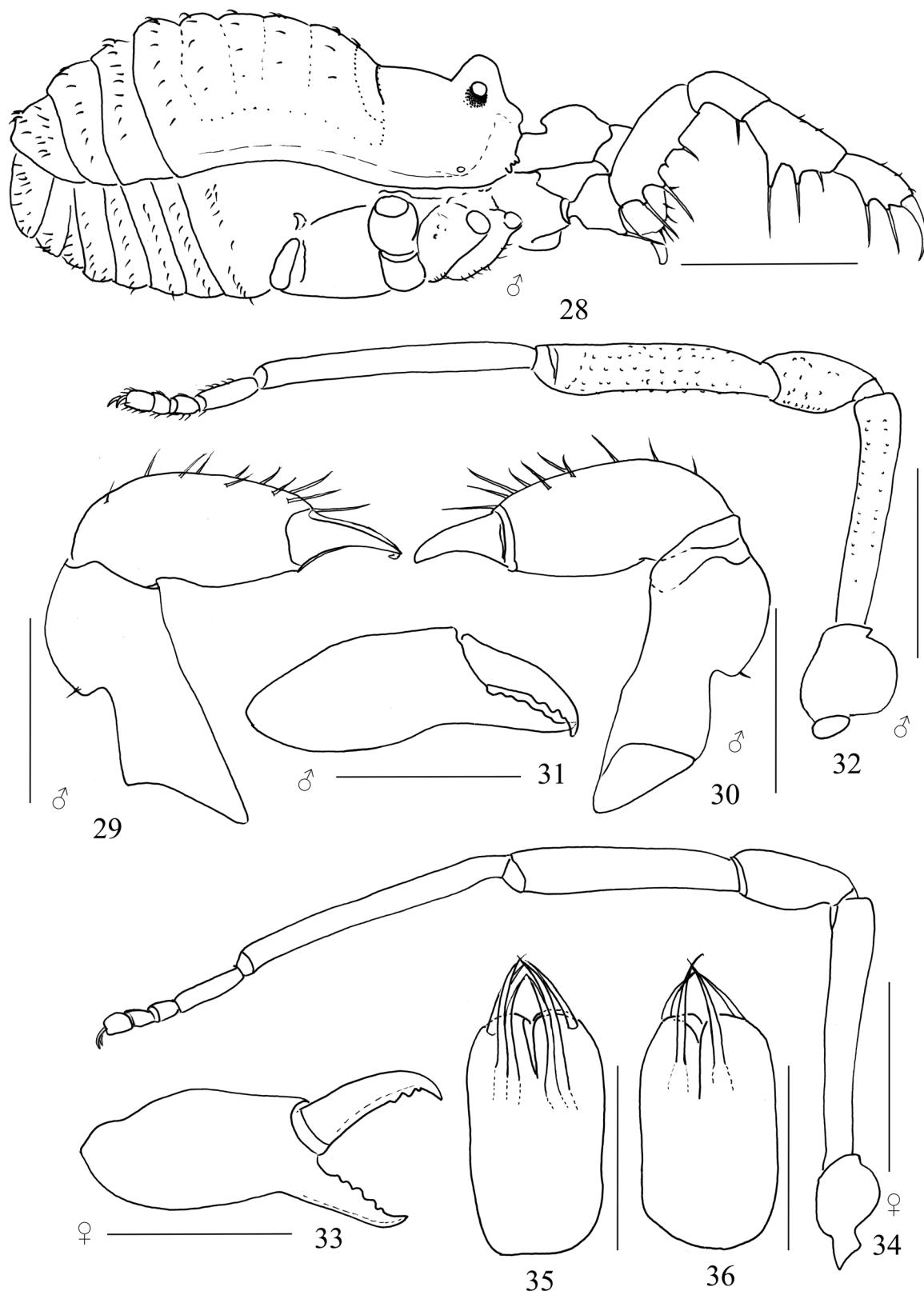


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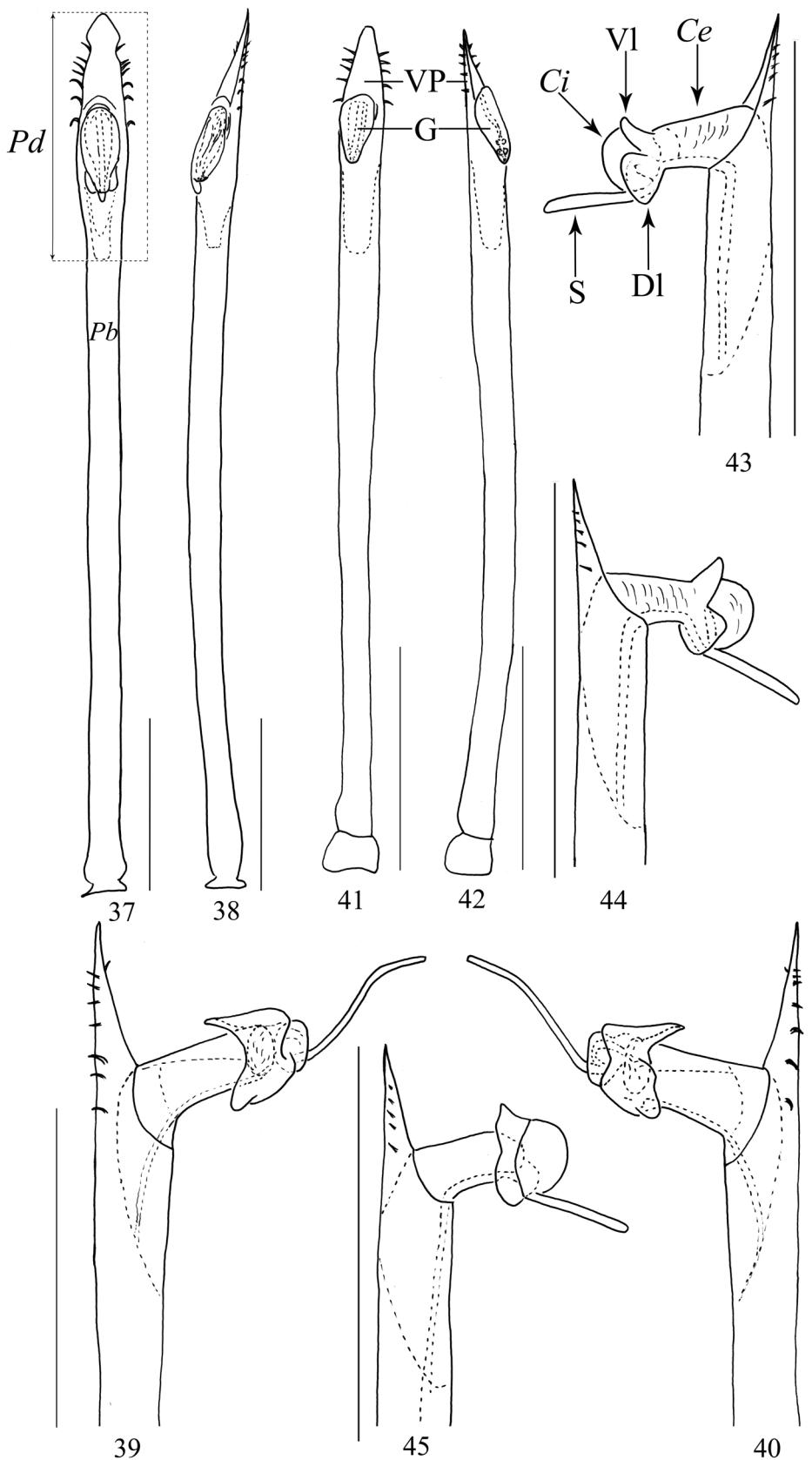
**FIGURES 21–22.** Live habitus of *Petrobunus chongqing* sp. nov.. 21. Male holotype. 22. Female paratype.



