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Two Schizomid Whip-Scorpions (Schizomida, Schizomidae) Found in Limestone Caves of the Ryukyu Islands and Taiwan*

With 23 Text-figures

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ABSTRACT During his stay for the cave surveys in the Ryukyus in 1972, Dr. S.-I. Uéno obtained 17 specimens of schizomid whip-scorpions. Of these, eleven specimens belong to *Schizomus sauteri* and the remainings to *Trithyreus siamensis* which has hitherto been known only from Bangkok. Descriptions and illustrations of these two species are given. Additional materials from the Ryukyus and Taiwan are also examined. Both the species are troglophilous, and the latter species has been found only in limestone caves in the areas here dealt with.

Until recently, *Schizomus sauteri* is known as the sole representative of schizomid whip-scorpion occurring in the Ryukyus and Taiwan. This species was originally described by Kraepelin in 1911 on the basis of Hans Sauter's materials. These were collected in Takao (=Kaohsiung), Taiwan. Subsequently, it was recorded from Chih-shang-yen near Taipei in Taiwan and also from Shuri in Okinawa-hontô of the Ryukyu Islands (Takashima, 1941).

The junior author has been carrying on arachnological surveys in the Ryukyus and Taiwan, and investigated many limestone caves. As a result, it has been clarified that *S. sauteri* widely ranges from Taiwan to Amami-Oshima Island and frequently occurs in limestone caves in the islands of Okinawa-hontô, Kumé-jima, Miyako-jima and Ishigaki-jima (Shimojana, 1972). He also reported in the same paper that three individuals of another species of schizomid whip-scorpion had been found in Mayaa-abu Cave lying at the central part of Okinawa-hontô Island. Although he described it concisely, he could not identify it with any of the theretofore

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known species.

During the cave surveys of the Ryukyus made in the summer of 1972, Dr. Shun-Ichi Uéno obtained 17 specimens of schizomid whip-scorpions including adults of the undetermined species in good condition. Dr. Uéno kindly gave the authors an opportunity to study on these materials. The result will be dealt with in the present paper, together with that of a re-examination of the above-mentioned material in the junior author's collection.

The limestone caves in which schizomid specimens were collected by Dr. Uéno are as follows:

1) Mayaa-abu Cave, at Mashiki, Ginowan-shi, Okinawa-hontô Island.
2) Mayaa-gama Cave, at Uezu, Gushikawa-shi, Okinawa-hontô Is.
3) Yajaa-gama Cave, at Nakachi, Gushikawa-son, Kumé-jima Is.
4) Muzuka-gaa Cave, at Higashinaka, Hirara-shi, Miyako-jima Is.
5) Iza-gaa Cave, at the same location as above.
6) Abucha-dô Cave, at Nakabari, Gusukubé-chô, Miyako-jima Is.

In addition to these, a schizomid specimen collected by him in Yin-chuan-tsang-hsia-tung Cave at Kuei-chiao-liu near Kaochun in Taiwan, is also investigated herewith.

The specimens examined are deposited in the Department of Zoology, National Science Museum, Tokyo.

Schizomus sauteri Kraepelin, 1911

[Japanese name: Yaito-mushi]

Schizomus sauteri Kraepelin, 1911, Mitt. naturh. Mus., Hamburg, **28**: 100, pl. figs. 2a–h. [♂♂, ♀♀, Takao, Formosa (in Hamburger Museum)].

Schizomus sauteri: Speijer, 1936, Mitt. zool. Mus. Berlin, **21**: 260 (Catalogue). —— Takashima, 1941, Acta arachnol., **6**: 94 (new locality and figures of legs and female flagellum); 1941, Biogeographica, **3**: 277; 1943, Acta arachnol., **8**: 22 (description); 1948, Acta arachnol., **10**: 100 (description); 1965, New Illust. Encycl. Fauna Jap., **2**: 341, 1 fig. (description). —— Esaki, 1949, Illust. Encycl. Fauna Jap., rev. ed., p. 1002, fig. 2849 ♀ (description). —— Shimojana, 1972, Idén, Tokyo, **26** (5): 100, figs. 1 & 2 (new localities).

