

## Occurrence of *Sinentomon* (Protura) in Japan

By

**Gentaro IMADATÉ**

Biological Laboratory, Konodai College, Tokyo Medical  
and Dental University, Ichikawa

(Communicated by Yoshinori IMAIZUMI)

The discovery of *Sinentomon* made by Miss W. YIN in 1965 is one of the most exciting events ever made in the history of proturan studies, as was stated by IMADATÉ (1966). The genus occurring in Central China exhibits a striking peculiarity in the unusual combination of its morphological characters. The type-species, *S. erythranum*, has been collected from East She-Shan, Shanghai, where it dwells in a hilly country covered with bamboo of the warm-temperate.

No representative of this genus had previously been met with in spite of my extensive survey of the proturan fauna made for about twenty years. In the summer of 1972, however, Dr. K. SAWADA unexpectedly brought about a male specimen of this genus from a grassland near the top of Mt. Ibuki-yama (C in Fig. 1) at about 1,300 m in altitude (Warmth Index (W. I.)=50), where the slope was covered with *Filipendula multijuga*, *Lingularis stenocephala*, etc. This collecting site belongs to the cool-temperate zone.

Two years later, Miss Tomiyo MATSUMOTO (now Mrs. OHMORI) obtained three adult specimens of *Sinentomon* at the foot of Monju-yama about 60 m above sea-level (W. I.=108), in Fukui City (A in Fig. 1), during the course of her study on the soil zoology made under the supervision of Professor H. SASAJI of Fukui University. Following to this, her colleague, Miss Yūko OYAMA collected in 1976 a considerable number of the proturan in various stages at Sengōdani (about 200 m alt.; W. I.=106) in Takefu City (B in Fig. 1). Their samples of soil and/or organic debris, usually consisting of about one liter under natural condition, were taken from spots about 80 cm<sup>2</sup> in space and 12 cm in depth. According to my observations made in October of 1976, these collecting sites are situated in thickets of Mōsō-bamboo, *Phyllostacys pubescens*, mixed with *Cryptomeria japonica*, in the warm-temperate zone. At both the localities, *Sinentomon* was found only from steeply slanting places with very few litters, where tightly intertwined bamboo-roots occupied an upper layer of soil to the depth of about 15 cm. In the same bamboo-thickets, there occur other proturans like *Eosentomon sakura*, *E. tokiokai*, *E. tuxeni*, *E. udagawai*, *Gracilentulus japonicus* and *Nipponentomon nippon*, but they were concentrated in such places as were flat and rich in organic debris. Such peculiar habitats of *Sinentomon* as noticed above seem to suggest that the proturan feeds on certain microorganisms associated with bamboo-roots.

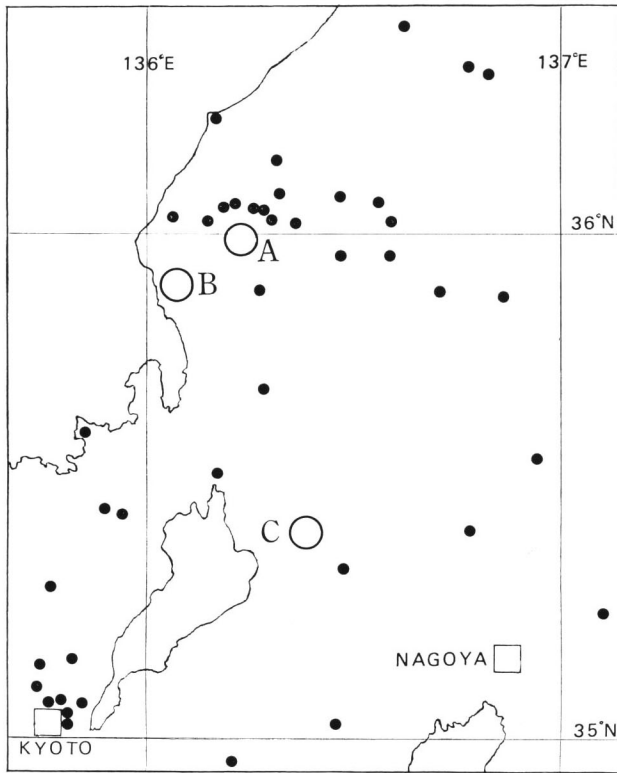


Fig. 1. Collecting sites of *Sinentomon yoroi* sp. nov. Solid circles show collecting sites of other proturans.

