

The Cave Millipeds of the Genus *Pterygostegia*
(Diplopoda, Diplomaragnidae)¹⁾

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Pterygostegia is a distinctive genus of the family Diplomaragnidae, being characterized by the markedly extended lateral keels on most of the body segments, and is endemic to limestone caves at the southwestern part of the Island of Shikoku in Japan. Originally established by MIYOSI (1958, pp. 180, 182) for a small milliped, *Pterygostegia kuroiwadensis*, collected in the limestone cave called Kuroiwa-dô, it has long been considered monotypic, as it was known only from several caves in Ehimé Prefecture. However, recent investigations have revealed that the members of this genus are widely distributed in Ehimé and Kôchi Prefectures, and that there are actually four different species, three of which seem to be new to science. One of the three was already described under the name of *P. obliqua* in the authors' recent report (MURAKAMI & KAWASAWA, 1975), and the remaining two will be named *P. anops* and *P. grandilobata* in the present article.

The purpose of this paper is to sum up all the knowledge hitherto gained of the genus. The four species are evidently allopatric in distribution. Two previously known species, *P. kuroiwadensis* and *P. obliqua*, are rather widely distributed; the former has been known from eighteen caves and potholes in the southwestern part of Ehimé Prefecture and the western part of Kôchi Prefecture, whereas the latter occurs in four caves lying in the Monobé-gawa and Kokubu-gawa drainages at the eastern part of Kôchi Prefecture. On the other hand, the two new species to be described in this paper are much more localized; *P. anops* has so far been known to occur only in a cave and a pothole lying in the Ohnogahara Karst, and *P. grandilobata* only in two caves at the central part of Kôchi Prefecture. Further collectings are needed to ascertain the actual distributional range of the latter species, particularly in relation to the ranges of *P. kuroiwadensis* and *P. obliqua*. It is, however, certain that *P. grandilobata* fills in the gap between the ranges of the two widespread species.

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Morphologically, *P. anops* and *P. grandilobata* appear to be directly related with each other. Both of them show a high degree of modification in lateral keels, which are much more elongate than those in the other two species. Though it is not easy to determine the phylogenetic relationship of the latter two, certain features, both somatic and gonopodal, seem to suggest a possible course of differentiation in the genus *Pterygostegia*. A summary of consideration on this point will be given at the end of this paper.

The specimens examined including the holotypes of the new species will be deposited in the Department of Zoology, National Science Museum, Tokyo. Some of the paratypes and duplicate specimens are retained in the senior author's collection.

Before going further, the authors wish to express their hearty thanks to Dr. Shun-Ichi UENO of the National Science Museum (Nat. Hist.), Tokyo, for his constant guidance and encouragement during the course of this study, for his collaboration at the field works, and for kindly reading the original manuscript. They are also greatly indebted to Messrs. Masazi UOZUMI, Morisato KIUCHI, Masataka YOSHIDA, Mitsuru HIRAKE, Norio KAJIMOTO, Minoru MATOBA and Setsuaki YAMAMOTO for submitting the interesting materials to the authors for study.

Genus *Pterygostegia* MIYOSI, 1958

Pterygostegia MIYOSI, 1958, Zool. Mag., Tokyo, **67**, pp. 180, 182; 1959, Über japanische Diplopoden, Osaka, pp. 125, 128.

Type-species. *Pterygostegia kuroiwadensis*, 1958, by original designation.

Diagnosis. A genus of cavernicolous diplomaragnids with 32 body segments in both sexes. Eyes generally present, with less than 30 black ocelli, but absent in one species. Tergites typically smooth, with remarkable wing-shaped lateral keels; keels well developed on mid-body segments, generally decreasing in width on segments 27–29, and perfectly absent on 30 and 31; three segmental setae regularly present on each keel, varying in shape and size according to species. Legs long and slender; femur moderately incurved; coxae of 8th legs in male with an oval bursa at each inner base.

Gonopods small, *in situ*, almost sunk in the body. Anterior gonopods consisting of syntelopodite and syncoxite; syntelopodite distally elongate, bearing a small fovea, and with a central lobe at the caudal base; syncoxite small, with a long pseudo-flagellum, which is very slender and largely concealed in syntelopodite. Posterior gonopods larger than anterior ones, consisting of several segments; coxa with two long processes, one of which, *in situ*, gets into the small fovea of syntelopodal process at the distal portion, the tip of this process being characteristic of respective species; telopodite composed of two segments.

Range. Known from about two dozen limestone caves and potholes at the eastern and western parts of Kôchi Prefecture and at the southwestern part of Ehime Prefecture in Shikoku, Japan.