**FIGURES 23–27.** *Petrobunus hebei* sp. nov. male holotype and female paratype. 23. Male body, dorsal view. 24. Same, ventral view. 25. Male, left pedipalp, ectal view. 26. Same, medial view. 27. Female body, dorsal view. Scale bars: 0.5 mm.



**FIGURES 28–36.** *Petrobunus hebei* sp. nov. male holotype and female paratype. 28. Male body, lateral view. 29. Male, left chelicera, medial view. 30. Same, ectal view. 31. Male, cheliceral fingers, frontal view. 32. Male, left leg IV, retrolateral view. 33. Female, cheliceral fingers, frontal view. 34. Female, left leg IV, retrolateral view. 35. Ovipositor, dorsal view. 36. Same, ventral view. Scale bars: 0.5 mm (28, 32, 34); 0.25 mm (29–31, 33, 35, 36).



**FIGURES 37–45.** Penis. 37–40. *Petrobunus chongqing* sp. nov. holotype, 41–45. *Petrobunus hebei* sp. nov. holotype. 37. Penis, dorsal view. 38. Same, lateral view. 39. Distal part of penis (expanded), lateral view. 40. Same, lateral view. 41. Penis, dorsal view. 42. Same, lateral view. 43. Distal part of penis (expanded), lateral view. 44. Same, lateral view. 45. Same, lateral view (fully expanded). *Ce*, capsula externa; *Ci*, Capsula interna; *DI*, dorsal lobe; *G*, glans; *Pb*, pars basalis; *Pd*, pars distalis; *S*, stylus; *VI*, ventral lobe; *VP*, ventral plate. Scale bars: 0.25 mm



**FIGURES 46–51.** Photographs and habitat of *Petrobunus hebei* sp. nov. male holotype and female paratype. 46. Male body and parts of appendages, dorsal view. 47. Same, ventral view. 48. Same, lateral view. 49. Female body and parts of appendages, dorsal view. 50–51. Habitat. Scale bars: 0.5 mm (46–49).

Female. (Figs. 27, 33, 34, 49). In general appearance similar to the male (Figs. 27, 49), with a slight difference in inner edges of cheliceral finger (Fig. 33) and leg IV not enlarged (Fig. 34).

Ovipositor (Figs. 35, 36) composed of two apical lobes, each bearing two dorsal setae, one ventral seta, and two apical setae.

**Measurements.** Male holotype (female paratype): body 1.51 (1.54) long, prosoma 0.64 (0.66) wide, opisthosoma 0.96 (1.08) wide; length-to-width ratio 1.57 (1.43). Ocularium 0.12 (0.14) long, 0.20 (0.21) wide. Pedipalp claw 0.19 (0.19) long. Penis 0.81 long. Measurements of pedipalp and legs as in Tables 3, 4.

**Habitat.** The specimens were collected by sifting leaf litter in shrubs close to the trail depicted in Figs. 50, 51.

**Distribution.** Known only from the type locality (Fig. 52).

**Notes.** *Petrobunus hebei* sp. nov. is the northernmost Laniatores species from China.

**TABLE 3.** Pedipalp and legs measurements of *Petrobunus hebei* sp. nov., holotype, length/width

	Trochanter	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
Pedipalp	0.15/0.15	0.32/0.11	0.24/0.11	0.26/0.14		0.21/0.09	1.18
Leg I	0.13/0.11	0.47/0.08	0.24/0.10	0.30/0.09	0.40/0.06	0.41/0.07	1.95
Leg II	0.16/0.12	0.62/0.08	0.28/0.11	0.44/0.09	0.50/0.06	0.61/0.07	2.61
Leg III	0.16/0.14	0.51/0.10	0.21/0.13	0.41/0.11	0.55/0.06	0.38/0.07	2.22
Leg IV	0.35/0.25	0.66/0.12	0.32/0.16	0.60/0.13	0.74/0.08	0.41/0.07	3.08