All the specimens thus obtained were submitted to me for study through the courtesy of Professor SASAJI. After a close examination, I came to the conclusion that the Japanese *Sinentomon* is specifically different from the Chinese one and is doubtless new to science. It will be described in this paper under the name of *Sinentomon yoroi*. On the other hand, I became aware of the insufficiency of my observations on *S. erythranum* made for preparing my previous account, above all on the structure of the maxilla, the shape and nomenclature of the foretarsal sensillae, and so on. Dr. S. L. TUXEN kindly informed me of the results of his renewed examination of the type-species, and let me have the manuscript of his paper on this point in order to avoid unnecessary confusion. Dr. TUXEN's paper is published alongside the present article by the kind arrangement of Dr. S.-I. UÉNO of the National Science Museum (Nat. Hist.), Tokyo.

The holo- and allotypes of the new *Sinentomon* are to be deposited in the collection of the National Science Museum (Nat. Hist.), Tokyo, and the paratypes are distributed to the collections of the Entomological Institute of Academia Sinica, Shanghai, the Universitetets Zoologiske Museum, Copenhagen, and the Biological Laboratory, Fukui University.

I wish herewith to express my deep appreciation to Professor Hiroyuki SASAJI for his kindness in submitting the invaluable specimens to me for study and in arranging my visit to the collecting sites of the new species. I am greatly indebted to Dr. Shun-ichi UÉNO for kindly reading the original manuscript, for giving valuable advice, and for arranging the publication of Dr. TUXEN's and my own articles in the same issue of the bulletin of his museum. My sincere thanks are also due to Mr. K. HISANO, Mrs. T. OHMORI, Miss Y. OYAMA and Dr. K. SAWADA for their kind cooperation in the course of the present study.

*Sinentomon yoroi* IMADATÉ, sp. nov.

(Figs. 2-11)

*Specimens examined.* Mt. Ibuki-yama, Shiga Pref.—1 ♂, 14-VIII-1972, collected by K. SAWADA. Monju-yama, Fukui Pref.—1 ♂ and 1 ♀, 30-VI-1974, collected by T. MATSUMOTO; 1 ♂, 15-X-1974, collected by T. MATSUMOTO. Sengôdani, Fukui Pref.—1 ♀, 3-V-1976, collected by Y. OYAMA; 2 ♂, 2 ♀, 1 L II and 1 L I, 16-V-1976, collected by Y. OYAMA; 5 ♂, 3 ♀ and 1 matusus junior, 25-V-1976, collected by Y. OYAMA and H. SASAJI; 2 ♂, 2 ♀, 1 L II and 1 L I, 1-VIII-1976, collected by Y. OYAMA; 1 ♂, 19-VIII-1976, collected by Y. OYAMA; 3 ♂, 1 ♀ and 1 L I, 2-IX-1976, collected by Y. OYAMA; 4 ♂, 6 ♀ and 2 L II, 10-X-1976, collected by Y. OYAMA, K. HISANO and H. SASAJI; 1 L II and 1 L I, 10-X-1976, collected by Y. OYAMA, K. HISANO, H. SASAJI and G. IMADATÉ.

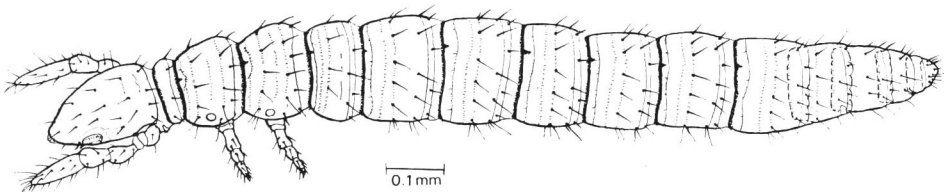


Fig. 2. *Sinentomon yoroi* sp. nov., adult.

Body extraordinary elongated as compared with other proturans. Length 1,660-1,840  $\mu$  in expanded adults. Integument heavily sclerotized and extremely thick, with symmetric or asymmetric rows of small spines, as in *S. erythranum*, and coloured brownish or dark brownish.

Head without rostrum. Clypeal apodeme not seen. Dorsal setae on head fairly long, while ventral setae short. Pseudoculus with 12-14 transverse grates and one intermittent longitudinal bar, PR=4.4-5.6; two anterior and one ventriposterior spines at the outer margin, as in *S. erythranum*. Mouthparts similar to those of the Chinese form. Mandible with four minute teeth distally. Maxillary palpus three-segmented, with two sensillae and tuft at the apex. Galea with fine lobes at the distal end. Labium with three distal setae. Labial palpus with two setae and tuft at the apex.

