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Contribution to the knowledge of the oribatid mite genus *Hardybodes* (Acari, Oribatida, Carabodidae) with description of a new species from the Philippines

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ABSTRACT

A new species of the genus *Hardybodes* (Oribatida, Carabodidae) is described from the nest of an unknown species of ants (Formicidae) in soil in Luzon Island, Philippines. *Hardybodes minutus* n. sp. differs from all species of the genus by the localization of notogastral setae (lm and h_2 inserted in the same longitudinal row dorsocentrally together with da , dm , dp , lp and h_1 versus lm and h_2 in dorsolateral positions and da , dm , dp , lp and h_1 inserted in dorsocentral positions in the other species). Revised generic diagnosis and an identification key to the four known species of *Hardybodes* are presented.

Keywords carabodid mites, new species, morphology, systematics, key, Formicidae, Philippines

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Introduction

The oribatid mite genus *Hardybodes* (Acari, Oribatida, Carabodidae) was proposed by Balogh, 1970 with *Hardybodes mirabilis* Balogh, 1970 as type species. It comprises three species (Balogh 1970; Mahunka 1995), which are distributed in the Oriental and Australian regions: *H. flabellatus* Mahunka, 1995 and *H. penicillatus* Mahunka, 1995 were described from soil of tropical forest on Borneo (Mahunka 1995); *H. mirabilis* Balogh, 1970 from litter of small forest in New Guinea and also recorded in different plant associations in the Philippines (Corpuz-Raros 1979) and in litter of tropical forests on Borneo (Mahunka 1987). Subías (2004, online version 2017) considers the genus *Carabodella* Mahunka, 1986(b) as the junior synonym of *Hardybodes*, including its type species *Carabodella calcarata* Mahunka, 1986(b) in the latter. However, we support independence of *Carabodella* after explanations of Fernandez *et al.* (2015).

In the course of taxonomic study of new materials of carabodid mites from the collection of the Museum of Natural History (University of the Philippines Los Baños), we found a new species of *Hardybodes*. It is the fourth representative of the genus, and the species is second only to *H. mirabilis* which was recorded earlier (e.g. Corpuz-Raros 1979) for the Philippine fauna.

This paper aims to describe and illustrate the new species, update generic diagnosis and give an identification key to known species of the genus *Hardybodes*.

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Materials and methods

Material examined — Holotype (male) and one paratype (male): Philippines, Luzon Island, boundary between Laguna and Quezon Provinces, University of the Philippines Land Grant, nest in soil of unknown species of ants (Formicidae) (the nest is located by following major ant trails), extracted with Berlese funnel, 23.I.2016 (collected by R. Garcia, J. Naredo and H. Klompen).

Methods — Specimens were mounted in lactic acid on temporary cavity slides for measurement and illustration. Body length was measured in lateral view, from the tip of the rostrum to the posterior edge of the ventral plate. Notogastral width refers to the maximum width of notogaster. Lengths of body setae were measured in lateral aspect. All body measurements are presented in micrometers. Formulas for leg setation are given in parentheses according to the sequence trochanter–femur–genu–tibia–tarsus (famulus included). Formulas for leg solenidia are given in square brackets according to the sequence genu–tibia–tarsus. Drawings were made with a camera lucida using a Leica transmission light microscope “Leica DM 2500”. Morphological terminology used in this paper follows that of F. Grandjean: see Travé and Vachon (1975) for references, Norton (1977) for leg setal nomenclature, and Norton and Behan–Pelletier (2009), for overview.

