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JAPANESE CHORDEUMATID MILLIPEDS. I.
ON THE GENUS *SPEOPHILOSOMA* TAKAKUWA
(DIPLOPODA, CHORDEUMATIDA, SPEOPHILOSOMATIDAE)

by William A. Shear, Nobuo Tsurusaki, and Tsutomu Tanabe

ABSTRACT

The Japanese milliped genus *Speophilosoma* is reviewed and three new species (*tottoriense*, *koyama*, *takanawa*) are described. *Speophilosoma akiyoshiense* Miyosi is redescribed from new specimens; the type material has been lost. The type and only material of *S. montanum* Takakuwa, type species of the genus, was destroyed in World War II. The family Speophilosomatidae may be most closely related to the European family Chordeumatidae, which has similar anterior gonopods.

This paper is the first in a series on the chordeumatid millipeds of Japan, based on the collecting activities of the second and third authors and some of their colleagues and associates. Future subjects will be the extraordinarily diverse genus *Diplomaragna* Attems (recently revised by Shear, 1991), a new genus of alpine millipeds in the family Conotylidae Verhoeff, and new genera in the families Neocambrisomatidae and Mastigophorophyllidae.

Chordeumatids are very small to medium-sized millipeds characteristic of cool, moist, forested habitats, though a few are known from tropical forests (Shear, 1994). They lack repugnatorial glands and bear six prominent setae on each segmental metazonite; the epiproct carries a pair of spinnerets. With some exceptions, they are ill-adapted to warm, dry conditions and the species have restricted distributions. Many species, genera, and even families have distributions that mark them as relicts. Because of their limited abilities to extend their ranges and their evidently ancient lineage, they provide excellent material for studying the biogeography of temperate and montane forests. However, confusion about their systematics has hampered their use for such a purpose, since it is first necessary to obtain a reliable classification and phylogeny. The first author has focused his research for the last two decades on this order of diplopods, carrying out revisions of families and genera, and establishing new taxa. The goal of this work has been to produce a phylogeny that will be of use in working out the biogeography of this group, especially in North America and around the margins of the Pacific Ocean.

The rich diversity of chordeumatids from western Europe has long been known (Schubart, 1934; Brolemann, 1935). The North American fauna was summarized by Shear

(1972), with subsequent papers providing revisions of major families and genera, and describing new taxa. Two areas with major chordeumatid faunas which remain largely unrevised are the region from the Balkans to the Caucasus Mountains, and northeastern Asia, including Japan.

The Japanese chordeumatid fauna was last inventoried by Miyosi (1959). Murakami & Kawasaki (1975, 1976) subsequently added new species of *Diplomaragna* (under the synonym *Pterygostegia* [Shear, 1990]). Shear (1987, 1988) has clarified the systematic position of some additional genera. However, it is clear from the results of recent collecting that the Japanese chordeumatid fauna is extremely rich, perhaps rivaling that of western North America in diversity at all levels from species to family, and in fact, sharing some elements in common – not a surprise to biogeographers.

The genus *Speophilosoma* was described in 1949 by Takakuwa, for the single species *S. montanum*, from a lava cave at the foot of Mt. Fuji, Yamanashi Pref., Honshu. Recognizing its unique and isolated nature, Takakuwa also described a new family, Speophilosomatidae. In 1958, Miyosi added a second species, *S. akiyoshiense*, from Tanuki-ana cave, Akiyoshidai, Yamaguchi Pref., Honshu. A record of the genus from Mt. Yushan, Taiwan, was based on a female (Wang, 1958), but this of course requires verification, since while female chordeumatids may be distinctive in the context of one fauna, they may not be in another.

Speophilosoma has always been difficult to place in the classification, but not because the original descriptions were unclear. Western authors simply failed to translate the Japanese text and relied on their own interpretations of the accompanying figures.

The eyes of the first author were opened when his coauthors sent specimens of *Speophilosoma akiyoshiense* Miyosi, and three new species (described below), and when one of them (Tanabe) provided an English translation of Miyosi's 1959 compendium on Japanese millipeds.

SYSTEMATIC TREATMENT

?Superfamily Chordeumatoidea Koch 1847
Family Speophilosomatidae Takakuwa 1949

Speophilosomatidae Takakuwa, 1949, p. 5; 1954, p. 131. Miyosi, 1959, p. 132. Shinohara, 1991, p. 69.