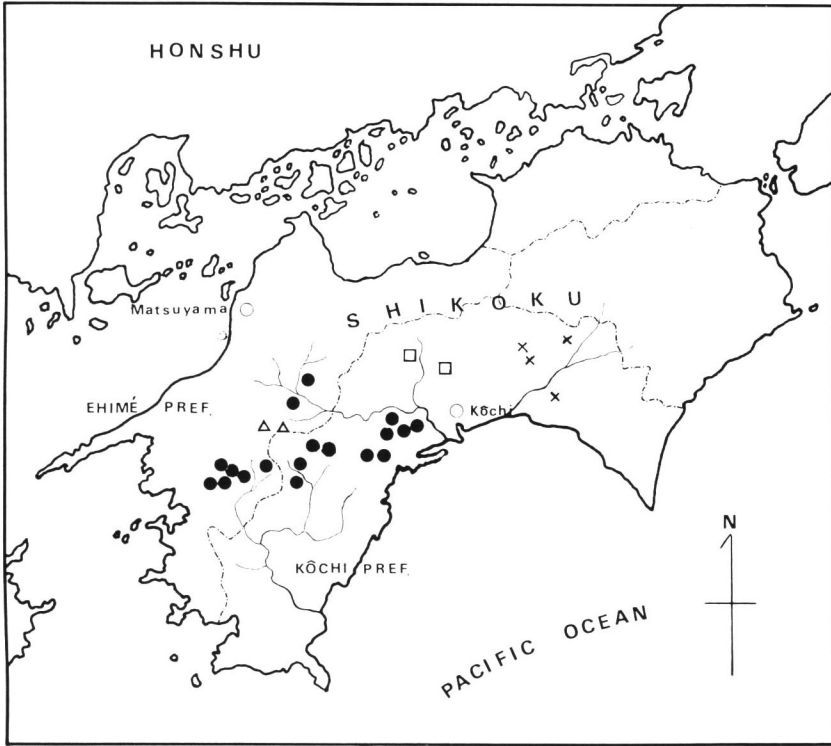


Fig. 1. Map showing the distribution of *Pterygostegia*. — *P. anops*, open triangles; *P. grandilobata*, open squares; *P. kuroiwadensis*, solid circles; *P. obliqua*, crosses.

Notes. Five genera of the family Diplomaragnidae have hitherto been recorded from eastern Siberia and Japan. Among them, the genus *Pterygostegia* is closely related to *Tokyosoma* VERHOEFF (1929, p. 1481; 1932, p. 515), whose members usually occur in epigeal habitats in the three southern main islands of Japan (Honshu, Shikoku and Kyushu). These genera are mutually very similar in the structure of male gonopods, but *Pterygostegia* differs from *Tokyosoma* in external characters, especially in the loss of body pigment and in the presence of wide lateral keels on most of the body segments.

In 1968, MURAKAMI and PAIK published a paper on the cave-dwelling myriapods from the southern part of the Korean Peninsula. In this report, they (p. 375) recorded a diplomaragnid milliped from the limestone cave called Kwangcheon-seon-gul. Though its systematic position has not been clarified yet, the Korean species in question is very similar to *P. grandilobata* in the somatic features. Without doubt, *Pterygostegia* is a milliped group very important for analyzing the faunal relationship between Japan and Korea.

Key to the Species

- 1 (4) Typical keels on mid-body segments slender, with small and clubbed segmental setae.
- 2 (3) No eyes; lateral keels on segment 29 well developed; central lobe of anterior gonopod small; (Rakan-ana Cave and Himegafuchi-no-taté-ana Pot).....
.....*P. anops* n. sp.
- 3 (2) Eyes present; lateral keels on segment 29 reduced; central lobe of anterior gonopod very large; (Shiroiwa-dô Cave and Anadori-dô Cave).....
.....*P. grandilobata* n. sp.
- 4 (1) Typical keels on mid-body segments relatively short, with moderately large and subacicular or liner segmental setae.
- 5 (6) Eyes consisting of less than 20 black ocelli; lateral keels nearly perpendicular to the body axis, each with a small incision on the lateral margin; central lobe of anterior gonopod triangular; coxal process of posterior gonopod nearly bicuspid at the end; (18 caves and potholes in Ehimé and Kôchi Prefectures).....
.....*P. kuroiwadensis* MIYOSI.
- 6 (5) Eyes consisting of 25 or more black ocelli; lateral keels moderately oblique forward, without incision on the lateral margin; central lobe of anterior gonopod pocket-shaped; coxal process of posterior gonopod tricuspid at the end; (4 caves at the eastern part of Kôchi Prefecture).....
.....*P. obliqua* MURAKAMI et KAWASAWA.

Pterygostegia kuroiwadensis MIYOSI

[Japanese name: Kuroiwayasude]

(Fig. 2)

Pterygostegia kuroiwadensis MIYOSI, 1958, Zool. Mag., Tokyo, **67**, pp. 180, 183, figs. 1-2.

Specimens examined. 1 ♂ (topotype), Kuroiwa-dô Cave, 29 November 1968, coll. by M. YOSHIDA; many specimens from 17 other caves and potholes as listed in the notes.

Color in alcohol pale grayish white or yellowish brown; antennae, tibia and tarsus of legs slightly pigmented in virescent brown; in life almost white. Length 18 to 20 mm, greatest width (including lateral keels) about 2.7 mm. Lateral keels well developed on mid-body segments, gradually narrowing toward both ends, and wanting on 29 to 31 and anal segments. The shape of head and of some selected segments are as shown in Fig. 2 A-C; the width values of them in a male specimen as follows:

Head = 1.35 mm	Collum = 1.07 mm	Seg. 2 = 1.21 mm
Seg. 3 = 1.28 mm	Seg. 4 = 1.50 mm	Seg. 5 = 1.78 mm
Seg. 7 = 2.28 mm	Seg. 11 = 2.71 mm	Seg. 25 = 2.28 mm
Seg. 26 = 2.00 mm	Seg. 27 = 1.64 mm	Seg. 28 = 1.28 mm.