The following abbreviations are used on the figures: *lam* – lamella; *ro*, *le*, *in*, *bs* – rostral, lamellar, interlamellar and bothridial setae, respectively; *tu* – tutorium; *con* – concavity; *c*, *da*, *dm*, *dp*, *la*, *lm*, *lp*, *h*, *p* – notogastral setae; *ia*, *im*, *ip*, *ih*, *ips* – notogastral lyrifissures; *gla* – opisthonotal gland opening; *csb* – circumgastric sigillar band; *h*, *m*, *a* – subcapitular setae; *v*, *l*, *d*, *cm*, *ul*, *sul*, *vt*, *lt* – palp setae; *cha*, *chb* – cheliceral setae; Tg – Trägårdh’s organ; Pd I, Pd II – pedotecta I and II, *dis* – discidium; *1a*, *1b*, *1c*, *2a*, *3a*, *3b*, *3c*, *4a*, *4b*, *4c* – epimeral setae; *g*, *ag*, *an*, *ad* – genital, aggenital, anal and adanal setae, respectively; *iad* – adanal lyrifissure; *p.o.* – preanal organ; ω , σ , ϕ – solenidia; ϵ – leg famulus; *v*, *ev*, *bv*, *l*, *d*, *ft*, *tc*, *it*, *p*, *u*, *a*, *s*, *pv* – leg setae.

The following collections are used: SMNH – Senckenberg Museum of Natural History, Görlitz, Germany; TSUMZ – Tyumen State University Museum of Zoology, Tyumen, Russia.

Systematics

Genus *Hardybodes* Balogh, 1970

Type species: *Hardybodes mirabilis* Balogh, 1970, p. 298

Updated generic diagnosis (based on Balogh 1970; Mahunka 1986a; Fernandez *et al.* 2013, 2015)

Adult — Carabodidae (e.g. Mahunka 1986a; Norton and Behan–Pelletier 2009). Body elongated, ratio (length/width): ≈ 2.0 . Body surface microgranulate, notogaster mostly tuberculate. Rostral margin rounded. Lamellae broad, well separated, located dorsolaterally. Translamella and interlamellar processes absent. Tutorium lineate or triangular distally. Rostral, lamellar and interlamellar setae short, setiform or slightly phylliform (exception: *le* bifurcate), *ro* inserted on prodorsal surface, near to the rostrum, *in* inserted on lamellae. Bothridial setae spatulate or thickened. Dorsosejugal region without deep concavities. Notogaster without large apophyses and ridges. Fifteen pairs of short, setiform or phylliform notogastral setae widely spaced, posterior part of notogaster with four pairs of setae (h_3 , p_1 – p_3). Humeral shoulders slightly developed, with two pairs of notogastral setae (c_2 , c_3). Epimeral setal formula 3–1–3–3; setae minute, *1a* inserted clearly anterior to *1b*. Four pairs of simple or slightly phylliform genital setae. Adanal setae ad_1 and ad_2 postanal, ad_3 preanal. Leg setae *u* on tarsi I setiform, II–IV thorn-like.

Juvenile instars — Not known.

***Hardybodes minutus* n. sp. (Figures 1-4)**

Zoobank: [E41DB0ED-5505-4971-9FC9-702D6C26463C](https://zoobank.org/E41DB0ED-5505-4971-9FC9-702D6C26463C)

Diagnosis — Body size: 281×135 – 143 . Rostral, lamellar and interlamellar setae short, narrowly phylliform, smooth. Bothridial setae of medium size, spathulate. Notogaster with hump-like median part and anterolateral and posterolateral concavities. Notogastral setae short, narrowly phylliform, smooth, setae *da*, *dm*, *dp*, *lm*, *lp*, *h*₁, *h*₂ inserted in a longitudinal row dorsomedially. Subcapitular setae *h* shorter than *a* and *m*. Epimeral, genital, aggenital and anal setae short, setiform, smooth. Adanal setae slightly phylliform, smooth. Leg tarsi IV with 11 setae (*pv*'' absent), setae *l*'' of genua I, II dilated distally.

Description — Measurements – Medium size. Body length: 281 (holotype, male), 281 (one paratype, male); notogaster width: 143 (holotype), 135 (paratype). Integument (Figs 1A, 2B, 4B) – Body brown. Body (including genital and anal plates, subcapitular mentum and genae) and legs densely granulate (diameter of granules up to 1), notogaster and some leg segments partially tuberculate (diameter of tubercles up to 8).