Diagnosis: Legpair 7 is a part of the gonopod complex (Fig. 1) and is uniquely modified, with two segments, the distal of which is apically divided into numerous cuticular filaments (not socketed setae). Members of the European family Chordeumatidae also have the seventh legpair modified and reduced, but the pattern of reduction (Brolemann, 1935) is different, with more than two segments (*Chordeuma*), a large basal coxite (*Mycogona*, *Orthochordeumella*, *Parachordeuma*), or with fused coxosternum and tiny apical articles (*Melogona*).

Type genus: *Speophilosoma* Takakuwa, by original designation.

Description: 26 segments. Mentum entire. Diplotergites with distinct shoulders but lacking paranota. Segmental setae long, acute. Legpairs 4-6 of males enlarged. Seventh legpair strongly reduced and modified, with globular coxae and single telopodite articles with a series of long cuticular filaments. Anterior gonopods lacking telopodites, transversely fused coxosternum with single acuminate coxite on each side, coxosternum extended mesally into a clavate rod bearing a pore connected to a large median gland dorsal to the gonopods. Coxae of posterior gonopods with long, curved median process, telopodites reduced, three-articled. Coxae 10 and 11 with glands and slight modifications, telopodites normal.

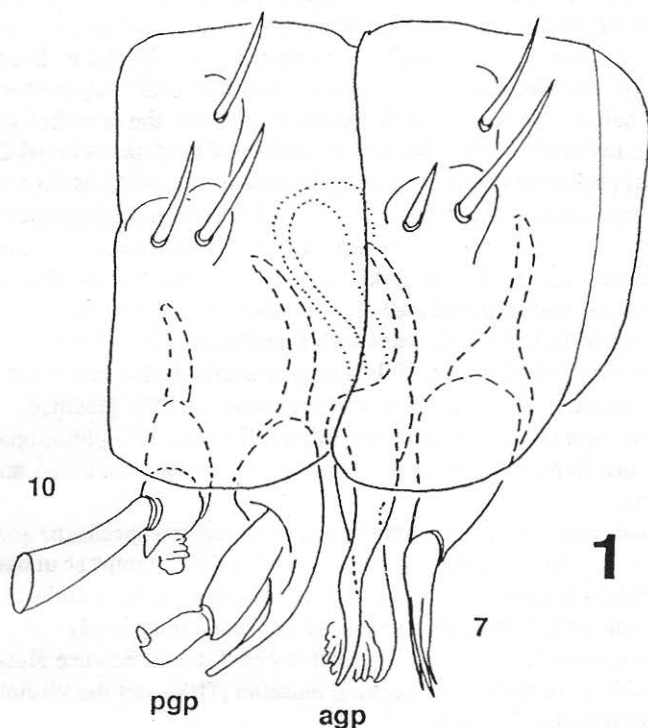


Fig. 1. Sketch plan of the gonopods of *Speophilosoma* species. Numbers refer to legpairs. agp, anterior gonopods; pgp, posterior gonopods.

Distribution: Kyushu, Shikoku, and southern Honshu, Japan; ?Taiwan (map 1).

Remarks: The interpretation of homologies in the gonopods of *Speophilosoma* is straightforward. The distal articles of the seventh legs are clearly telopodites, articulated to basal coxae. Not noticed by previous authors was the small group of three, basally fused filaments on the distoposterior margin of the coxae of these appendages. The highly modified anterior gonopods consist of a unitary structure which appears to be a coxosternum, produced from the fusion of the coxae and sternal elements. The median process may be entirely sternal, or (an interpretation we favor) mostly or entirely colpocoxal, formed from the sclerotized bases of coxal glands. Thus the pore opening at the tip of the process would be from the coxal gland homolog, now fused in the midline. The gland lies immediately above the sternum, in the ventral body cavity. The lateral processes, which show an obsolete articulation with the sternal region, are therefore angiocoxites – developed from the sclerotized wall of the podomere. The coxal processes of the posterior gonopods would also appear to be angiocoxal.

On the basis of a number of characteristics of the male gonopods, speophilosomatids may be the sister group of the exclusively western European family Chordeumatidae. The degree of reduction of the seventh pair of legs, and their incorporation in the gonopod complex, is unusual and shared by all members of these two families. *Osellasoma caoduroi* Mauriès 1984 is a trimerophorine neoatractosomatid in which the seventh legpair is also very reduced and modified, but which belongs to an unrelated superfamily on other grounds; reduction of the

seventh legpair does not occur in any other neoatractosomatids. The anterior gonopods (modified from the eighth legpair) are also quite similar in the families Chordeumatidae and Speophilosomatidae, consisting of a median coxosternal piece flanked by large coxites.

