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Report on Oribatid Mites in Eco-Friendly Agriculture with a Description of Third New Species of the Genus *Cosmogalumna* from the Litter of Coconut Palm Tree on Ishigaki Island, in Southern Japan

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Abstract

Oribatids are subdived taxonomically into Macropylina, Apterogastrina and Pterogasterina. In the field of eco-friendly agriculture, the number of Pterogasterina species was clearly larger than in the field with tillage management or chemical fertilizer application. This indicates that an increase in the number of Pterogasterina species is a bio-indicator of eco-friendly agriculture. A new species of the Pterogasterina, *Cosmogalumna hiroyoshii*, was collected from coconut palm tree litter on Ishigaki Island, in southern Japan. Characteristic features of the new species include thick rostral setae which are not extending in front of the anterior rostral margin; a bimucronate rostrum; setae *le* inserted lateral to the carina L between L and L; the polygonal structure on the prodorsal, notogastral, pteromorphal surfaces, and ventral plate; and on the alveoli of dorsal setae, granules on and around each area porosa.

Key words: Pterogasterina, *Cosmogalumna hiroyoshii* sp. nov., Oribatid mites, Ishigaki Is., Eco-friendly Agriculture

Soil animals are divided into four categories by the method in which they are collected: macrofauna, dry mesofauna, wet mesofauna and microfauna (Nakamura, 2000). Together with collembola, oribatid mites are the main component in the dry mesofauna of cropfield soil (Nakamura, 1988; Nakamura *et al*., 2000). Oribatid mites are about 0.1-1.6 mm in body length, and have a dark brown and chitinized body. About 9,000 species are known world-wide, and 900 species are found in Japan (Balogh, 1972; Fujikawa, 1991; Fujikawa *et al*., 1993). In a broad sense, they are saprophagous (Wallwork, 1976) and are often called 'moss mites'. But many of them feed on fungi (Matsuzaki and Itakura, 1991; Nakamura *et al*., 1991, Nakamura, 1993). A recently discovered species, *Scheloribates azumaensis* ENAMI, NAKAMURA et KATSUMATA, 1996, from Japanese cropfields, actively ate *Rhizoctonia solani* KÜHN, a plant pathogenic fungus, and prevented root rot of radish under laboratory conditions (Enami and Nakamura, 1996). This indicates that oribatid mites possess great potential as agents for the biological control of soil-borne crop root diseases.

Recently, eco-friendly agriculture has been emphasized. Based on the opinion that eco-friendly agriculture should also be friendly to soil animals (cf. Nakamura, 1998), studies on the effect of various agricultural practices on soil animals have been carried out. For instance, soil animals were more numerous and complicated in no-tillage cultivation than in tillage cultivation (Nakamura, 1988), or in organic farming than in chemical-intensive farming (Fujikawa, 1976; Nakamura *et al*., 2000). Organic mulch of crop residues and chopped weeds help create a healthy environment for soil animals, especially enchytraeids and earthworms (Nakamura *et al*., 2003). Trials involving the artificial introduction of soil animals into a crop field proved that a certain species could colonize the crop fields when the introduction was carried out together with forest litter (oribatid mites by Fujikawa, 1988; macro animals by Nakamura, 1998). This suggests that organic materials transferred into crop fields provide a medium for settlement of soil animals, in addition to supplying organic fertilizer for the crops. In tropical regions, coconut palm litter is thought to be an important mulch material.

Since oribatids are subdivided taxonomically into two types: the Lower (Primitive) Oribatei (=Macropylina; ex. *Eniochthonius minutissimus* BERLESE, 1904, Fig. 1A) and the Higher Oribatei (=Brachypylina) of the Apterogasterina (ex. *Oppiella nova* (OUDEMANS, 1902), Fig. 1B) and Pterogasterina (Balogh, 1972), the species complex plays a bioindicator in agroecosystems (Behan-Pelletier, 1999; Enami, 2000). In the natural forest of Japan, the number of Apterogasterina species was numerous (Fujikawa, 2004). In the crop fields, on the other hand, the number of Pterogasterina species was numerous (Nakamura, 1989; Enami, 2000). And the number of Pterogasterina species was clearly larger in fields where no-tillage was practiced (Nakamura, 1989) or organic materials were applied to the surface soil (Fujikawa, 1988; Nakamura, 1998), as