Prothorax with a row of tubercles on both sides of the posterior margin of tergite.

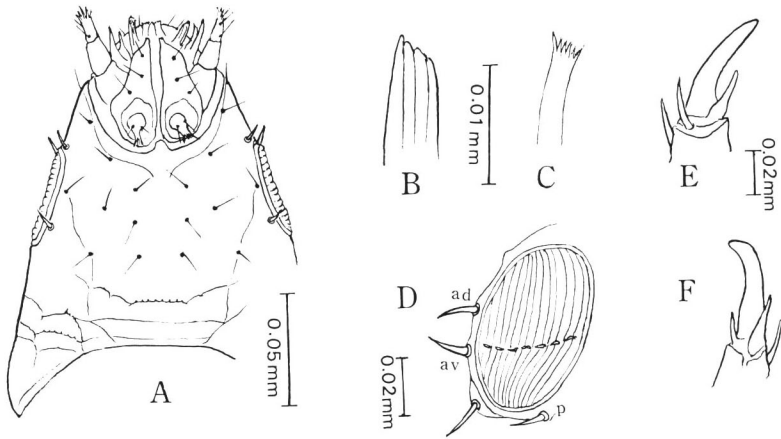


Fig. 3. *Sinentomon yoroi* sp. nov. — A, Head, ventral view; B, mandible; C, galea; D, pseudoculus, ad, av and p: anterior and ventriposterior spines; E, middle claw; F, hind claw.

Meso- and metathoraces with a pair of the tubercles on the tergal posterior margin. In *S. erythranum* these tubercles are absent.

Meso- and Metathoraces with a pair of spiracles respectively. The structure is the same as described by TUXEN (1977) in *S. erythranum*.

Foreleg with 9 setae on coxa, 5 on trochanter, 13 on femur, 14 on tibia, 30 setae and 13 sensillae on tarsus. Tarsus 93–100  $\mu$  in length; claw 23–24  $\mu$ , TR=4.2–4.3; empodium and s-shaped seta subequal in length, 9–10  $\mu$  long, EU=0.4; tarsal setae consisting of 9 dorsal ( $\alpha$  1–9), 10 ventral ( $\beta$  1–9 and 6'), 5 exterior ( $\gamma$  1–5) and 6 interior setae ( $\delta$  1–6);  $\beta$  6' a little distal to sensillae *c* and *c'*; dorsal sensilla *t* 1 thick, *t* 2 slender and *t* 3 thick, a little longer than *t* 1; exterior sensilla *a* subequal to *t* 1 in shape, *b* slender and long, *c* long and gently curved, *d* thick and a little shorter than *a*, *e* absent, *f* and *g* thick, subequal in length to each other; interior sensilla *a'* short and pointed, *b'* subequal to *a'*, *c'* very close to *c*, but thick and blunt, *c''* a little thick and short.

Middle leg with 5 setae on coxa, 4 on trochanter, 8 on femur, 9 on tibia and 14 on tarsus. Tarsus 36–40  $\mu$ ; claw boat-shaped, with an empodium and a short spine. Dorsal spine on tarsus distinct.

Hind leg with 5 setae on coxa, 4 on trochanter, 7 on femur, 9 on tibia and 14 on tarsus. Middle femur with 5 dorsal setae, but only 4 on hind femur. Hind tarsus 40–44  $\mu$ ; claw same as middle one. Dorsal spine on tarsus distinct.

The position and shape of setae and sensillae on three pairs of legs invariable through the postembryonic development from larva I to adult.

Abdomen I–XI with posterior limbi. Limbus with fine striae and small hollows directly behind posterior setae. Abdominal appendage I two-segmented, with one long and three short setae; appendages II and III unisegmented and with two setae. Mouth of the abdominal gland on abdomen VIII covered with simple lid, no pectinated structure. Double Y-shaped apodemes with a pair of *x*-shaped accessory apodemes visible