**TABLE 4.** Pedipalp and legs measurements of *Petrobunus hebei* sp. nov., female paratype, length/width

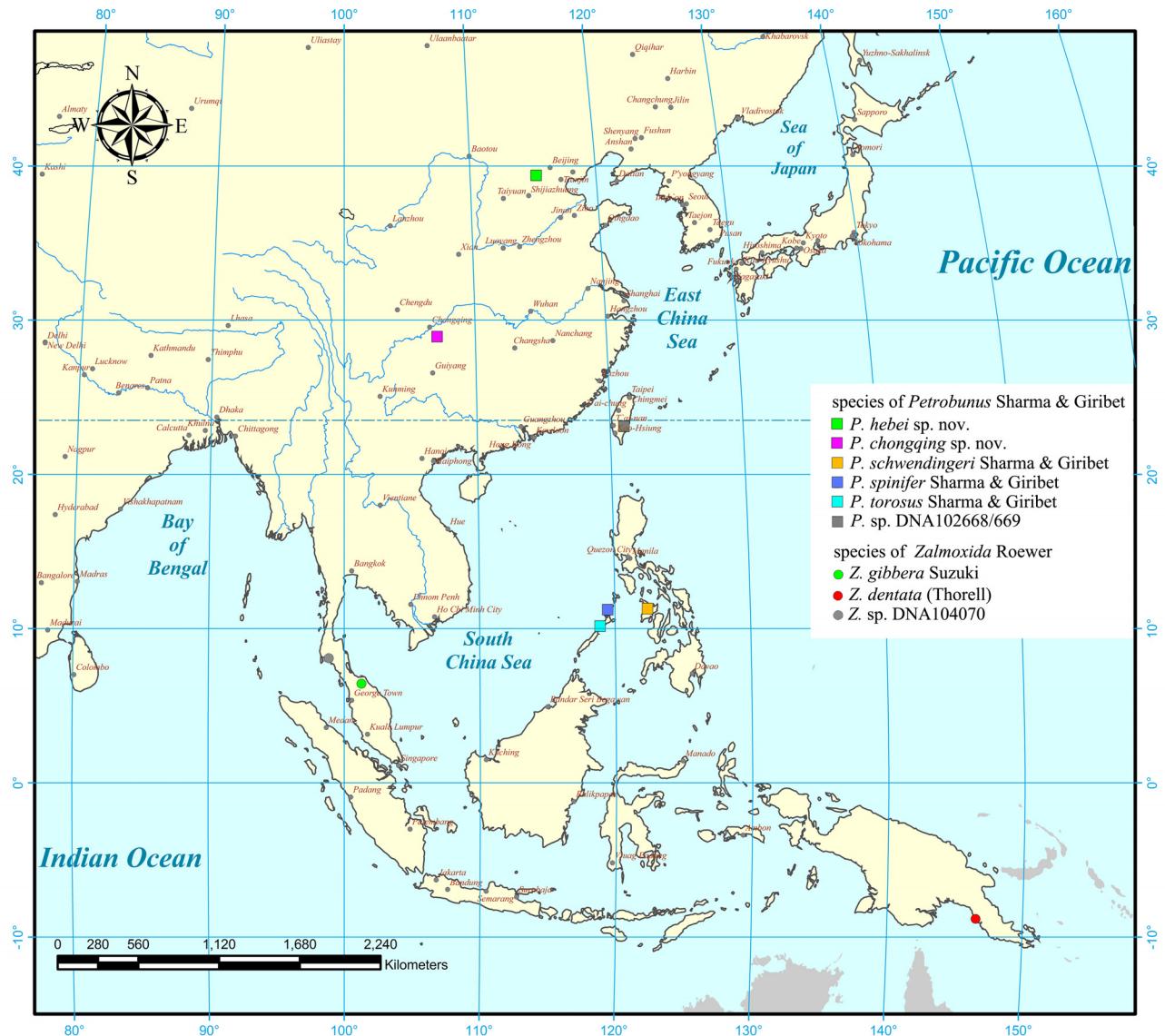
	Trochanter	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
Pedipalp	0.18/0.15	0.35/0.13	0.23/0.12	0.27/0.15		0.24/0.10	1.27
Leg I	0.14/0.12	0.49/0.09	0.24/0.11	0.32/0.09	0.43/0.06	0.38/0.05	2.00
Leg II	0.16/0.13	0.64/0.09	0.32/0.11	0.47/0.09	0.55/0.06	0.60/0.05	2.74
Leg III	0.16/0.16	0.55/0.09	0.24/0.13	0.41/0.10	0.55/0.06	0.39/0.05	2.30
Leg IV	0.23/0.16	0.73/0.11	0.31/0.13	0.66/0.11	0.73/0.08	0.40/0.05	3.06