However, there are differences which certainly justify maintaining the two families and even questioning their close relationship. In speophilosomatids, the seventh legs are uniquely modified, with the telopodite article bearing a number of long, unsocketed filaments. The median coxosternal projection of the anterior gonopods has a pore at its tip, which connects via a long channel to a large gland in the body cavity. The posterior gonopods of Chordeumatidae have complex, rather than simple, coxites, and the single remaining telopodite article is enlarged, rather than having several reduced articles. In Chordeumatidae, the tenth legs are entirely vestigial, having been reduced to just a sternum and tiny coxal remnants, while the eleventh legs have extremely large coxae with eversible glands on their anterior faces; the eleventh telopodites are strongly reduced. In speophilosomatids, the tenth and eleventh legs have normal telopodites, both bear glands, and the coxae are little modified.

Chordeumatids have no close European relatives. If indeed speophilosomatids are their sister group, the two families must have separated a very long time ago and gone their separate evolutionary ways.

Speophilosomatids are still known only from a relatively few specimens and localities, so the taxonomy presented in this paper is no more than a first attempt at understanding the family. We hope that some future Japanese myriapodologist, able to collect widely and at different seasons, will undertake a full revision of this interesting family.

Type and other material has been deposited in the National Science Museum (Natural History), Tokyo (NSMT), Tokushima Prefectural Museum (TPM) and the Virginia Museum of Natural History, Martinsville (VMNH).

Speophilosoma Takakuwa 1949

Speophilosoma Takakuwa, 1949, p. 5; 1954, p. 132. Miyosi, 1959, p. 132. Shinohara, 1991, p. 70.

Diagnosis and Description: as for the family.

Type species: *Speophilosoma montanum* Takakuwa, by monotypy. The original spelling of the species name, "montanus", was corrected by Jeekel (1970), to accord with the generic name, which takes a neuter adjective.

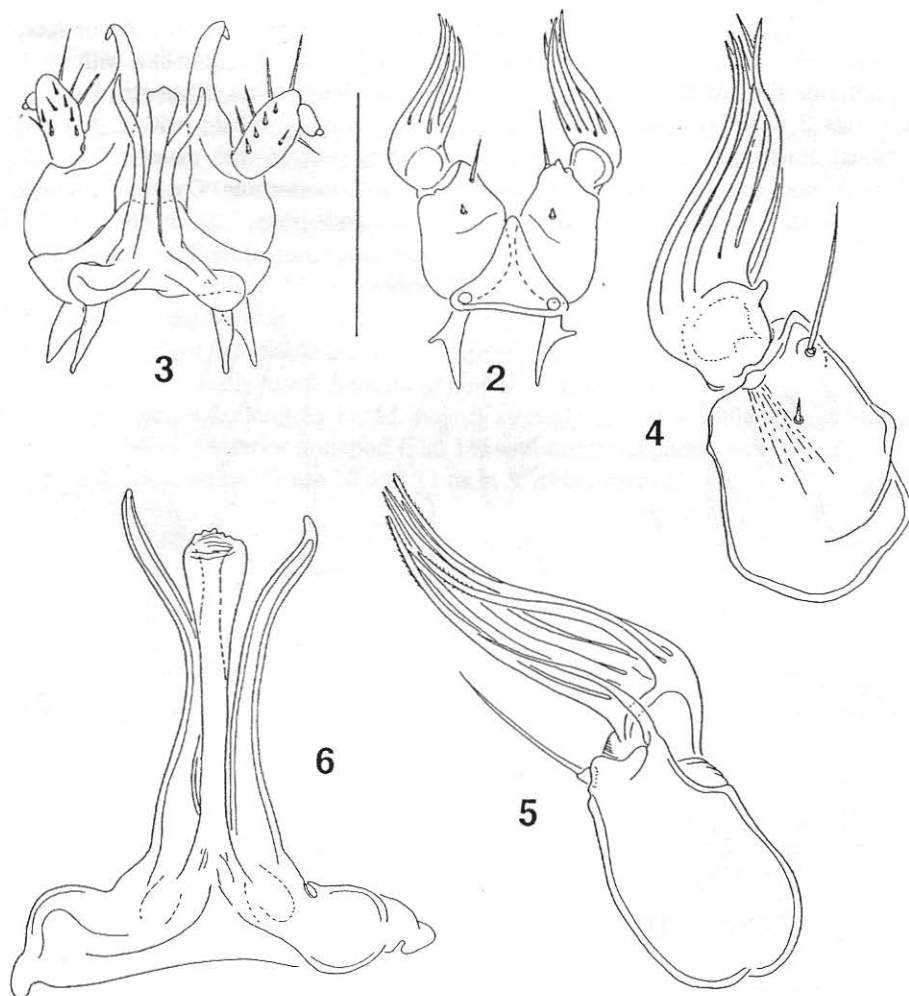
The genus seems to fall naturally into two species groups. In the first, including *akiyoshiense* and *tottoriense*, the gonopods are relatively small and the median process of the anterior gonopods is simple; the second group (*montanum*, *koyama*, *takanawa*) has larger gonopods, and the median process is apically winged. Two of these species (*montanum* and *takanawa*) have two rather than one process on the posterior gonopod coxae. It is possible that these three species are geographic variants rather than full species.