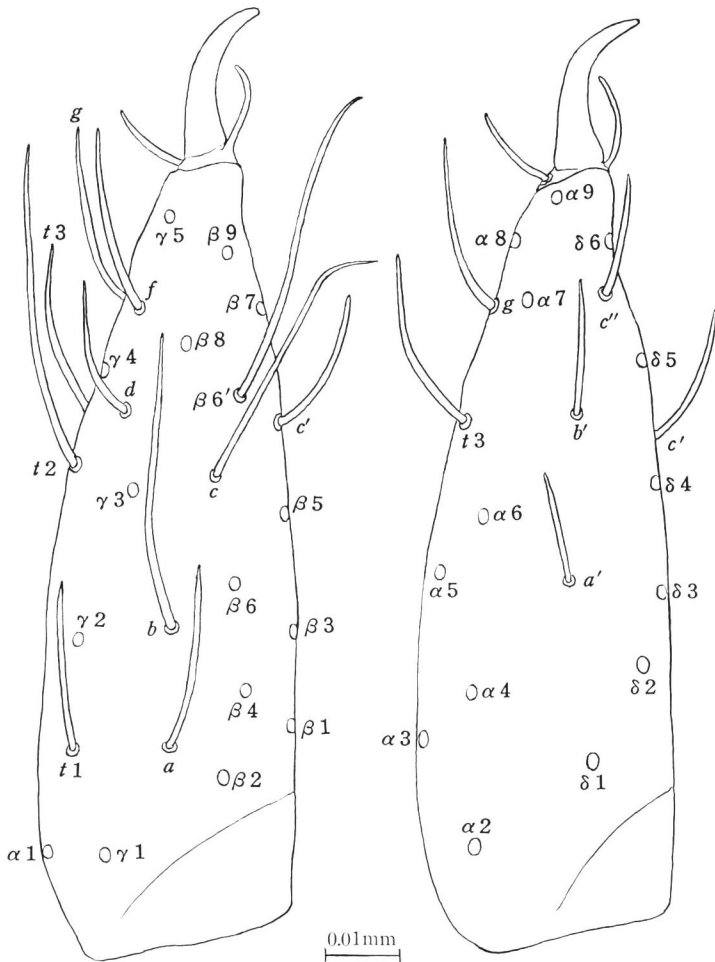


Fig. 4. *Sinentomon yoroi* sp. nov.; foretarsus, exterior (left) and interior (right) views.

at about the center of abdominal terg. VIII. On abdomen VIII–XI dorsal and ventral sclerites completely fused, no distinction present among tergite, pleurite and sternite.

Male and female genital organs accord with those of *S. erythranum*. Stylus of the female squama genitalis possibly bipartite.

Chaetotaxy (Table 1 and Fig. 8) similar to that of *S. erythranum*, but abdominal terg. VIII with five pairs of anterior setae, terg. IX with four pairs of anterior setae and posterior central seta, terg. X with a pair of 2 a in the present new species.

Socket of the body setae often connected with a canal (or nerve) through thick integument; posterior accessory setae with longer canals and anterior setae with shorter ones usually.

Holotype: ♂, Sengôdani, Takefu City, Fukui Pref., 25-V-1976, collected by Y.

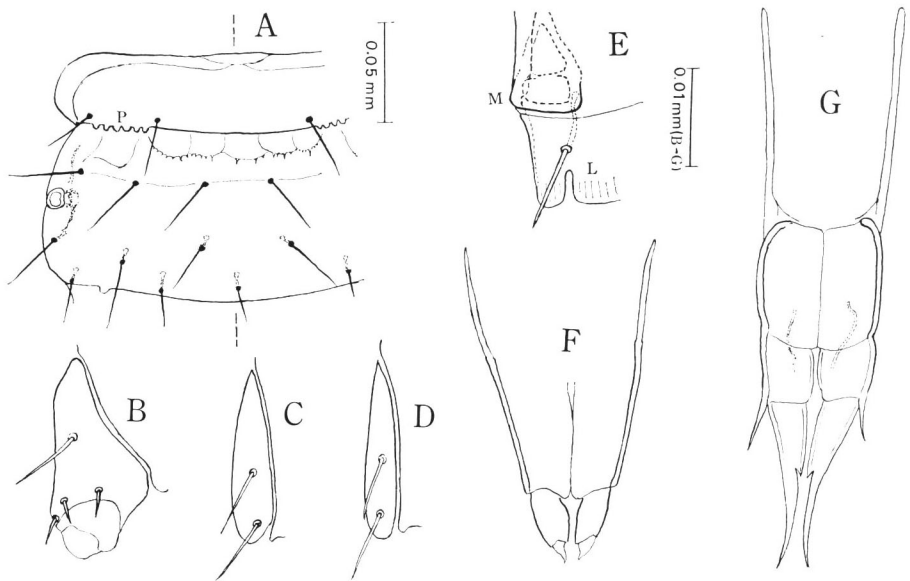


Fig. 5. *Sinetomon yoroi* sp. nov. — A, Pro- and mesothoraces, dorsal view, p: tubercles of posterior margin; B, abdominal appendage I; C, abdominal appendage II; D, abdominal appendage III; E, mouth of abdominal gland on abdomen VIII, M: lid of mouth, L: posterior limbus; F, female squama genitalis; G, male squama genitalis.