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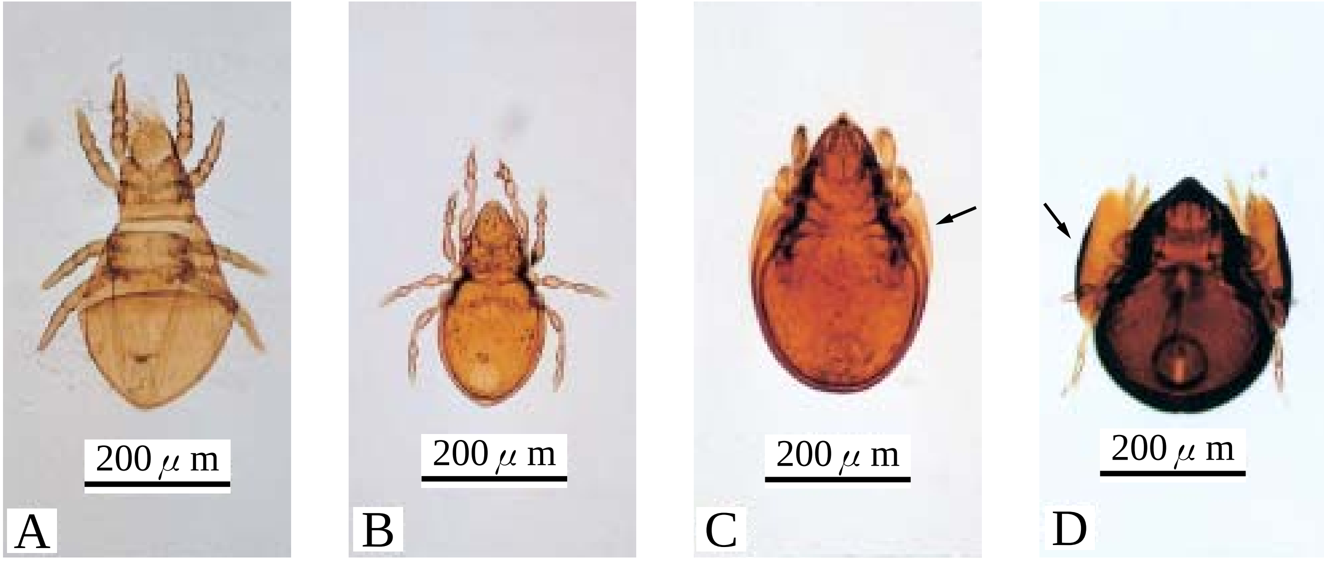

Fig. 1. Species of the Lower (Primitive) and the Higher oribatids. A: *Eniochthonius minutissimus* (BERLESE, 1904) of the Lower oribatids, B: *Oppiella nova* (OUDEMANS, 1902) of Apterogasterina, the Higher, C: *Transoribates agricola* NAKAMURA et AOKI, 1993 of Pterogasterina, the Higher, and D: The new species of Pterogasterina, the Higher. Black arrows show pteromorphae.