Prodorsum (Figs 1A–B, 2A, 3A) — Rostrum broadly rounded. Lamellae slightly shorter than prodorsum, broadly triangular distally. Rostral (10), lamellar (10) and interlamellar (10–12) setae narrowly phylliform, smooth. Bothridial setae (36–41) with short stalk and longer, spathulate, barbed head. Exobothridial setae and their alveoli absent. Tutoria with triangular tip. Anterolateral parts of prodorsum with pair of concavities.

Notogaster (Figs 1A–B, 2A–B, 3B) — Median part elongate, hump-like. Anterolateral and posterolateral parts with one large concavity. Humeral shoulders indistinct in dorsal view. Fifteen pairs of notogastral setae short (4–6), narrowly phylliform, smooth; of these, seven pairs (*da*, *dm*, *dp*, *lm*, *lp*, *h*₁, *h*₂) inserted in longitudinal row dorsomedially, *c*₁ and *da* located close to each other. Lyrifissures, opisthonotal gland openings and circumgastric sigilla band well visible.

Gnathosoma (Figs 3C–E) — Subcapitulum longer than wide (57 – 61×49 – 53). Subcapitular setae (*a*, *m*, 6–8; *h*, 4–6) setiform, smooth. Adoral setae and their alveoli absent. Palps (32–36) with setation 0–2–1–3–8(+ ω), *acm* absent. Solenidia (1/2 length of palptarsi) thickened, blunt-ended, pressed to the palptarsal surface. Postpalpal setae (2) spiniform, smooth. Chelicerae (57–65) with two setiform, barbed setae, *cha* (16–18) longer than *chb* (10–12). Trägårdh's organ tapered.

Epimeral and lateral podosomal regions (Figs 1B, 2A) — Epimeral setal formula 3–1–3–3. All setae short (4), setiform, smooth. Pedotecta I represented by large and broad scales, pedotecta II are small scales, broadly triangular, rounded distally in ventral view. Discidia triangular, rounded distally.

Anogenital region (Figs 1B, 2B, 3B) — With indistinct concavities and ridges. Four pairs of genital, one pair of aggenital and two pairs of anal setae short (4–6) setiform, smooth. Three pairs of adanal setae (*ad*₁, *ad*₂, 6–8; *ad*₃, 4–6) slightly phylliform, smooth, *ad*₁, *ad*₂ inserted on the arch-like ridge posterior to the anal aperture. Adanal lyrifissures not discerned under the cerotegumental layer.

Legs (Figs 4A–D) — Claw of each leg strong, smooth. Porose areas of femora and trochanters III, IV well visible. Formulas of leg setation and solenidia: I (1–4–3–4–16) [1–2–2], II (1–4–3–3–15) [1–1–2], III (2–3–1–2–15) [1–1–0], IV (1–2–2–2–11) [0–1–0]; homology of setae and solenidia indicated in Table 1. Famulus of tarsi short, erect, blunt-ended, inserted proximal to ω_1 . Solenidium ϕ_1 of tibiae I long, setiform, other leg solenidia thickened, blunt-ended. Setae *l*'' of genua I, II strongly dilated distally (palmate), barbed.

Type deposition — The holotype (ethanol with drop of glycerol) is deposited in SMNH; one paratype (ethanol with drop of glycerol) is deposited in TSUMZ.

Figure 1 *Hardybodes minutus* n. sp.: A – dorsal view; B – ventral view (legs except trochanters III, IV not illustrated). Scale bar 45 μ m.

Figure 2 *Hardybodes minutus* n. sp.: A – anterior part of body, lateral view (legs except trochanter III not illustrated); B – posterior part of body, lateral view (legs except trochanter IV not illustrated). Scale bar 45 μ m.

Figure 3 *Hardybodes minutus* n. sp.: A – prodorsum, frontal view; B – posterior view; C – subcapitulum, ventral view; D – palp, right, antiaxial view; E – chelicera, left, paraxial view. Scale bar 45 µm (A, B), scale bar 15 µm (C–E).