OYAMA and H. SASAJI.

Allotype: ♀, Sengôdani, Takefu City, Fukui Pref., 10-X-1976, collected by Y. OYAMA, H. SASAJI and K. HISANO.

Paratypes: Monju-yama, Fukui City, Fukui Pref. — 1♂ and 1♀, 30-VI-1974, collected by T. MATSUMOTO; 1♂, 15-X-1974, collected by T. MATSUMOTO. Sengôdani, Takefu City, Fukui Pref. — 1♀, 3-V-1976, collected by Y. OYAMA; 2♂ and 2♀, 16-V-1976, collected by Y. OYAMA; 4♂ and 3♀, 25-V-1976, collected by Y. OYAMA and H. SASAJI; 2♂ and 2♀, 1-VIII-1976, collected by Y. OYAMA; 1♂, 19-VIII-1976, collected by Y. OYAMA; 3♂ and 1♀, 2-IX-1976, collected by Y. OYAMA; 4♂ and 5♀, 10-X-1976, collected by Y. OYAMA, K. HISANO and H. SASAJI.

*Maturus junior.* Length of body 1,520  $\mu$  in an expanded specimen. Integument well sclerotized, but not so thick as compared with that of adult, 4  $\mu$  at about middle of abdominal terg. VI, while 6-7  $\mu$  at the same place in adult. Body coloured yellow-brownish, foretarsus slightly darker than the other parts. With the exception of the absence of genitalic organ, most of the specific features are similar to those of the adults, but the thoracic tubercles are rudimentary, abdominal terg. XI is extremely reduced, and the following setae are absent: dorsal A 1 on abdomen IX, dorsal 1a, 2a, 3a and ventral c on abdomen X and ventral 1 and 3 on abdomen XI. Canal of body setae almost invisible.

Foretarsus 93  $\mu$  long, claw 21  $\mu$ , TR=4.4, empodium and s-shaped seta 8-9  $\mu$

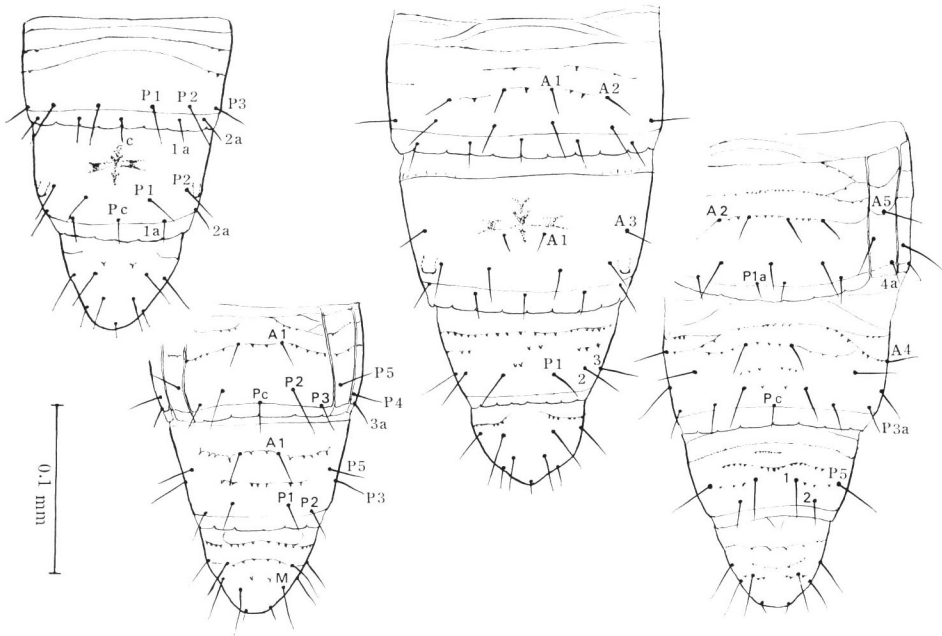


Fig. 6. *Sinentomon yoroi* sp. nov.; chaetotaxy of abdomen VII-telson, larva I (left), dorsal (upper) and ventral (below) views, and larva II (right), dorsal (upper) and ventral (below) views.

long, EU=0.4. Middle tarsus  $34\ \mu$  and hind one  $40\ \mu$ .