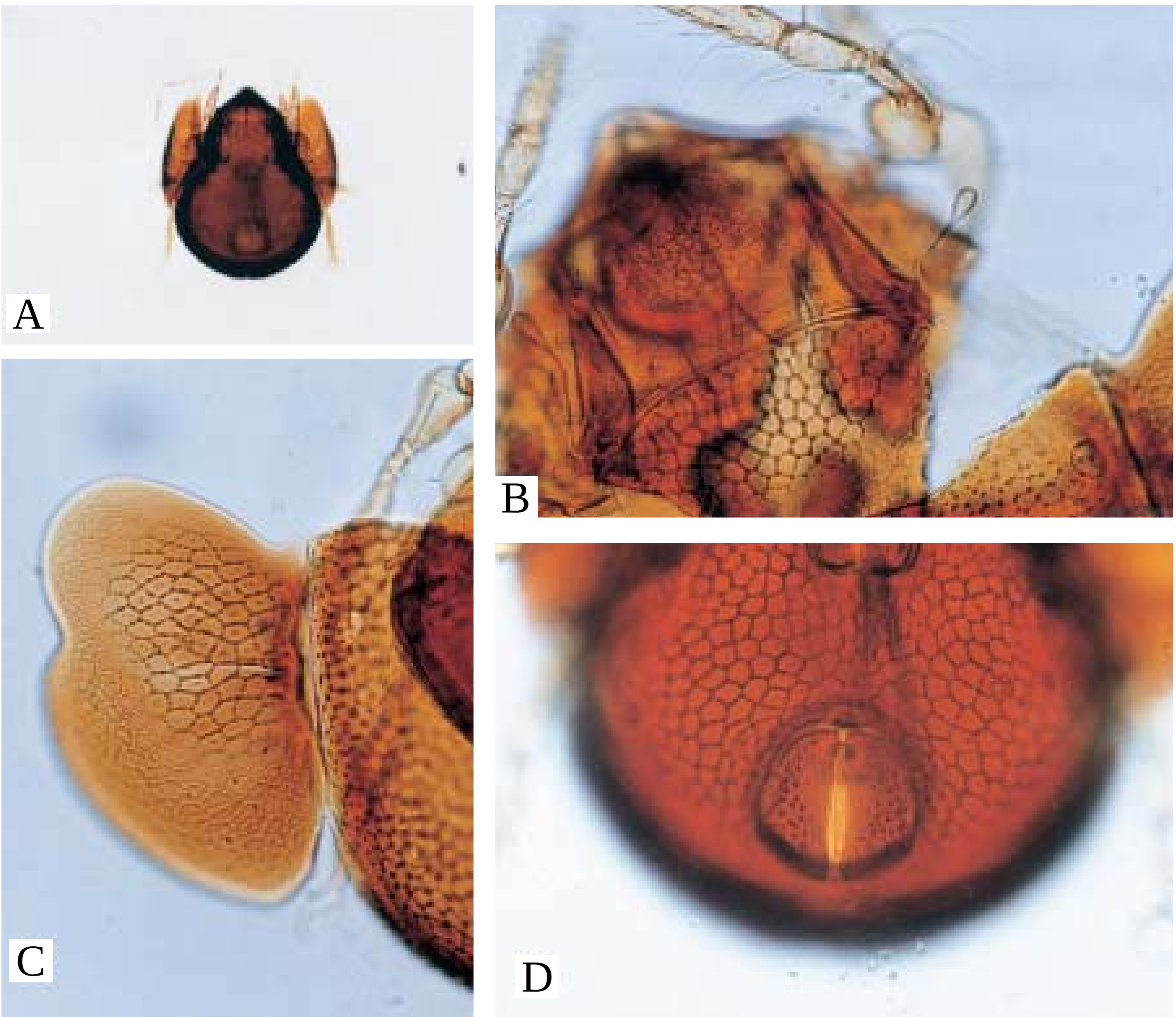

Fig. 2. *Cosmogalumna hiroyoshii* sp. nov. NSMT-Ac 11738 and 11739. A: Dorsal view, B: Prodorsum, C: Pteromorphae and D: Anal region.

compared with tillage management or chemical fertilizer application. Furthermore, all of the dominant species belong to Pterogasterina; *Eporibatula sakamorii* (AOKI, 1970) in the cropped heavy clay soil of Nayoro Nature Farm, the northern district (Fujikawa, 1988), and *Transoribates agricola* NAKAMURA et AOKI, 1989 (Fig. 1 C) in the cropped andosol of National Inst. Agro-Environmental Science, Tsukuba, the central district (Nakamura, 1989), respectively. In the cropped andosol of National Tohoku Agric. Exp. Stn., Fukushima, the northern district, the number of individuals of *Scheloribates azumaensis* of Pterogasterina was enormous (Nakamura, 1998). These results suggest that an increase in the number of Pterogasterina species is a bio-indicator of eco-friendly agriculture.

The new species being reported here also belongs to the genus *Cosmogalumna*, one of the members of the Pterogasterina group, which have well developed pteromorphae and area porosae (Fig. 1D). The pteromorphae of this species are especially clear and thick, with a large light colored polygonal reticulated pattern (Fig. 2A & B) which is covering whole body. The question is its function: do the pteromorphae protect against enemies and desiccation by covering the body, and/or against an increase of body temperature by fanning, or do they help it to fly for wind dispersion as Collembola suggested by Farrow and Greenslade (1992). The various species with such a large polygonal network are collected from tropical or subtropical areas. Other questions are whether the network is helpful for heat radiation, or for collecting raindrop by expansion of the body surface area. The present new species, *Cosmogalumna hiroyoshii*, was collected from coconut palm tree litter on Ishigaki Island. In tropical district including Ishigaki Island, the palm tree litter is thought to be the mulch and compost materials.

In 1988 Aoki defined the genus *Cosmogalumna*, and described a new, and type, species, *Cosmogalumna ornata*, from Nakanoshima Island in the Tokara Islands (Aoki, 1988). So far as the authors know, only one species has been added to this genus. The second species, *C. imperfecta* AOKI et HU, 1993 was collected from Yunnan Province in southern China (Aoki and Hu, 1993). The species described in this report was also collected from a subtropical region, Ishigaki Island, and is the third member of the genus. The notation follows that of Hammen (1980).