Material examined. 2♂♂, 2♀♀ and 3 larval ♀♀, Mayaa-gama Cave, Uezu, Gushikawa-shi, Okinawa-hontô Is., 23. vii. 1972; 1 ♀ and 1 larval ♀, Yajaa-gama Cave, Nakachi, Gushikawa-son, Kumé-jima Is., 4. viii. 1972; 2♂♂, Abucha-dô Cave, Nakabari, Gusukubé-chô, Miyako-jima Is., 2. viii. 1972.

Male. Body length (from apex of propeltidium to tip of flagellum), 3.82–4.38 mm. Propeltidial length, 1.10–1.17 mm.

Coloration. Body light brownish grey in general view. Ventral side of cephalothorax whitish with pale brownish colour and that of abdomen pale yellowish grey. Ventro-distal margin of each coxa reddish brown. Flagellum pale brown. Membraneous parts white.

Cephalothorax. Propeltidium protruding in the anterior margin as shown

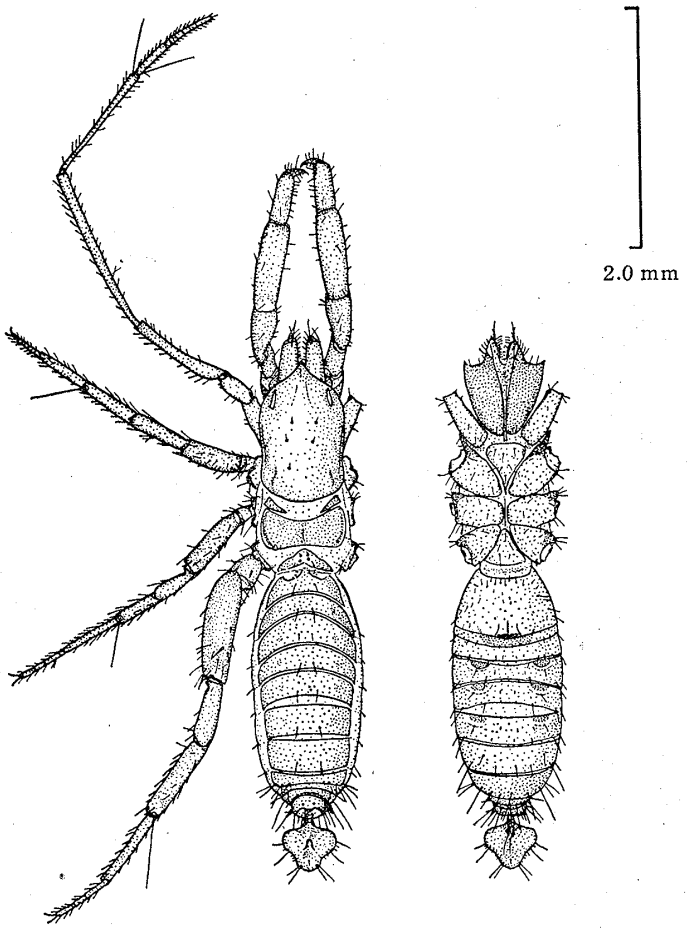


Fig. 1. *Schizomus sauteri*, male, of Abucha-dô Cave, Miyako-jima Island. Left, dorsal side; right, ventral side.

in Figs. 1 and 2; projecting antero-median portion with a pair of short setae and a single longer one followed by three successive pairs of setae; a pair of whitish eye-spots well-defined. Second thoracic tergite (metapeltidium) composed of a single plate which has a vague median line or rarely divided into two sclerotized parts. Cephalic sternum subtriangular, and longer than wide; anterior margin straight, with rounded angles on each side.