We think that reference to the accompanying illustrations is a more satisfactory means of identification than would be given by verbalized key statements. This is a preliminary restudy of the genus, and we propose the three new species names below as hypotheses to be tested by further collection and analysis of geographic variation. Our task was complicated by the absence of type material for the previously described species.

Speophilosoma montanum Takakuwa
Map 1

Speophilosoma montanus Takakuwa 1949, p. 5. Miyosi, 1959, p. 132.

Male holotype from a lava cave at the foot of Mt. Fuji, Yamanashi Pref., central Honshu. The holotype was destroyed in a fire in 1945, caused by an air raid on Matsuyama, Shikoku, whence the type had been evacuated from Tokyo. Though Takakuwa's paper was not published until 1949, it had evidently been prepared during the Second World War.



Figs. 2-6. *Speophilosoma akiyoshiense*. Fig. 2. Legpair 7, anterior view. Fig. 3. Anterior and posterior gonopods, anterior view. Fig. 4. Left leg 7, anterior view. Fig. 5. Left leg 7, posterior view. Fig. 6. Anterior gonopods, anterior view. Scale lines: 0.6 mm for figs. 2, 3; 0.15 mm for Figs. 4-6.

Speophilosoma akiyoshiense Miyosi

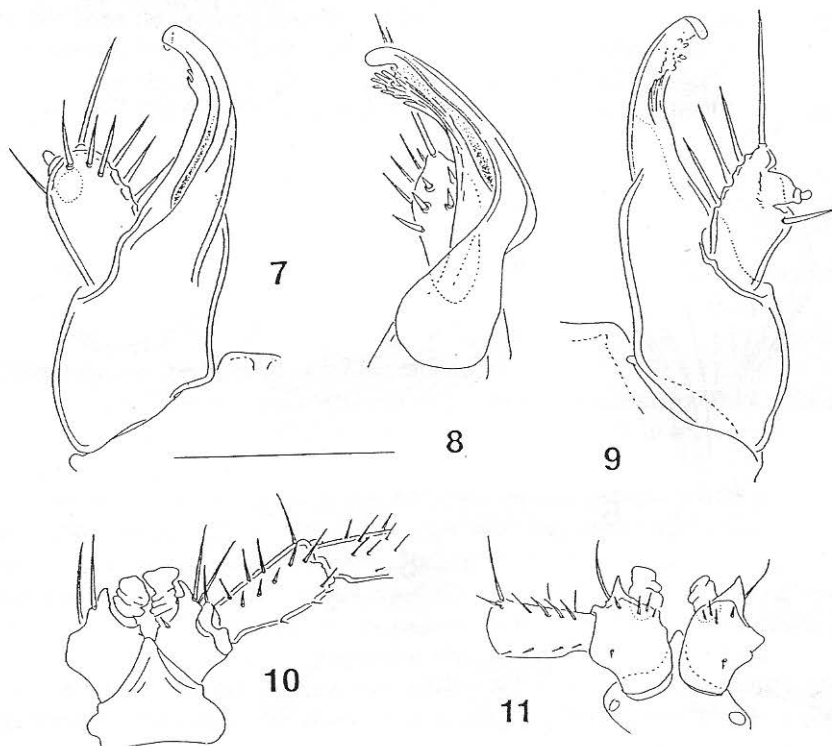
Figures 2-11, Map 1

Speophilosoma akiyoshiense Miyosi 1958, p. 298; 1959, p. 132.

Male holotype from Tanuki-ana Cave, Akiyoshidai, Yamaguchi Pref., Honshu, Japan. The holotype was lost after being deposited in Miyosi's collection.