Cosmogalumna hiroyoshii sp. nov.

[Japanese name: Hiroyoshi-kazarifurisodedani]

Measurements (2 exs.) **and color**: Body length, 336 μm; wide, 257 μm. Light yellowish brown.

Body surface: The whole integument on prodorsum, notogaster, pteromorphae and ventral plate with fine granules and distinct light colored polygonal network. Lamellar region of prodorsum, on and around area porosae, genital and anal plates densely covered by irregular dark colored granules. Femora with striate pattern of granules.

Prodorsum: According to depressed specimen, rostrum bimucronate; mucrones convergent, forming a trapezoid concavity (Fig. 3C). A large elliptical light area of weak chitinisation present just behind the concavity. Rostral setae (*ro*) thick, originating ventrally. Lamellar setae (*le*) shorter than *ro*, inserted between carinae L and L, just lateral to carinae L. Carinae extending for about half length of prodorsum. Interlamellar setae (*in*) and exobothridial setae (*ex*) located at the same level. Setae *le*, *in* and *ex* short, setiform and slightly roughened. Sensilli (*ss*) composed of a thin stem and an expanded head which bears bristles; *ss* extending at the level of antero-margin of carinae (Fig. 3A). Relative lengths: *ss* > *ro* > *le* > *ex* > *in* (Fig. 3D).

Notogaster: Circular in form with a small indentation at the medial portion of the posterior margin which is not seen in depressed specimen. Length as long as, or slightly longer than width. Pteromorphae extending for a short distance in front of carinae L and S on prodorsum; furrow (*st* after Grandjean, 1966) remarkable (Fig. 3E). Five pairs of area porosae present; the relative sizes: Ad > Aa > A_1 > A_3 > A_2 (Figs. 3F-H). Ten pairs of alveoli of dorsal setae present. Lyrifissures *ia*, *im*, *ip* and *ips* discernible; *im* located at inverse apomedial line and antero-laterally to A_1.

Ventral region: Genito-anal setae: (6 or 5−1−2−3); genital setae variable in number; all setae short and glabrous (Fig. 4D). Relative lengths: g_1 > g_2 to g_6 > ad_1 > *an* > *ag* ≒ ad_2, ad_3. Lyrifissures *iad* situated parallel to the lateral side of anal aperture and almost mid-distance between the levels of two anal setae (Fig. 4E). Adanal setae ad_3 inserted lateral to *iad*. Epimeral setae *1a*, *3b* and *4a* present; relative lengths: *3b* ≒ *3* x *1a*; *1a* ≒ *4a*. Alveoli *4b* present (Fig. 4B). Subcapitulum diarthric, bearing each one pair of anterior (*a*), medial (*m*) and posterior (*h*) infracapitular setae (Fig. 4A); all setae smooth; relative lengths: *a* ≒ *h* > *m*. Genito-anal, epimeral and infracapitular setae inserted at the end of a dark colored inner capsule.

Legs: All legs heterotridactylous; median claw thicker than lateral ones, with a dent ventrally at the middle portion. Leg chaetotaxy including famulus, but excluding solenidia, I (1−4−3−4−20); II (1−4−3−4−15); III (2−2−1−3−15); IV (1−2−2−3−11). Solenidiotaxy, I (1−2−2); II (1−1−2); III (1−1−0); IV (0−1−0). On tarsus I, solenidion ω_1 bacilliform, coupled with *ft''*; solenidion ω_2 setiform, inserted posterior-laterally to ω_1; famulus ε setiform, shorter than *ft''*, inserted anterior to and between solenidia (Fig. 5A). All solenidia on leg II bacilliform (Fig. 5D), but solenidia on tibia I, genu I (Fig. 5B), tibia III (Fig. 5F), genu III (Fig. 5G) and tibia IV (Fig. 5H) setiform. Trochanter III with *v'*, of long setiform bearing barbs unilaterally, and *l'* of remarkable like a trigonal pyramid (black arrow in Fig. 5G).