Chelicerae. The length of first segment (between tip of proximal margin and tip of immovable digit), 0.81 mm; second segment, 0.36 mm. Inner surface as shown in Fig. 3. First segment bearing a long seta at the apex of dorsal margin, four medium-sized and three short simple spines on inner surface, nine long feathered setae and two medium-sized spines on the anterior half of venter, four simple or feathered setae on distal margin of both the surfaces, three modified long expanded setae (blood-hairs) distally, and some long feathered setae on both sides of the membraneous part of the distal margin; immovable digit with six teeth between the basal and apical main teeth (Fig. 4), also bearing seven short feathered setae closely lined at

the inner surface. Second segment or movable digit with a row of 20 short distally feathered and curled setae, 15 hyaline teeth of serrula and one guard tooth on inner surface.

Pedipalpi. Total length, 2.80–3.42 mm. Trochanter shorter than femur, and weak in distal projection which forms an angle of 100°; ventral margin roundly convex, with seven strong setae; inner surface with a single short tooth at about distal fifth and with some short setae. Femur relatively long, roundly convex dorsally, and margined with setae; ventral margin approximately straight and one-third the length of dorsal margin. Patella longer than tibia. Tarsus shorter than trochanter, and two immovable spurs and many setae.

Legs. First leg longer than body length, but not very long; tibia shorter than patella or femur; combined metatarsi and tarsus shorter than tibia; second metatarsus shorter than tarsus (Fig. 7 a); terminal segment of tarsus a half the length of second metatarsus. Coxae of second to fourth legs as shown in Fig. 1 right. Fourth legs stouter than other legs; femur robust, its greatest depth about one-third its length.

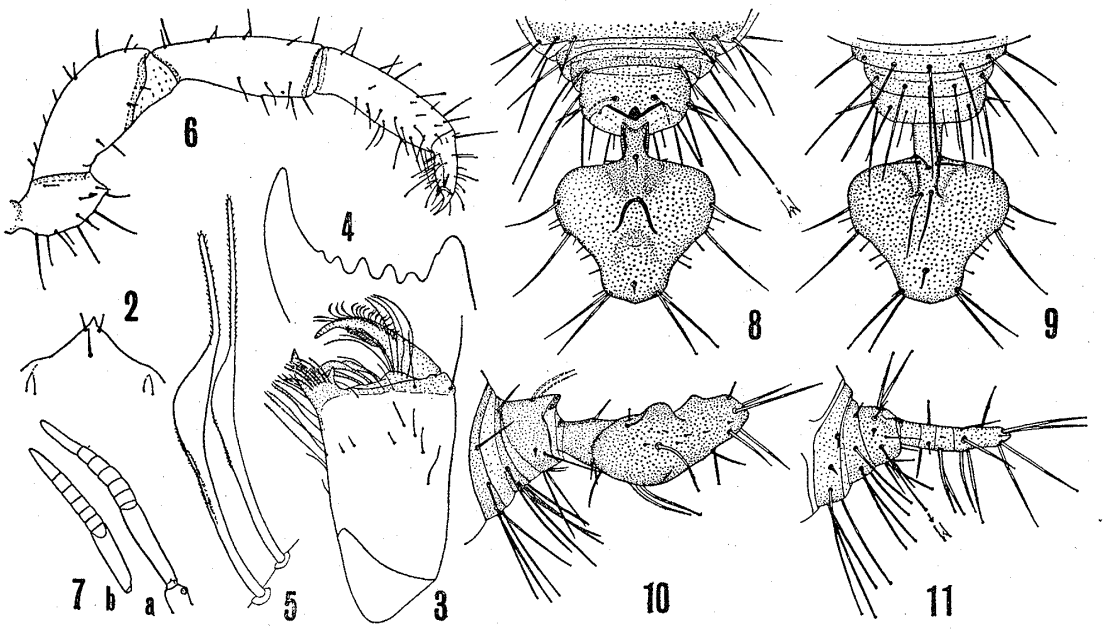
Measurements (in mm) of right legs, showing the linear distance between mid-points of joints, are as follows. The measurement of tarsus includes the length of claw.