Description of male from Shimabara-shi, Nagasaki Pref., Kyushu: length, about 5 mm, width 0.35 mm. Antennae missing. Color white, with 6 black ocelli. Metazonites with distinct shoulders, segmental setae less than half width of segments, acute, sharply curved dorsally. Legpairs one and two reduced in size but with full complement of articles; legpairs three to six enlarged, not otherwise modified.

Legpairs 7 (Figs. 2, 4, 5) with subglobular coxae bearing two setae on anterior face, single unsocketed filament on posterior side; telopodite single-articled, button-like, with small hook on anterior side; distally divided into eight or nine long, acute filaments. Anterior gonopods (Figs. 3, 6) with coxae and sternum fused, coxosternum (probably with angiocoxal contributions) drawn out mesally as long, apically flaring process with membranous tip; channel inside connects to large median gland dorsal to coxosternum. Coxites (probably colpocoxites) long, thin, sinuously curved. Posterior gonopods (Figs. 7-9) with large coxae



Figs. 7-11. *Speophilosoma akiyoshiense*. Fig. 7. Left posterior gonopod, anterior view. Fig. 8. Left posterior gonopod, mesal view. Fig. 9. Left posterior gonopod, posterior view. Fig. 10. Coxae of legpair 10, anterior view. Fig. 11. Coxae of legpair 11, posterior view. Scale lines: 0.15 mm for Figs. 7-9; 0.3 mm for Figs. 10, 11.

bearing single, acuminate coxal process with group of fimbriae subapically; tip of coxite may be notched. Telopodite with three articles, basal largest, setose, distal two (three?) articles very much reduced, partially withdrawn into basal article. Coxae of legpairs 10 and 11 (Figs. 10, 11) with glands, slightly modified.

Females similar to males, but slightly larger (to 6 mm long), with eight or ten ocelli.

New record: JAPAN: Kyushu, Shimabara-shi, Nagasaki Pref., from litter, 25 October 1985, male, three females, T. Tanabe leg. (TPM).

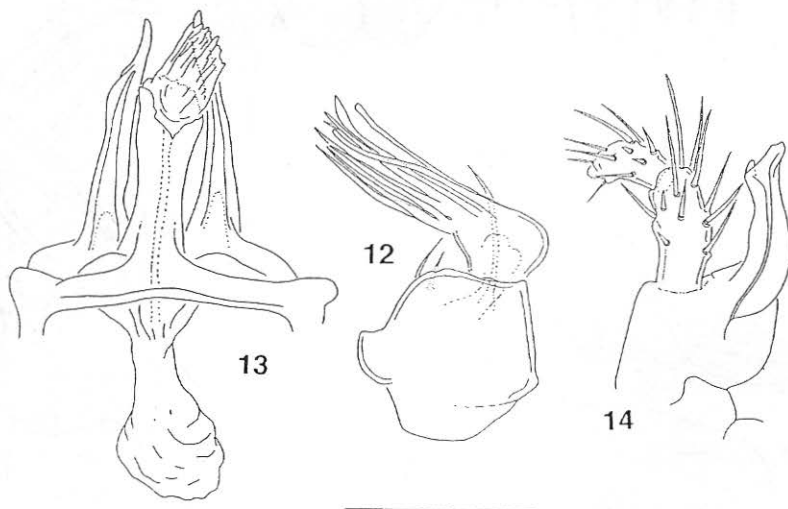
Note: Determination of our specimens is based on their close conformation to the drawings and description of Miyosi (1958, 1959), as the type material has been lost. The type, however, was described as having four, rather than six, ocelli.

***Speophilosoma tottoriense*, new species**

Figures 12-14, Map 1

Material: Male holotype (NSMT) from broad-leaf evergreen forest, 40 m elevation, Mt. Kyūshō, Tottori, Tottori Pref., Honshu, Japan, 19 November 1991, N. Tsurusaki leg. Male and female paratypes (VMNH), and two female paratypes (NSMT) from *Abies firma* and *Pinus densiflora* forest, 40 m elevation, Oochidani, Tottori Pref., 22 November 1991, N. Tsurusaki leg. Male and female paratypes (NSMT) from evergreen broadleaf forest, 60m elevation, Sakadani Shrine Fukube-son, Iwami-gun, Tottori Pref., 14 March 1992, N. Tsurusaki leg.