Figure 4 *Hardybodes minutus* n. sp.: A – trochanter, femur and genu of leg I, right, antiaxial view; B – leg II (trochanter partially covered by pedotectum II), right, antiaxial view; C – leg III except tarsus, left, antiaxial view; D – leg IV, left, antiaxial view. Scale bar 15 µm.

Table 1 Leg setation and solenidia of adult *Hardybodes minutus* n. sp.

Leg	Tr	Fe	Ge	Ti	Ta
I	<i>v'</i>	<i>d</i> , (<i>l</i>), <i>bv''</i>	(<i>l</i>), <i>v'</i> , σ	(<i>l</i>), (<i>v</i>), φ_1 , φ_2	(<i>ft</i>), (<i>tc</i>), (<i>it</i>), (<i>p</i>), (<i>u</i>), (<i>a</i>), <i>s</i> , (<i>pv</i>), ε , ω_1 , ω_2
II	<i>v'</i>	<i>d</i> , (<i>l</i>), <i>bv''</i>	(<i>l</i>), <i>v'</i> , σ	(<i>l</i>), <i>v'</i> , φ	(<i>ft</i>), (<i>tc</i>), (<i>it</i>), (<i>p</i>), (<i>u</i>), (<i>a</i>), <i>s</i> , (<i>pv</i>), ω_1 , ω_2
III	<i>l'</i> , <i>v'</i>	<i>d</i> , <i>l'</i> , <i>ev'</i>	<i>l'</i> , σ	(<i>v</i>), φ	(<i>ft</i>), (<i>tc</i>), (<i>it</i>), (<i>p</i>), (<i>u</i>), (<i>a</i>), <i>s</i> , (<i>pv</i>)
IV	<i>v'</i>	<i>d</i> , <i>ev'</i>	<i>d</i> , <i>l'</i>	(<i>v</i>), φ	<i>ft''</i> , (<i>tc</i>), (<i>p</i>), (<i>u</i>), (<i>a</i>), <i>s</i> , <i>pv'</i>

Note: Roman letters refer to normal setae, Greek letters to solenidia (except ε = famulus). Single prime (') marks setae on the anterior and double prime (") setae on the posterior side of a given leg segment. Parentheses refer to a pair of setae. Tr – trochanter, Fe – femur, Ge – genu, Ti – Tibia, Ta – tarsus.

Etymology — The specific name *minutus* refers to the small body size of the new species.

Comparison — The new species differs from all species of the genus by the localization of notogastral setae *lm* and *h*₂ in same longitudinal row together with *da*, *dm*, *dp*, *lp* and *h*₁ (versus *lm* and *h*₂ inserted in dorsolateral position, setae *da*, *dm*, *dp*, *lp* and *h*₁ inserted in dorsocentral position).

Key to known species of *Hardybodes*

- Bothridial setae thickened, without distinct heads; notogastral tubercles forming polygonal pattern; body size: 295–379 × 138–170.....*Hardybodes penicillatus* Mahunka, 1995 (see also Fernandez *et al.* 2015). Distribution: Borneo.
— Bothridial setae with well-developed spatulate heads; notogastral tubercles not forming polygonal pattern 2
- Notogastral setae *lm* and *h*₂ inserted dorsocentrally in the same longitudinal row together with *da*, *dm*, *dp*, *lp*, *h*₁; body size: 281 × 135–143.....*Hardybodes minutus* n. sp. Distribution: Philippines.
— Notogastral setae *lm* and *h*₂ inserted in dorsolateral position, setae *da*, *dm*, *dp*, *lp*, *h*₁ inserted in dorsocentral position 3
- Notogaster tuberculate; rostral setae simple, lamellar setae bifurcate; body size: 324 × 146 *Hardybodes mirabilis* Balogh, 1970 (see also Fernandez *et al.* 2013). Distribution: New Guinea, Philippines, Borneo.
— Notogaster not tuberculate; rostral and lamellar setae phylliform; body size: 266–319 × 123–153 *Hardybodes flabellatus* Mahunka, 1995. Distribution: Borneo.

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