*Larva II.* Length of body 1,080–1,200  $\mu$  in expanded specimens. Integument well sclerotized, 1–2  $\mu$  thick at about middle of abdominal terg. VI. Body colour light-brownish, foretarsus a little darker. Such important features as mouthparts and foretarsal sensillae accord with those of the succeeding stages. Foretarsus 74–81  $\mu$ , claw 19–20  $\mu$ , TR=4.1, empodium and s-shaped seta 7–8  $\mu$  long, EU=0.4. Middle tarsus 32–34  $\mu$ , hind one 34–37  $\mu$ .

*Larva I.* Length of body 830–940  $\mu$  in expanded specimens. Integument not so thick, but exceptionally well sclerotized and coloured yellowish compared with other proturans in the same stage. Important characters, such as mouthparts and foretarsal sensillae, well accord with those of the succeeding stages. Double Y-shaped apodemes with a pair of  $\alpha$ -shaped accessory apodemes on abdomen VIII more distinct than those of the adult. Foretarsus 64–66  $\mu$ , claw 19  $\mu$ , TR=3.6, empodium and s-shaped seta 6–7  $\mu$ , EU=0.4. Middle tarsus 31  $\mu$ , hind one 32–33  $\mu$ .

*Distribution.* Japan (Honshu).

*Notes.* The specific name, *yoroi*, meaning armour in Japanese, is derived from the peculiarly thick integument and its accessories possessed by this species.

The present new species is easily distinguished from *S. erythranum* by the absence of foretarsal sensilla *e*, by the presence of anterior setae on abdomen IX as well as by the

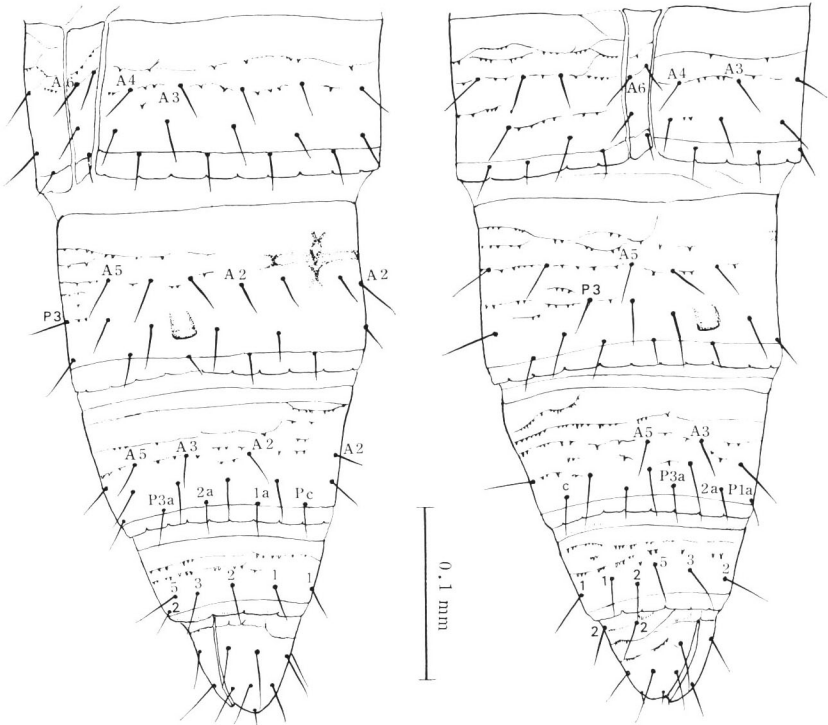


Fig. 7. *Sinentomon yoroi* sp. nov.; chaetotaxy of abdomen VII-telson, matus junior, latero-dorsal (left) and lateroventral (right) views.

presence of a row of tubercles on either side of the posterior margin of prothorax. Besides, the Chinese species is smaller in body size than the present species.

Abnormalities in chaetotaxy are not so rare in *S. yoroi*. For example, in the adult, asymmetric absence and/or displacement of setae A 2, A 5, etc., on abdomen VIII-IX are frequently observed and the absence or displacement of P c on those segments is also found. In larval stages, asymmetric absence of ventral P 1a on abdomen II-VII very frequently occurs in the stage of larva II, but no abnormality is found in larva I.