Holotype: length about 5 mm, width 0.35 mm, antennal article three 0.25 mm long. Color white, with 10 black ocelli. Structure as described above for *S. akiyoshiense*, but legpair seven (Fig. 12) with telopodite article more sharply elbowed where nine filaments arise, three medial filaments basally fused. Anterior gonopods (Fig. 13) more robust, sternocoxal process about three times as long as broad, not so strongly flaring apically; lateral coxites not sinuously curved. Posterior gonopod (Fig. 14) with distal telopodite articles not as reduced; coxite without fimbriae. Coxae 10 and 11 as in *S. akiyoshiense*.



Figs. 12-14. *Speophilosoma tottoriense*. Fig. 12. Left leg 7, anterior view. Fig. 13. Anterior gonopods, anterior view. Fig. 14. Left posterior gonopod, anterior view. Scale line: 0.15 mm.

Female paratype: length about 6.2 mm, width 0.4 mm, antennal article three 0.25 mm long. 12 ocelli. Nonsexual characters as in male.

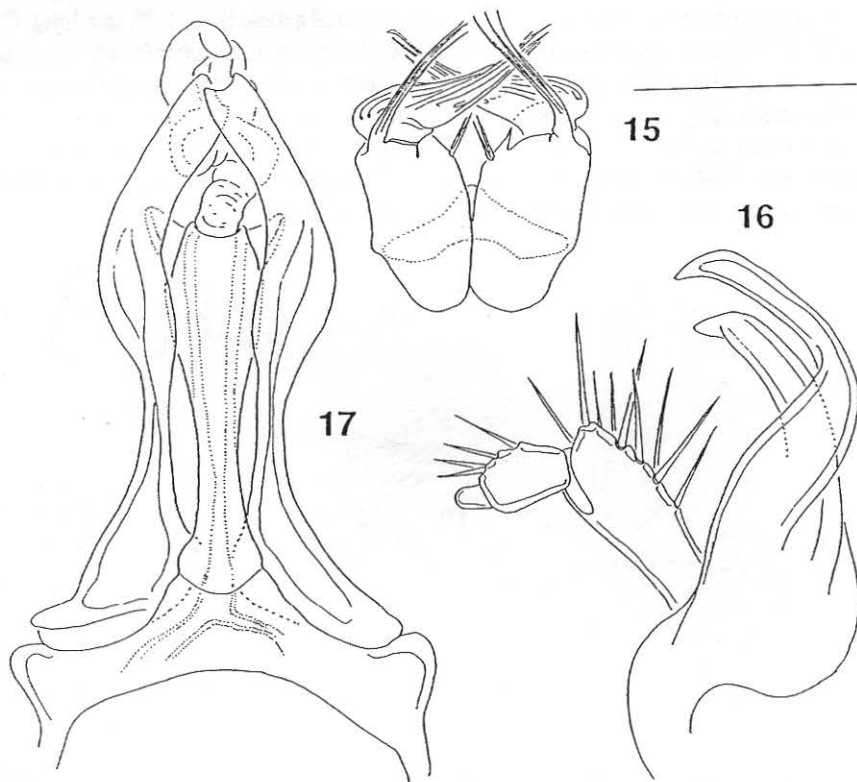
Note: Three females with 12 ocelli, probably this species, were taken at the Momodani Shrine, Momodani, Tottori Pref., 14 March 1992, N. Tsurusaki leg. (NSMT).

***Speophilosoma takanawa*, new species**

Figures 15-17, Map 1

Material: Male holotype (NSMT) from *Fagus crenata* forest, Mt. Takanawa, 930 m elevation, Ehime Pref., Shikoku, Japan, 1 January 1993, N. Tsurusaki leg; male paratype (VMNH) from same locality, but 940 m elevation, 3 May 1993.

Holotype: length about 5.8 mm, width 0.5 mm, antennal article three 0.3 mm long. Color white, with 7 black ocelli in two rows of 5 (dorsal) and 2. Legpairs one and two reduced in size but with full complement of articles; legpairs three to six enlarged, not otherwise modified. Legpair seven (Fig. 15) with telopodite article sharply turned mesally so that filaments cross in midline. Anterior gonopods (Fig. 16) large, median process narrow at base, with fixed articulation (may be an artifact) to sternum, flaring at tip into two winglike lateral extensions; ropy, hardened, secretory mass extruded from pore. Angiocoxites broadly based,



Figs. 15-17. *Speophilosoma takanawa*. Fig. 15. Legpair 7, posterior view. Fig. 16. Anterior gonopods, anterior view. Fig. 17. Left posterior gonopod, anterior view. Scale line: 0.3 mm for Fig. 15; 0.15 mm for Figs. 16, 17.

with narrow stems and flared tips, enclosing apex of median process. Posterior gonopods (Fig. 17) with two distinct coxites curving laterally, telopodite articles typical. Coxae 10 and 11 as in *S. akiyoshiense*.