## Discussion

Petrobunidae is part of a loose aggregation of families of Laniatores regarded as the superfamily Epedanoidea (*sensu* Sharma & Giribet 2011). The monophyly of Epedanoidea remains an open question, as a recent phylogenomic analysis of Opiliones did not find unambiguous support and stability for this superfamily (Fernández *et al.* 2017). The epedanoids are instead united by a characteristic biogeographic distribution: they are all largely restricted to southeast Asia. The exception to this rule, the family Podoctidae, is additionally found in the Mascarene Islands, East Africa, and parts of Melanesia and Micronesia, but the phylogeny of the group is strongly consistently with an ancestral range in southeast Asia as well (Sharma *et al.* 2017).

The description of *Petrobunus* from the Chinese mainland contributes to the known biodiversity of the group (Fig. 52), which was previously restricted to three Philippine species and one undescribed Taiwanese morphospecies that was included in a molecular phylogeny of Laniatores (Sharma & Giribet 2011). Intriguingly, the localities in the Philippines where *Petrobunus* was described are all interpreted to be of continental origin (northern Panay and the island of Palawan). Taken together with the continental association of the sister genus, *Zalmoxida* (restricted to the Thai-Malay Peninsula and New Guinea, with one undescribed morphospecies known from Sumatra; Sharma & Giribet 2011) and the new species we describe here, the family Petrobunidae appears to exhibit limited capacity for transoceanic dispersal. Such limited dispersal ability of southeast Asian harvestman families has provided apt model systems for study of comparative historical biogeography in this regional theater, such as Stylocellidae (e.g., Clouse & Giribet 2010; Giribet *et al.* 2012) and Sandokanidae (Sharma & Giribet 2009). However, other families of harvestman have also been shown to possess remarkable dispersal capacity. For example, the distribution of Zalmoxidae partially overlaps that of Petrobunidae and far more Philippine species of zalmoxids are known than petrobunids (Sharma 2012; Sharma *et al.* 2012). Zalmoxids are clearly Neotropical in origin and thus their diversity in southeast Asia cannot be attributed to *in situ* diversification alone (Sharma & Giribet 2012). Renewed interest in the taxonomy of poorly understood families like Petrobunidae may thus provide an additional test cases for models of range evolution in the opiliofauna of southeast Asia.

The discovery of *Petrobunus* additionally provides a potential biogeographic link between known species endemic to continental islands (Palawan, Panay, and Taiwan) and its sister genus *Zalmoxida*. Understanding of how these species are related may close gaps in their biogeographic disjunctions. Future efforts should aim to assess phylogenetic relationships within the petrobunids using molecular sequence data in tandem with taxonomic efforts.



**FIGURE 52.** Geographic distribution of Petrobunidae taxa.

### Acknowledgements

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