At this opportunity, I would like to make some comment on Dr. TUXEN's opinion about the phylogenetic position of *Sinentomon*. His discussion seems largely sound, and all the important morphological characters pointed out in it are also found in the Japanese species of the genus. However, I cannot agree with him on the significance of his fourteenth character, the "striate band". As he emphasizes, *Sinentomon* bears many specialized features, but most of them may have been secondarily acquired in the process of "thickening of integument". Having dealt with *S. erythranum*, I (1966, p. 279) misunderstood the origin of this specialization and suggested that it might be an adaptation to a dry climate. This supposition was proved wrong by the discovery of *S. yoroi*, which occurs under a humid climate. The thickening of integument seems to



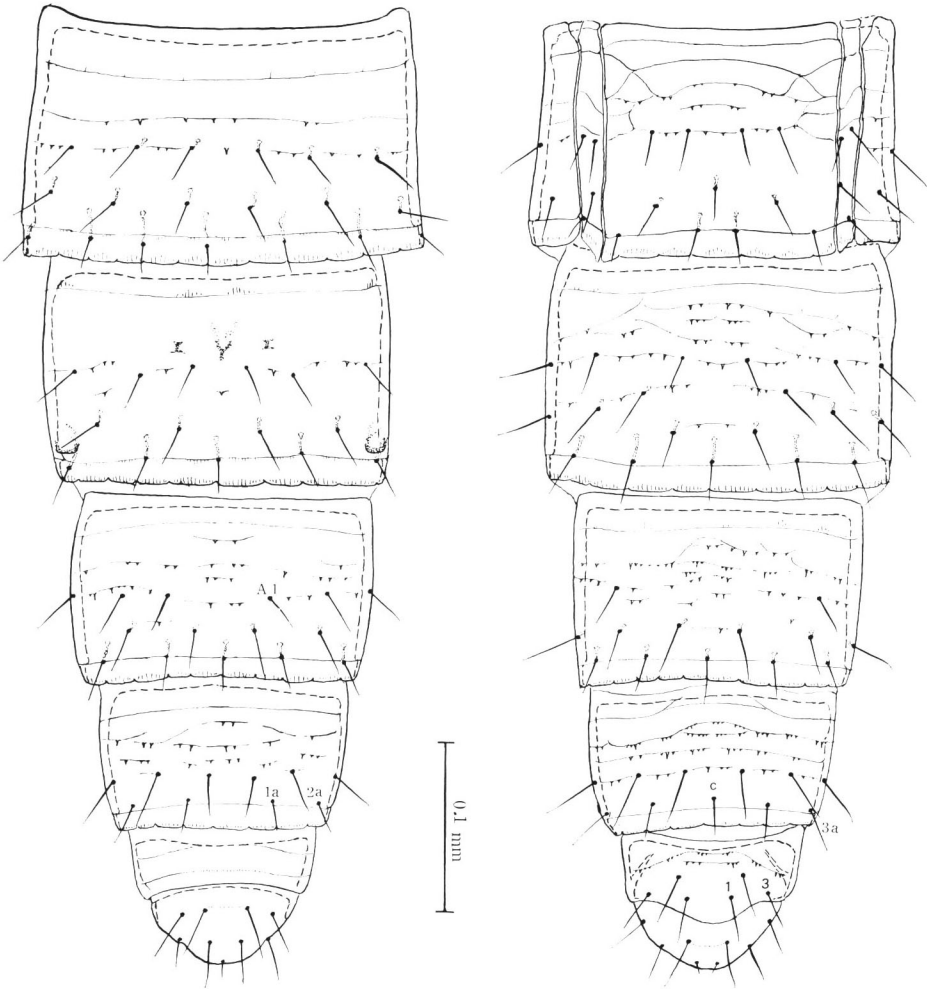


Fig. 8. *Sinentomon yoroi* sp. nov.; chaetotaxy of abdomen VII-telson, adult, dorsal (left) and ventral (right) views. Dotted line shows the thickness of integument.

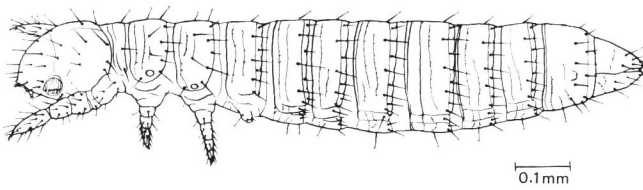


Fig. 9. *Sinentomon yoroi* sp. nov.; larva I.