Head large, covered with short hairs. Eyes triangular, with 15-18 black ocelli in 5

or 6 transverse series. Antennae long and slender, about 4 mm in length; articles 2–5 cylindrical; article 6 rather subclavate with sensory hairs disto-marginally; article 7 small, rather oblong; the ratio in length of articles 2–7 in a male specimen is 15:32:21:26:10:8. Collum narrower than head, semicircular, with acute setae at the middle of the surface and a seta on each posterior corner. Lateral keels present and well developed in segments 2 through 28, though they are very small in segments 2–3 and 28. Typical keels as shown in Fig. 2 B, F and G, wider than long, extending horizontally and nearly perpendicular to the median body axis; lateral part almost

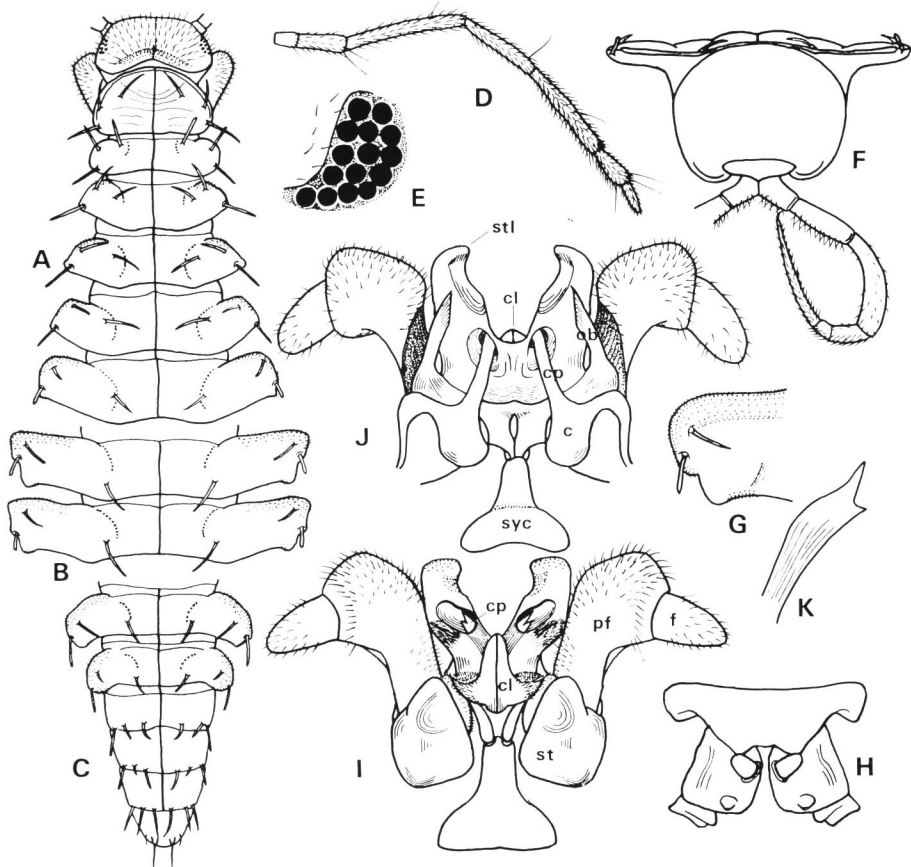


Fig. 2. *Pterygostegia kuroiwadensis*, a topotypical male, of Kuroiwa-dô Cave. — A, Head and six succeeding segments, dorsal aspect. B, 11th and 12th body segments. C, Caudal end of body (from 27th through anal segments). D, Right antenna. E, Eyes of right side. F, Caudal aspect of 15th body segment. G, Outer part of left lateral keel on segment 11. H, Coxae of leg 8, frontal aspect. I, Anterior and posterior gonopods, caudal aspect. J, Frontal aspect of the same. K, Tip of coxal process, showing bicuspid tip. c=coxa, cl=central lobe, cp=coxal process, f=femur, ob=outer branch, pf=prefemur, st=sternite, stl=syntelopodal process, syc=syncoxite.

square, with a small incision at the middle of side margin; scapular area microscopically scabrous; dorsal surface slightly convex, with three segmental setae on each side. Segmental setae large, subacicular or linear, arranged as shown in Fig. 2 B in typical segments; external seta situated just in front of the lateral incision, and not projecting beyond the posterior corner; medial seta longer than others, slightly curving inward, and projecting beyond the posterior margin of metazonite; the distance between medial and internal setae is about four or five times that between internal and external ones. In male, legs long and slender; femur moderately incurved; coxa of leg 8 distally somewhat swollen, sparsely covered with short hairs on the surface, and with an oval bursa at each inner base (Fig. 2 H).

Gonopods small, *in situ*, almost sunk in the body, though telopodites of posterior gonopods are slightly visible in outer view. The relation of anterior and posterior gonopods are as shown in Fig. 2 I and J. Both the gonopods bear the following specific characters. Anterior gonopods: Syntelopodite distally elongate forming obtuse and triangular process (stl) and median sinus U-shaped. Central lobe (cl) large and triangular, with the distal portion slightly projecting beyond the median sinus of syntelopodite; its inner surface densely covered with microscopic hairs. Posterior gonopods: Coxal process (cp) unequally bicuspid at the end (Fig. 2 K); outer branch (ob) with weak marginal striation distally. Telopodal femur (f) oblong.

Notes. This species is easily distinguished from the other known species by having lateral incision on keels. It is widely distributed in Ehimé and Kôchi Prefectures, and its collecting data excluding the topotypical specimens are as given below:

Ehimé Pref.