Material examined: Holotype (NSMT-Ac 11738) from litter of coconut palm tree (*Satakentia liukuensis* MOORE, 1969, Family Palmae) in Ishigaki Island, Okinawa Pref., Oct. 25, 2000, H. Shiraishi; 1 paratype (NSMT-Ac

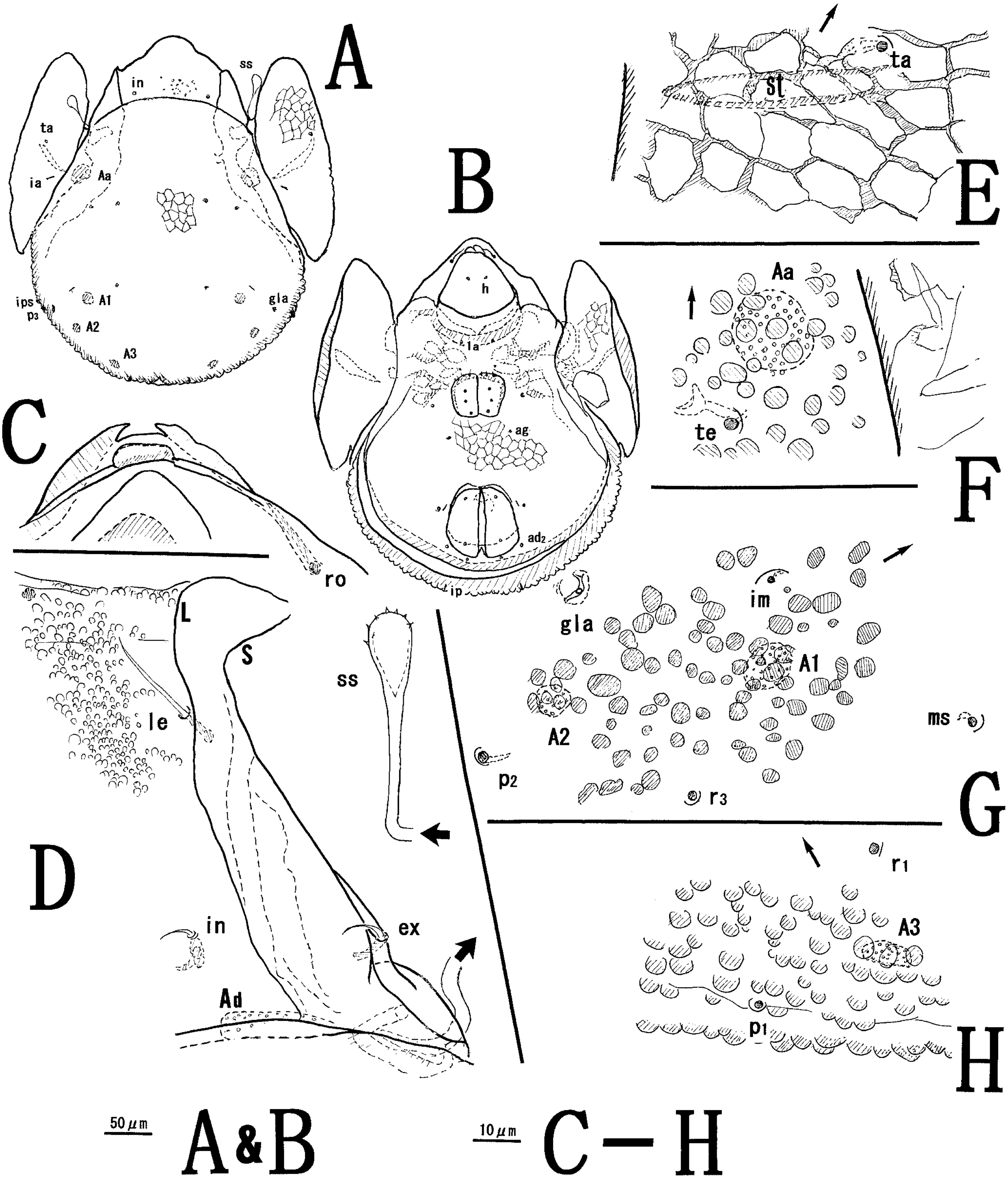

Fig. 3. *Cosmogalumna hiroyoshii* sp. nov. A & B: NSMT-Ac 11738; C to H: NSMT-Ac 11739. A: Dorsal view, B: Ventral view, C: Rostrum, D: Right lamellar region, E: Furrow on pteromorph, and F to H: Area porosal region. *ro*: Rostral seta; *le*: Lamellar seta; *in*: Interlamellar seta; *ex*: Exobothridial seta; *ss*: Sensillus; *ta*, *te*, *im*, *ms*, r_1, r_3, p_1 and p_2: Dorsal setae; Aa, A_1, A_2 and A_3: Area porosae; gla: Glanular opening; L: Lamellar line; S: Sublamellar line; st: Furrow. Black arrows in Figs. E to H direct to rostrum.