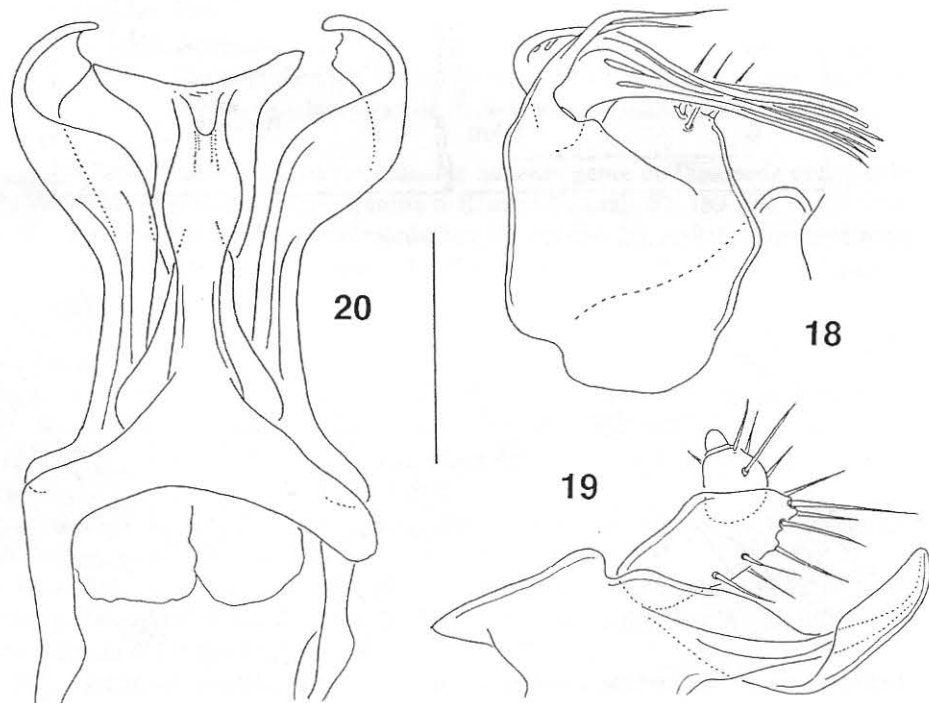
Female not collected.

Note: This species bears some resemblances to the description of *S. montanum*, but the angiocoxites of the anterior gonopods are distinctly different. We have little information about the ranges of individual *Speophilosoma* species, so this may be a variant of *S. montanum*, in which case it can be synonymized later. However, the differences seem to us to indicate species status.

***Speophilosoma koyama*, new species**

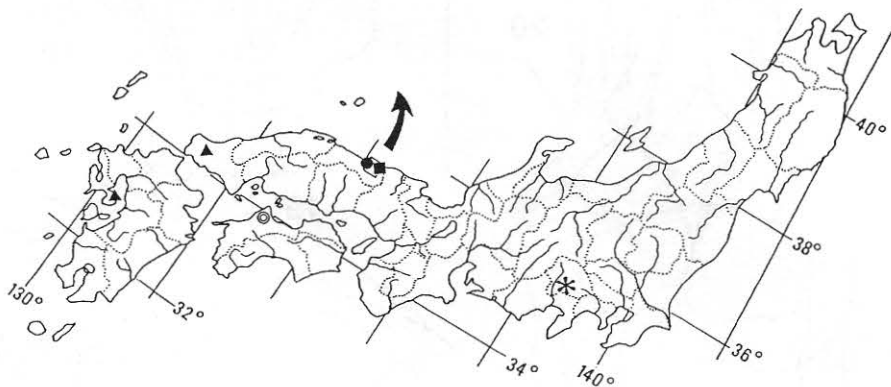
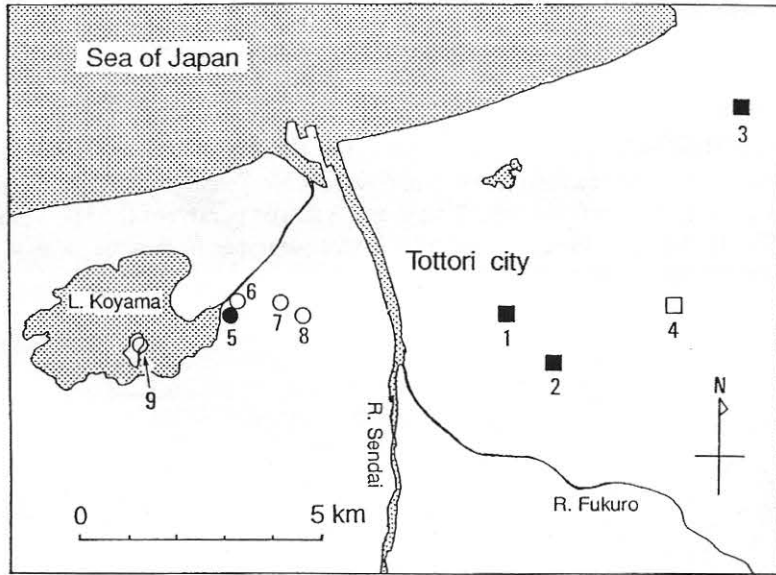
Figures 18-20, Map 1