1. 1 ♂, Chigeo-daiichi-dô Pot, Chigeo, Akanma-yama, Uwa-chô, 2 May 1967, by T. KAWASAWA.
2. 1 ♂, 3 ♀♀, Chigeo-daisan-dô Pot, Chigeo, Akanma-yama, Uwa-chô, 2 May 1967, by S. UÉNO & T. KAWASAWA.
3. 3 ♀♀, Shiinokidaba-no-taté-ana Pot, Shiinokidaba, Nomura-chô, 9 November 1971, by S. UÉNO; 1 ♀, the same pot, 9 November 1971, by T. KAWASAWA; 6 ♂♂, 10 ♀♀, the same pot, 29 April 1972, by Y. MURAKAMI.
4. 4 ♂♂, 6 ♀♀, Karaiwa-dô Cave, Shiminda, Nomura-chô, 8 November 1971, by M. HIRAKE.
5. 1 ♂, 1 ♀, Chinkara-dô Cave, Kubodani, Nomura-chô, 8 November 1971, by M. YOSHIDA; 1 ♀, the same cave, 8 November 1971, by N. KAJIMOTO.
6. 2 ♂♂, 4 ♀♀, Anagami-dô Cave, Narukumi, Kawatsuminami, Shirokawa-chô, 31 October 1970, by S. UÉNO; 1 ♀, the same cave, 31 October 1970, by T. KAWASAWA; 1 ♂, 4 ♀♀, the same cave, 9 May 1971, by M. MATOBA; 2 ♂♂, 3 ♀♀, the same cave, 21 October 1972, by S. UÉNO.
7. 1 ♂, Ryûgû-dô Cave, Ryûgû, Mimido, Mikawa-mura, 17 January 1976, by N. KAJIMOTO.

Kôchi Pref.

8. 1 ♀, Kurumaba-dô Cave, Miyanono, Yusuhara-chô, 9 May 1971, by M.

- MATOBA; 1 ♂, 2 ♀♀, the same cave, 8 November 1971, by S. UÉNO & M. YOSHIDA.
9. 2 ♀♀, Ja-no-ana Cave, Tonomori, Hirono, Yusuhara-chô, 26 March 1971, by T. KAWASAWA & S. YAMAMOTO; 4 ♀♀, the same cave, 11 April 1971, by M. MATOBA.
 10. 1 ♂, 2 ♀♀, Tatsugamori-daini-dô Pot, Ochimen, Yusuhara-chô, 30 April 1967, by S. UÉNO.
 11. 2 ♂♂, Nagasawa-dô Cave, Nagasawa, Komiguchi, Yoshiuno, Higashitsunomura, 11 April 1971, by T. KAWASAWA; 1 ♂, the same cave, 11 April 1971, by M. MATOBA; 2 ♂♂, the same cave, 7 November 1971, by N. KAJIMOTO; 1 ♂, the same cave, 7 November 1971, by M. YOSHIDA; 3 ♀♀, the same cave, 20 October 1972, by S. UÉNO.
 12. 1 ♂, Ryûjin-dô Cave, Kainokawa, Hayama-mura, 23 November 1973, by N. KAJIMOTO; 2 ♂♂, the same cave, 23 March 1974, by S. UÉNO; 1 ♀, the same cave, 5 May 1974, by S. UÉNO; 3 ♂♂, 4 ♀♀, the same cave, 24 November 1974, by N. KAJIMOTO.
 13. 1 ♂, Atagosama-no-ana Cave, Kainokawa, Hayama-mura, 17 May 1970, by T. KAWASAWA.
 14. 1 ♂, Oshigataké-dô Cave, Nishiyama, Sakawa-chô, 13 April 1970, by S. UÉNO; 1 ♂, 2 ♀♀, the same cave, 13 April 1970, by T. KAWASAWA.
 15. 7 ♂♂, 3 ♀♀, Tsukiiiké-daini-dô Cave, Iwaiguchi, Sakawa-chô, 29 April 1975, by Y. MURAKAMI, T. KAWASAWA & M. UOZUMI; 1 ♂, the same cave, 22 June 1975, by S. UÉNO.
 16. 5 ♂♂, 4 ♀♀, Konpira-dô Cave, Tsukadani, Togano, Sakawa-chô, 30 April 1968, by S. UÉNO.
 17. 1 ♂, 1 ♀, Yokokura-dô Cave, Mt. Yokokura-yama, Ochi-chô, 3 April 1974, by S. UÉNO; 2 ♂♂, 1 ♀, the same cave, 3 April 1974, by N. KAJIMOTO.

Pterygostegia obliqua MURAKAMI et KAWASAWA

[Japanese name: Naname Kuroiwayasude]

Pterygostegia obliqua MURAKAMI et KAWASAWA, 1975, Annot. zool. Japon., **48**, p. 192, fig. 1; type-locality: Tengenjôji-dô Cave in Kôchi Pref.

Notes. This species has been known from four limestone caves lying in the drainage areas of the Monobé-gawa and Kokubu-gawa Rivers at the eastern part of Kôchi Prefecture. In the shape of lateral keels and gonopods, it is closely related to *P. kuroiwayadensis*, and can be regarded as the eastern counterpart of the latter.

Pterygostegia anops n. sp.

[Japanese name: Menashi Kuroiwayasude]

(Fig. 3)

Diagnosis. Small troglobiontic species similar to the following new species in

the external features, but readily distinguished from the latter species by the absence of eyes, by the well developed keels on segment 29, and by the details of male gonopods.