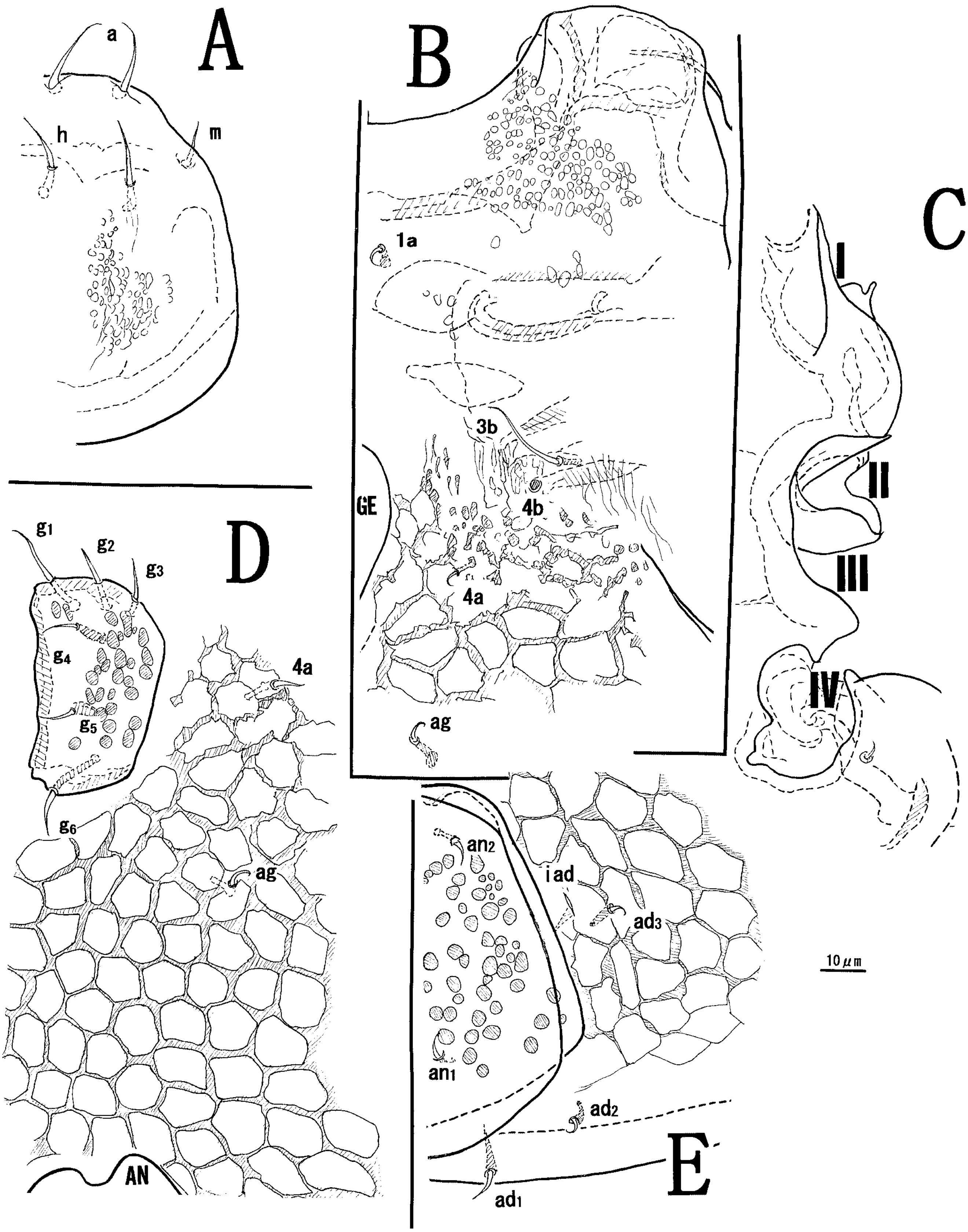

Fig. 4. *Cosmogalumna hiroyoshii* sp. nov. NSMT-Ac 11739. A: Infracapitular region, B: Epimeral region, C: Coxal region of leg I to IV, D: Genital region, E: Anal region. *a*, *m* and *h*: Anterior, medial and posterior infracapitur setae, respectively; *an*: Anal seta; *ad*: Adanal seta; *ag*: Aggenital seta; *g*: Genital seta; *1a*, *3b* and *4a*: Epimeral setae; *4b*: Alveoli; *iad*: Adanal lyrifissure.