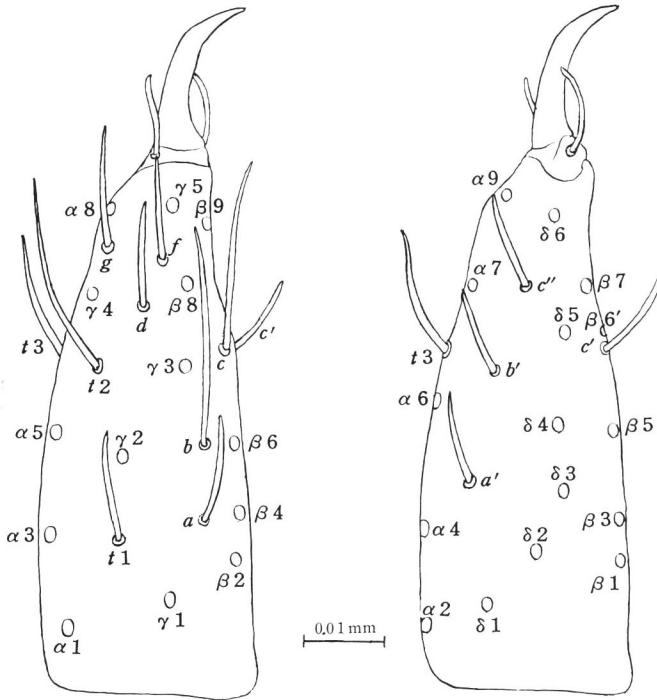


Fig. 10. *Sinentomon yoroi* sp. nov.; larva I, foretarsus, exterior (left) and interior (right) views.

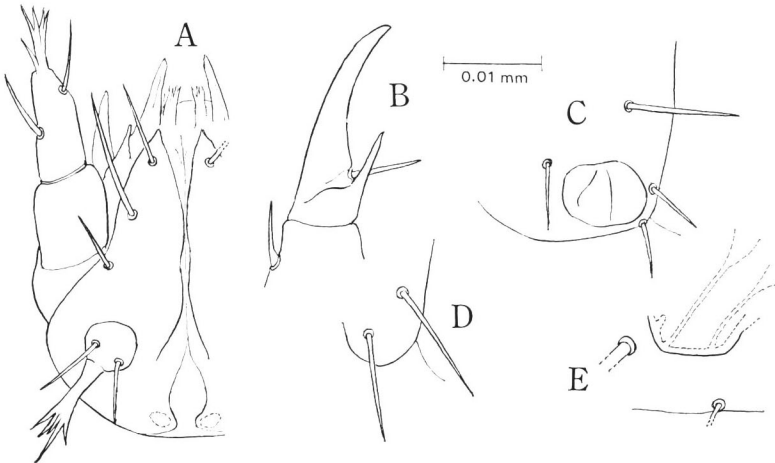


Fig. 11. *Sinentomon yoroi* sp. nov.; larva I. — A, Mouthparts, ventral view; B, hind claw; C, abdominal appendage I; D, abdominal appendage II; E, mouth of abdominal gland on abdomen VIII.



be correlated with the peculiar mode of its life, that is, a life in narrow spaces among tightly intertwined bamboo-roots.

I prefer to divide the peculiarities of *Sinentomon* roughly into two groups. One of them comprises such characters as are related to the thickening of integument. The other group consists of such characters as the toothed mandible, fringed galea, pointed lacinia and the peculiar structure of female squama genitalis, which do not seem to bear any relation with the modification of integument. These are a mélange of fundamental characters taken out from Eosentomidae, Protentomidae and Acerentomidae, which strongly suggests the familial independency of Sinentomidae.

As compared with other proturans, *Sinentomon* shows a peculiar process of postembryonic development of its chaetotaxy. Like eosentomids and protentomids, the ventral A 1 is "primary" and the A 2 "secondary" on abdomen II-VII, but the dorsal A 1 and 2 firstly appear together with A 5 among the six pairs of anterior setae in the stage of larva II, a process which is typical to acerentomids. Further, another "primary" seta, dorsal P c, exists in *Sinentomon*, but not in other families. The chaetotaxial development in *Sinentomon* is summarized in Table 1.

In my present view, Sinentomidae is a good family, and any suprafamilial classification is not needed in the order Protura because of its existence.

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