Male holotype. Body small and white, with 32 segments. Length approximately 15 mm, greatest width (including lateral keels) about 2.6 mm. Lateral keels very elongate. The shape of head and of some selected segments as shown in Fig. 3 A-C; the widths of them as follows:

Head =1.07 mm	Collum=0.78 mm	Seg. 2=0.85 mm
Seg. 3=1.07 mm	Seg. 5=1.71 mm	Seg. 6=2.41 mm
Seg. 10=2.57 mm	Seg. 23=2.35 mm	Seg. 26=2.07 mm
Seg. 27=1.78 mm	Seg. 28=1.50 mm	Seg. 29=1.07 mm.

Head large, normal in shape, moderately covered with short hairs. Eyes absent. Antennae long and slender, reaching back to the posterior margin of segment 6; the ratio in length of articles 2-7 is 11:23:17:23:9:7. Collum semicircular, with six long segmental setae, the surface being weakly rugose at middle. Lateral keels present and well developed in segments 2 through 29, and abruptly wanting in segments 30 and 31. Typical keels on mid-body segments very wide and slender (ratio of W:L=30:11 in segment 13), slightly reflexed, and nearly perpendicular to the median body axis; outer part moderately narrow and with rounded side margin; dorsal surface and marginal area microscopically scabrous, and with three segmental setae on each side. Segmental setae small and clubbed, typically arranged as shown in Fig. 3 B and F; medial setae very small and bent inward; the distance between medial and internal setae is about eight times that between internal and external ones. Legs 1 and 2 small, with rather long hairs along the ventral surface of postfemur through tarsus; coxae of leg 7 distally swollen; coxae of leg 8 distally protuberant, moderately concave on the frontal surface, and with an oval bursa at each inner base (Fig. 3 G).

Gonopods small, similar to those of *kuroiwadensis* and *obliqua* in basic shape, though differing from them in certain details. Anterior gonopods: Syntelopodal process (stl) rather thin, and with a small fovea at the middle, and with a longitudinal ridge on the caudal side; median sinus wide and V-shaped. Central lobe (cl) small, moderately swollen, and densely covered with microscopic hairs on the surface. Posterior gonopods: Coxa (c) semiovoid in frontal view, with a long and slender coxal process (cp) and an outer branch (ob); tip of coxal process simple as shown in Fig. 3 K. Femur (f) of telopodite very small.

Type-series. 1 ♂, Rakan-ana Cave, at Koya, Nomura-chô, Ehimé Prefecture, 1 May 1967, coll. by S. UÉNO; 1 ♂ (holotype), the same cave, 7 May 1967, coll. by T. KAWASAWA; 1 ♂, the same cave, 1 May 1975, Y. MURAKAMI, T. KAWASAWA & M. UOZUMI.

Further specimen examined. 1 ♀, Himegafuchi-no-taté-ana Pot, at Terayama in the eastern part of the Ohnoghara Karst, on the boundary between Ehimé and Kôchi Prefectures, 28 April 1968, coll. by S. UÉNO.

Notes. In 1969, the junior author published a paper on the arthropod fauna of

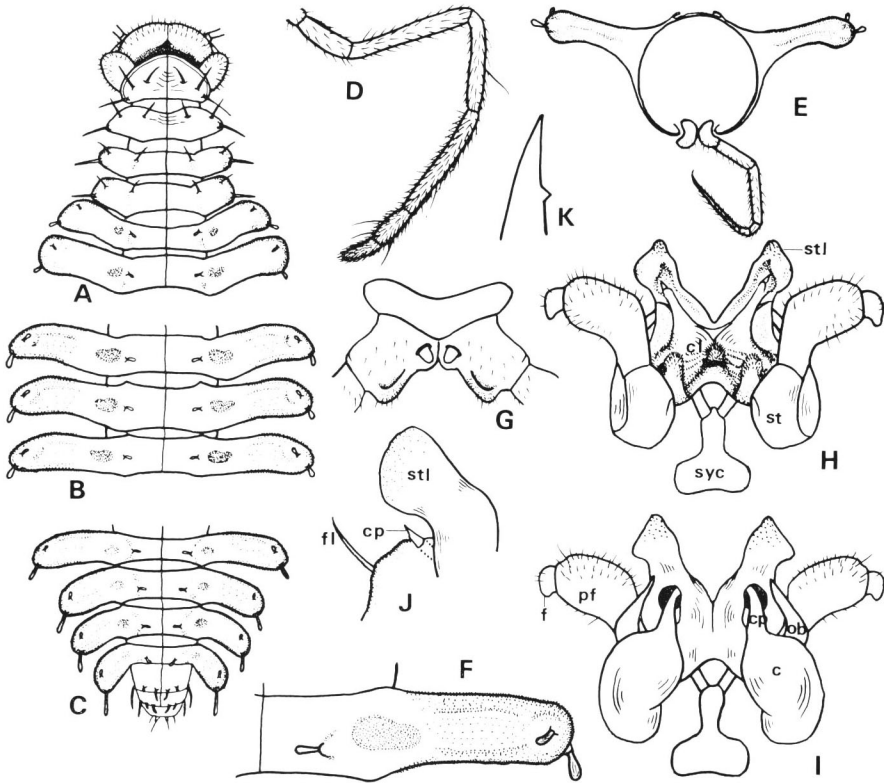


Fig. 3. *Pterygostegia anops* n. sp., holotype, of Rakan-ana Cave. — A, Head and six succeeding segments, dorsal aspect. B, 13th, 14th and 15th body segments. C, Caudal end of body (from 26th through anal segments). D, Left antenna. E, Caudal aspect of 17th body segment. F, Right keel of 12th segment, dorsal aspect. G, Coxae of leg 8, frontal aspect. H, Anterior and posterior gonopods, caudal aspect. I, Frontal aspect of the same. J, Terminal part of left syntelopodal process, mesial aspect. K, Tip of coxal process. c=coxa, f=femur, fl=pseudo-flagellum, ob=outer branch, pf=prefemur, st=sternite, stl=syntelopodal process, syc=syncoxite.