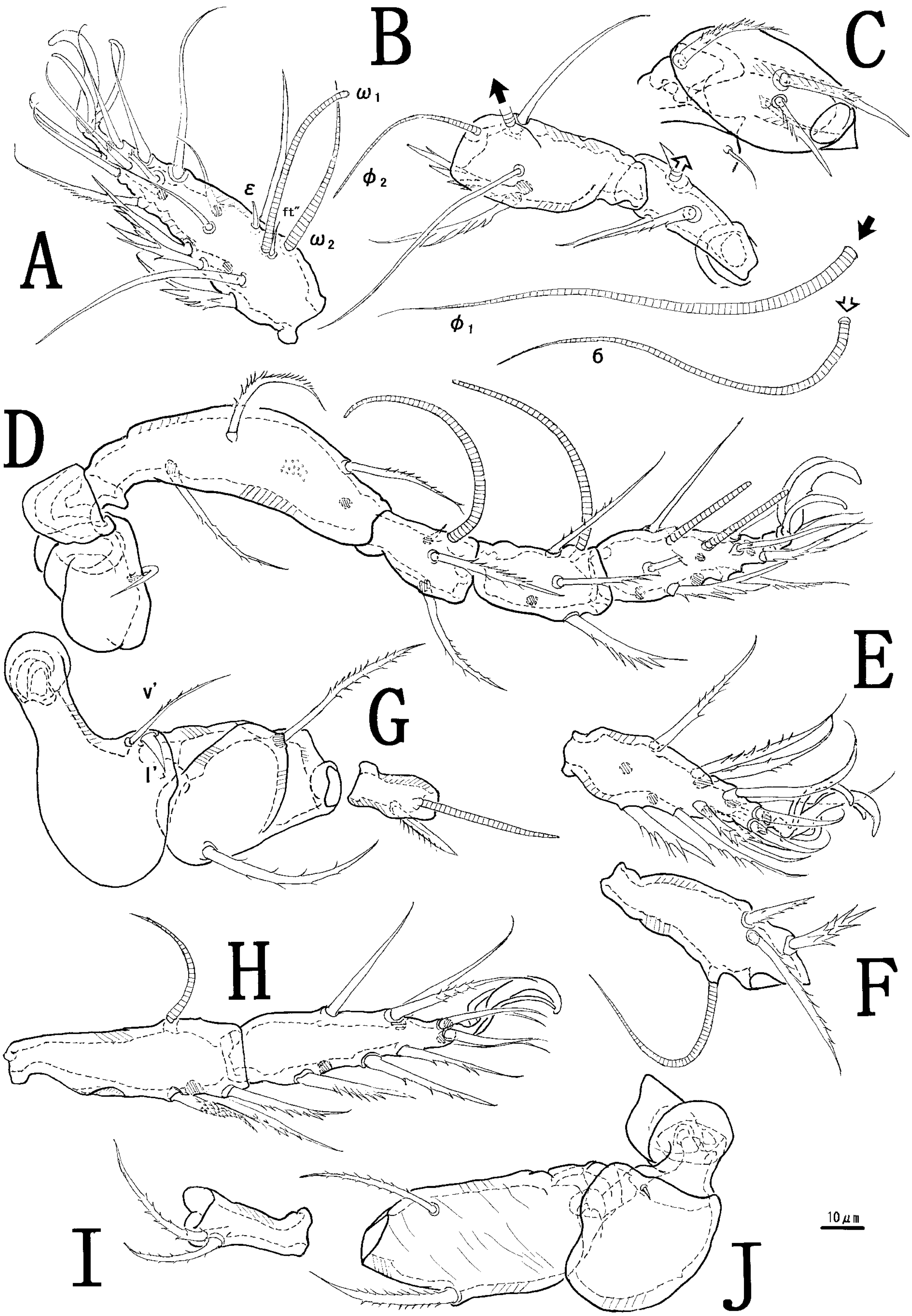

Fig. 5. *Cosmogalumna hiroyoshii* sp. nov. NSMT-Ac 11739. A: Right tarsus I, B: Right tibia I and genu I, C: Left femur I and a part of trochanter I, D: Left leg II, E: Right tarsus I, F: Right tibia III, G: Right genu III to trochanter III, H: Right tarsus IV and tibia IV, I: Left genu IV, J: Right femur IV and trochanter IV.