Material: Male holotype, two female paratypes (NSMT), male and female paratypes (VMNH) from evergreen broad-leaf forest, 5 m elevation, Mt. Tenjinsan, Koyama, Tottori Pref., 10 February 1992, N. Tsurusaki, leg., 7 male and 3 female paratypes (NSMT, VMNH) from same locality, 18 February 1992; 2 male and 3 female paratypes from same locality, 21 April 1993 (NSMT, VMNH).



Figs. 18-20. *Speophilosoma koyama*. Fig. 18. Right leg 7, posterior view. Fig. 19. Anterior gonopods, anterior view. Fig. 20. Left anterior gonopod, anterior view. Scale line: 0.15 mm.

Holotype: length about 5 mm, width 0.45 mm, antennal article three 0.25 mm long. Color white, with 3 or 4 black or poorly pigmented ocelli. Legpairs one and two reduced in size but with full complement of articles; legpairs three to six enlarged, not otherwise modified. Legpair seven (Fig. 18) with about 6-8 filaments. Anterior gonopods (Fig. 19) similar to those of *S. takanawa*, but differing in detail as shown; median process with a relatively broader base and more prominent wings at the apex, angiocoxites more sharply curved. Posterior gonopods (Fig. 20) with single, twisted coxal process; telopodite articles typical. Legpairs 10 and 11 with coxal glands.



Map 1. Distribution of *Speophilosoma* spp. in Japan. Asterisk: *S. montanum*. Filled circle: *S. koyama*. Double circle: *S. takanawa*. Triangles: *S. akiyoshiense*. Filled squares: *S. tottoriense*. Open circles and an open square in an enlarged map of Tottori city denote localities of female specimens which may belong to *S. koyama* and *S. tottoriense* respectively. 1, Mt. Kyushu; 2, Oochidani; 3, Sakadani Shrine; 4, Momodani; 5, Mt. Tenjinsan; 6, Urayama; 7, Ishibayama; 8, Yoshiyama; 9, Is. Aoshima.

Female paratype: length about 5.5 mm, width 0.5 mm, antennal article three 0.25 mm long. Ocelli 5, black, well-defined.

Note: Like the previous species, the winged median process of the anterior gonopods makes *S. koyama* resemble *S. montanum*, but again the gonopod differences seem significant.

The following collections contained only females, but are presumed to be *S. koyama* because of their proximity to the type locality and possession of 4-6 ocelli. All are from Tottori Prefecture, and all collections are by N. Tsurusaki (see map 1). Is. Aoshima in Lake Koyama, Tottori, *Pinus densiflora* forest, 30 m elevation, 6 December 1991, female; Mt. Ishiba (=Ishibayama), Koyama, evergreen broadleaf forest, 10 m elevation, 3 December 1991, 4 females; Mt. Tenjinsan, Koyama, evergreen broadleaf forest, 5 m elevation, 3 and 16 December 1991, 13 females; Mt. Urayama, Koyama, evergreen broadleaf forest, 30 m elevation, 30 November 1991, female; Mt. Yoshiyama, Iwayoshi, evergreen broadleaf forest, 10 m elevation, 3 December 1991, female.

Map 1 shows, on the enlarged map of Tottori city, that the distribution of this species and that of *S. tottoriense* are separated from one another by the River Sendai. The difference in ocellus number seems to be consistent.

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