Rakan-ana Cave in Ehimé Prefecture, and recorded a *Pterygostegia* without specific name. This milliped is herewith identified with the present new species. Morphologically, *P. anops* is most highly specialized among the known members of the genus, being characterized mainly by the absence of eyes, by the remarkable elongation of lateral keels and by the presence of well developed keels on the 29th body segment.

Rakan-ana Cave lies at the northwestern foot of the Ohnogahara Karst, the highest limestone plateau in Southwest Japan. The cave is well known among Japanese speleologists not only by being the largest limestone cave in Shikoku, but also by the existence of various cave animals. The present new milliped was found on the damp

muddy floor near the central part of the cave, called "Tainai-kuguri", and at the innermost of the large branch passage called "Migi-hondô" (cf. UÉNO, 1957, p. 189; KAWASAWA, 1969, p. 3).

A female specimen, doubtless referable to this new species in view of its external features, was collected by Dr. UÉNO at the bottom of the pothole called Himegafuchi-no-taté-ana. This pothole is situated at the eastern part of the same karstic plateau, about 5.5 km E of Rakan-ana Cave. The milliped was found on the damp muddy floor about 19 m below the surface. Himegafuchi-no-taté-ana Pot is well known as the habitat of an ultra-evolved trechine, and was described by Dr. UÉNO in 1971 in his account of the beetle (cf. UÉNO, 1971).

Pterygostegia grandilobata n. sp.

[Japanese name: Tosa Kuroiwayasude]

(Fig. 4)

Diagnosis. Small, depigmented troglobiontic species similar in appearance to *P. anops*, but can be distinguished from the latter by the narrow lateral keels on segment 29, by the presence of eyes, and by the shape of large central lobe of male gonopods.

Male holotype. Body small and white, with 32 segments. Length approximately 12 mm, greatest width (including lateral keels) about 2.4 mm. Lateral keels very similar in shape to those of *P. anops*. The shape of head and of some selected segments as shown in Fig. 4 A-C; the widths of them as follows:

Head =0.92 mm	Collum=0.71 mm	Seg. 2=0.85 mm
Seg. 3=0.92 mm	Seg. 10=2.21 mm	Seg. 11=2.35 mm
Seg. 24=2.35 mm	Seg. 25=2.00 mm	Seg. 26=1.86 mm
Seg. 27=1.65 mm	Seg. 28=1.37 mm	Seg. 29=0.86 mm.

Head large, normal in shape. Eyes present, triangular, with 11 ocelli in 4 or 5 transverse series; ocelli almost achromatic, but those of the lowermost row are slightly pigmented. Antennae long and slender, reaching back to the middle of segment 6; the ratio in length of articles 2-7 is 11:28:18:22:9:9. Collum normal in shape, with three erect segmental setae on each side; surface weakly rugose at middle. Lateral keels present in segments 2 through 29, though being narrow in segments 2-3 and 29. Dorsum slightly arched, polished on the surface. Lateral keels and segmental setae essentially similar to those of *P. anops* in the shape and arrangement, but differing in details as follows: Typical keels on mid-body segments somewhat longer and narrower than those of *anops*, though they are likewise elongated (ratio of W:L=35:16 in segment 14) and nearly horizontal; keels on segment 29 reduced; medial setae clubbed and moderately elongate, and somewhat larger than those of *anops*; the distance between medial and internal setae is about five times that between internal and external ones. Legs long, slender and normal in shape, but with the following specific