Table 1. Comparison in some features among three species of the genus *Cosmogalumna*

	C. ornata Aoki, 1988	*C. imperfecta* Aoki et Hu, 1993	*C. hiroyoshi* sp. nov.
Ro	rounded	rounded	bimucronate
ro	fine; extending in front of anterior rostral margin	extending in front of anterior rostral margin	thick; not extending in front of anterior rostral margin; not seen from above
le	< *ro*; between L and S	≒ *ro*; lateral to L	< *ro*; lateral to L
PN	notogaster, Ge-An	notogaster, Ge-An	prodorsum, notogaster ptero-morphae, ventral plate
BL	317(330)342μm	326－365μm	336μm
BW	256(264)270μm	276－287μm	257μm
Coll.	Mt. Mitake, Nakanoshima Is. of Tokara Islands	natural forest Xishuangbanna of Yunnan in China	coconut palm tree in Ishigaki Is., Okinawa prefecture

Ro: Rostrum; *ro*: Rostral seta; *le*: Lamellar seta; L: Lamellar line; S: Sublamellar line; PN: Polygonal network; Ge-An: Ventral surface between genital and anal apertures; BL: Body length; BW: Body width; Coll.: Place where samples were collected.

Table 2. Comparison in a few features among species of different genera with body surface covered by a reticulated pattern

	Trachygalumna bisulcata Balogh, 1960	*Flagellozetes porosus* Balogh, 1970	*Cosmogalumna* spp.
le	between L and L	between L and S	between L and S, or L and L
ds	short, partly absent	all long, flagellate	alveoli
Ap	punctiform	developed	developed
Gr	absent	absent	present
PN	notogaster, Ge-An pteromorphae	notogaster, prodorsum, pteromorphae	notogaster, Ge-An (prodorsum, pteromor-phae, notogaster & ventral plate of the new species)
BL	250μm	529μm	317－365μm
BW	202μm	329μm	256－287μm
Coll.	Africa	Ceylon	Tokara Is., Ishigaki Is., China

le: Lamellar seta; ds: Dorsal seta; Ap: Area porosae; Gr: An aggregation of granules on and around each area porosa; PN: Polygonal network; Ge-An: Ventral surface between genital and anal apertures; BL: Body length; BW: Body width; Coll.: Place where samples were collected.

11739): the same data as holotype. Types are deposited in the National Science Museum, Tokyo.

Remarks: The new species is conspicuous by the body surface covered by a network-like pattern. Surface structure of this kind is seen in some known species, for examples, *Cosmogalumuna ornata* Aoki, 1988, *C. imperfecta* Aoki et Hu, 1993, *Flagellozetes porosus* Balogh, 1970 and *Trachygalumna bisulcata* Balogh, 1960. However, the present species differs from *T. bisulcata* by having developed area porosae and polygonal structure on prodorsal surface, from *F. porosus* by having alveoli of dorsal setae, granules on and around each area porosa, and lamellar setae inserted between L and L, from *C. ornata* by having polygonal structure on prodorsal and pteromorhal surface, thick rostral setae not extending in front of anterior rostral margin, bimucronate rostrum, and setae *le* inserted lateral to carinae between L and L, and from *C. imperfecta* by having polygonal structure on prodorsal and pteromorphal surface, bimucronate rostrum, and rostral setae longer than lamellar setae, not extending in front of anterior rostral margin, as summarized in Tables 1 and 2.

Ethymology: The new species was named in honor of the late Mr. Hiroyoshi Shiraishi (1968－2002), a researcher at the Tohoku National Agricultural Experiment Station. Mr. H. Shiraishi, while working at the Ministry of Agriculture, Forestry, and Fisheries of Japan, studied soil animals, especially oribatid mites (Shiraishi and Aoki, 1994) and springtails (Collembola) (Shiraishi *et al*., 2003), as the agents for biological control of soil-borne crop root diseases. This new species was obtained from his samples during a survey for collembolan fauna in the subtropical Ishigaki Island.

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摘　　要

中村好男・藤川德子：環境保全型農業とササラダニ類の関係についての一考察および１新種の記載

畑地土壌のササラダニ類は３群，Macropylina, Apterogastrina および Pterogasterina，に区分される．無耕起や有機物被覆条件下にあるいわゆる環境保全型農業のササラダニ類は，耕起や化成肥料施用条件に比べ Pterogasterina の種の割合が多く，環境保全型農業の生物指標の可能性が見受けられる．この Pterogasterina に属するカザリフリソデダニ属の新種を記載した．本種は石垣島では有機物被覆や堆肥材料として有望なヤシ林床から採集され，深い湾入部を持つ吻と前体部，後体部，翼状突起及び腹板の全表面が亀甲模様をもつ特徴により同属種から区別される．この標本は故　白石啓義（1968－2002）氏の採集によるものである．同氏は農林水産省において，土壌動物研究の立場から農業の技術改革を目指していた．その功績を讃えて *Cosomogalumna hiroyoshii* sp. nov. ヒロヨシカザリフリソデダニ（新称）と命名した．