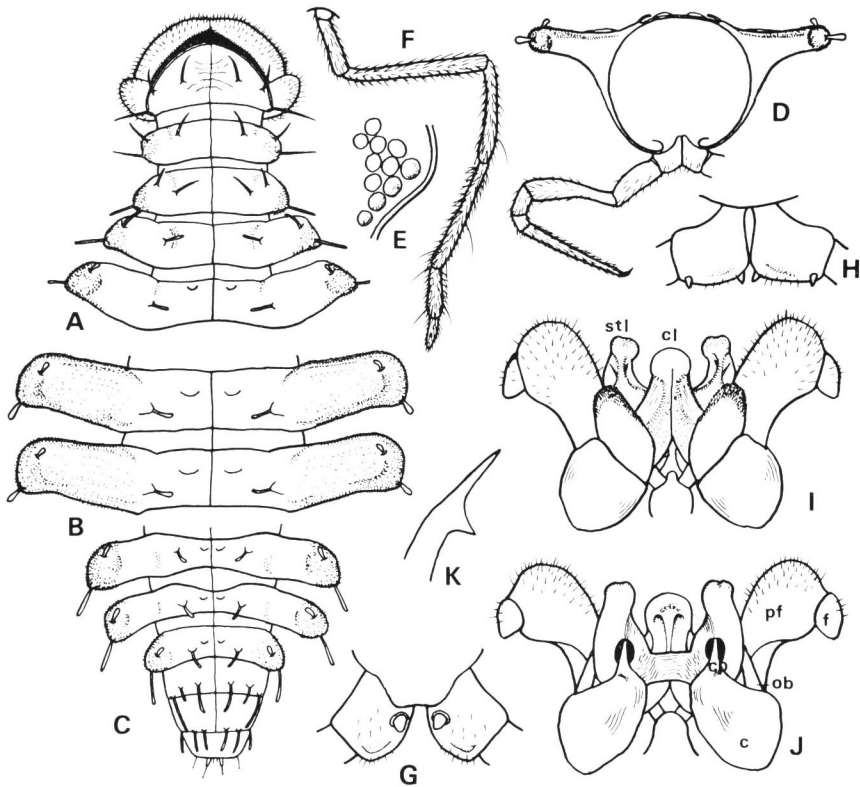


Fig. 4. *Pterygostegia grandilobata* n. sp., holotype, of Shiroiwa-dô Cave. — A, Head and five succeeding segments, dorsal aspect. B, 14th and 15th body segments. C, Caudal end of body (from 27th through anal segments). D, Caudal aspect of 15th body segment. E, Eyes of right side. F, Left antenna. G, Coxae of leg 8, frontal aspect. H, Coxae of leg 9, frontal aspect. I, Anterior and posterior gonopods, caudal aspect. J, Frontal aspect of the same. K, Tip of coxal process.

c=coxa, cl=central lobe, cp=coxal process, f=femur, ob=outer branch, pf=prefemur, stl=syntelopodal process.

characters: Coxae of leg 8 distally protuberant, and with an oval bursa at each inner base (Fig. 4 G); coxae of leg 9 with two small tubercles near each ventral side (Fig. 4 H).

Gonopods basically similar to those in *P. anops* and in the other known members of the genus; the shape of anterior and posterior ones as shown in Fig. 4 I and J. Anterior gonopods: Syntelopodal process (stl) similar in appearance to that of *P. anops*, but the median sinus is angular U-shaped. Central lobe (cl) very large, projecting distally beyond the base of median sinus. Posterior gonopods: Coxa (c) with long coxal process (cp) and outer branch (ob); coxal process forming a peculiar shape at the tip as shown in Fig. 4 K. Femur (f) of telopodite small.

Type-specimen. 1 ♂, 8 November 1970, Shiroiwa-dô Cave, at Shiroiwa, Kagami-

mura, Kôchi Pref., coll. by T. KAWASAWA.

Further specimens examined. 1 ♀, 15 April 1970, Anadori-dô Cave, at Kuzu, Kamiyakawa, Gohoku-mura, Kôchi Pref., coll. by S. UÉNO; 2 ♀♀, 30 April 1975, the same cave, by Y. MURAKAMI, T. KAWASAWA & M. UOZUMI; 1 ♀, 21 June 1975, the same cave, by S. UÉNO.

Notes. The present new species is closely related to *P. anops* of Rakan-ana Cave. They are mutually very similar in the shape of lateral keels, which are much more elongate than those in the other species. Geographically, however, they are widely separated from each other, Shiroiwa-dô Cave being about 60 km distant to the east from Rakan-ana Cave, and the intervening area between their ranges is occupied by *P. kuroiwadensis*. Further investigations are necessary to ascertain the extent of distribution of the respective forms, but both *P. anops* and *P. grandilobata* may be the cave-dwellers older than the other two.

As was briefly described by UÉNO (1957, p. 206), Shiroiwa-dô Cave is horizontally developed just above the water level on the right side of the Kagami-gawa River. Most of the troglobiontic animals known from this cave are confined in the innermost room. The present milliped was also found there, on damp muddy floor.

Four specimens of a troglobiontic *Pterygostegia* were obtained in the limestone cave called Anadori-dô, lying about 18 km to the northwest from Shiroiwa-dô Cave. They cannot be determined satisfactorily because of the absence of males, but are most probably conspecific with the present new species, since their external features are identical with those of the latter. Their locality cave is open on the right side of the Kamiyakawa-gawa, a tributary of the Niyodo-gawa River, about 150 m above the water of the ravine. It is a simple cave developed along the passage of a subterranean stream, and the floor is largely composed of metamorphic rocks and very rugged. The milliped was found under stones on muddy floor or crawling on the wall at the inner part of the cave.

Discussion

As was already described, the four known species of the genus *Pterygostegia* are readily discriminated from one another by external and gonopodal features, above all by the form of lateral keels, the shape of the tip of coxal precess in the posterior gonopods, and the condition of eyes. These specific characters are not only useful for classification, but seem to show a possible phylogenetic relationship among them.

The most obvious of the three characters is the form of lateral keels on respective body segments. In *P. kuroiwadensis*, which has the widest distributional range, the lateral keels are well developed in the 2nd to the 28th segments but are absent in the 29th. Most of them have a small incision on the side margin, a character that does not exist in the other species. In *P. obliqua*, the keels are somewhat shorter than in *P. kuroiwadensis*, but they are inclined forwards and not notched at the side; the 29th segment bears vestigial keels not comparable to those on the 28th. In *P. grandilobata*, the keels become longer and are distinct even in the 29th segment. Their develop-

ment reaches a maximum in *P. anops*, which has strikingly elongated keels on most of the body segments including the 29th. Thus, the following series can be recognized on the basis of the degree of development of lateral keels: *P. kuroiwadensis* — *obliqua* — *grandilobata* — *anops*.

A similar tendency is shown by the reduction of eyes and the shape of the apical part of gonopodal coxal process, but in a slightly different order (cf. Fig. 5). The eyes are best developed in *P. obliqua* and are entirely absent in *P. anops*; in *P. kuroiwadensis*,

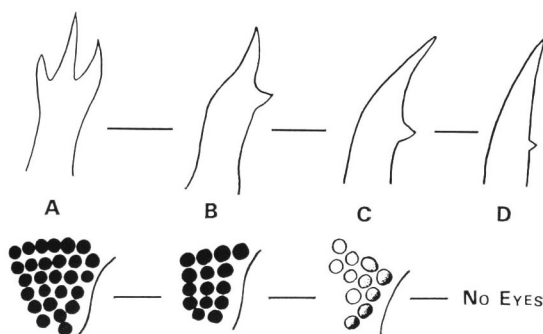


Fig. 5. Change of the apical part of coxal process in posterior gonopod and the reduction of eyes among the members of *Pterygostegia*. Heavy lines indicate possible phylogenetic relationship. — A, *P. obliqua*; B, *P. kuroiwadensis*; C, *P. grandilobata*; D, *P. anops*.

they are reduced in size and in the number of ocelli, but are still perfectly functional, while in *P. grandilobata*, most of the ocelli become achromatic. In this character, *P. obliqua* is doubtless least specialized, *P. kuroiwadensis* is the next and followed by *P. grandilobata*, and *P. anops* shows the highest modification. A more progressive change is found in the apical part of coxal process in the posterior gonopods from *P. kuroiwadensis* to *P. anops*, but *P. obliqua* has a tricuspid coxal process and is widely isolated from the other three. The phylogenetic meaning of this organ is not known, so that it is difficult to decide on this character if *P. obliqua* is more primitive than the others.

In any case, *P. kuroiwadensis* and *P. obliqua* seem to be the two basic species of the genus *Pterygostegia*, having been derived from a common ancestor and becoming differentiated through geographical isolation. *Pterygostegia grandilobata* may also be a derivative from the same ancestral stock, but as it is better adapted to caves, it may have had a longer history of subterranean existence than *P. kuroiwadensis* and *P. obliqua*. *Pterygostegia anops* is confined to the highest karstic plateau in the Island of Shikoku and shows the highest modification of morphological characters. It must be the oldest cave-dweller of the genus, and is comparable in this respect to the ultra-evolved trechine beetle, *Nipponaphaenops erraticus*, which is also endemic to the same karstic plateau.

Postscript

After the manuscript of this paper was sent for printing, the junior author obtained three specimens of a *Pterygostegia* with the aid of Dr. Shun-Ichi UÉNO. They were found in a baited trap set by Mr. Norio KAJIMOTO about a month before at the bottom of the pothole called "Ishigami-dô". This pothole lies at an elevation of about 1,000 m on the northern slope of Mt. Torigata-yama, which towers at the eastern extension of the Ohnogahara Karst. The distance between Himegafuchi-no-taté-ana Pot and Ishigami-dô Pot is about 17.5 km.

After a close examination, it became evident that the specimens belong to *P. kuroiwadensis*. This was most unexpected, since the pothole is cold and harbours *Nipponaphaenops*, which coexists with *P. anops* in Himegafuchi-no-taté-ana Pot. The collecting data of the new material of *P. kuroiwadensis* are as given below:

1 ♂, 2 ♀♀, Ishigami-dô Pot, Mt. Torigata-yama, Niyodo-mura, Kôchi Prefecture, 27 May 1976, coll. by S. UÉNO, in a baited trap set by N. KAJIMOTO on 2 May 1976.

References

- KAWASAWA, T., 1969. The arthropod fauna of Rakan-ana Cave in western Shikoku. *Gensei* (Kôchi Entomological Society), (20): 1-8. (In Japanese.)
- MIYOSI, Y., 1958. Beiträge zur Kenntnis japanischer Myriopoden. 24. Aufsatz: Über eine neue Gattung von Diplopoda. *Zool. Mag., Tokyo*, **67**: 180-183. (In Japanese, with German résumé.)
- 1959. Über japanische Diplopoden. i-iii+1-223 pp., with 3 folders & 19 pls. Osaka, Arachnological Society of East Asia. (In Japanese.)
- MURAKAMI, Y., & K. Y. PAIK, 1968. Results of the Speleological Survey in South Korea 1966. XI. Cave-dwelling myriapods from the southern part of Korea. *Bull. Natn. Sci. Mus., Tokyo*, **11**: 363-384.
- & T. KAWASAWA, 1975. Two new cave millipeds from Kôchi Prefecture, Southwest Japan. *Annot. zool. Japon.*, **48**: 191-197.
- UÉNO, S.-I., 1957. Studies on the Japanese Trechinae (VI) (Coleoptera, Harpalidae). *Mem. Coll. Sci. Univ. Kyoto*, (B), **24**: 179-218, with 1 pl.
- 1971. Occurrence of an aphaenopsoid trechine beetle in Japan. *Ann. Spéléol.*, **26**: 451-462.
- VERHOEFF, K. W., 1929. Arthropoda: Diplopoda, Lief. 9 (pp. 1361-1522). In BRONN, *Klassen und Ordnungen des Tier-Reichs*, **5** (II-2). Leipzig, Akademische Verlagsgesellschaft.
- 1932. Diplopoden-Beiträge. (124. Diplopoden-Aufsatz.). *Zool. Jahrb., Syst.*, **62**: 469-524, pls. 4-6.