	Pedipalp	1st leg	2nd leg	3rd leg	4th leg
Coxa	0.56 (0.53)	0.53 (0.51)	0.46 (0.42)	0.37 (0.32)	0.34 (0.31)
Trochanter	0.44 (0.43)	0.32 (0.34)	0.20 (0.20)	0.21 (0.23)	0.33 (0.32)
Femur	0.72 (0.67)	1.20 (1.23)	0.89 (0.87)	0.72 (0.75)	1.20 (1.17)
Patella	0.70 (0.70)	1.40 (1.39)	0.49 (0.47)	0.34 (0.34)	0.56 (0.52)
Tibia	0.58 (0.54)	1.00 (0.98)	0.47 (0.51)	0.41 (0.41)	0.71 (0.75)
Metatarsi	—	0.35 (0.34)	0.41 (0.46)	0.50 (0.50)	0.70 (0.72)
Tarsus	0.40 (0.39)	0.47 (0.50)	0.36 (0.40)	0.45 (0.42)	0.49 (0.49)
Total	3.40 (3.25)	5.27 (5.29)	3.28 (3.33)	3.00 (2.98)	4.33 (4.28)

The values before parentheses are measurements in the largest individuals, and the values in parentheses are the averages of measurements with four adults including the largest one.

Abdomen. First tergite relatively large and chevron-shaped, with two pairs of very short spines (under low magnification "very short spines" appear to be simple tubercles) and with a pair of mesal setae on posterior margin. Each of second to ninth abdominal tergites with a pair of mesal setae; second abdominal tergite with a pair of round depression on the anterior margin and with three pairs of very short spines anteriorly to these depressions. Tergites third to ninth simply shaped. Segments tenth to twelfth as shown in Figs. 8–10; tip of long setae on ventral side bifurcate or trident.

Flagellum. Heart-shaped seen from above, and large in comparison with the body; slightly longer than wide; dorsal surface with two protuberances at apical one half and the other one at apical one-third of the main piece (Fig. 8); in lateral view



Figs. 2–10. *Schizomus sauteri*, male. —— 2. Anterior margin of cephalothorax. —— 3. Inner aspect of right chelicera. —— 4. Distal end of immovable digit of chelicera. —— 5. Long modified expanded setae of distal margin of first segment of chelicera. —— 6. Inner aspect of pedipalp. —— 7 a. Metatarsus-tarsus of first leg. —— 8–10. Dorsal, ventral, and lateral aspects of flagellum and three posterior abdominal segments.

Figs. 7 b and 11. *Schizomus sauteri*, female. —— 7 b. Metatarsus-tarsus of first leg. —— 11. Lateral aspect of flagellum and three posterior abdominal segments.

central part showing maximum height (Fig. 10); length (including stalk): 0.51–0.54 mm, width: 0.41–0.43 mm, height: 0.24–0.25 mm.

Female. Body length (from apex of propeltidium to tip of flagellum), 4.02–4.35 mm. Propeltidial length, 1.07–1.13 mm.

Coloration. The same as the male, but with paler flagellum.

Cephalothorax. Second thoracic tergite (metapeltidium) distinctly separated into a pair of sclerotized parts.

Pedipalpi. Similar to those in the male but shorter; distal process of trochanter weak, forming an angle slightly exceeding 115°. Measurements are shown together with those of legs.

Legs. First leg longer than body length, but shorter than that of the male; especially second metatarsus shorter (Fig. 7 b). Measurements (in mm) of each right leg are given on the following page by the same method as in the case of the male.

Flagellum. Elongate, cylindrical, and divided into four sections by sutures (Fig. 11); distal section approximately equal to three proximal sections combined; first section with no spine; second section with two long and two short setae; third section with two long setae ventrally and two short spines laterally; last section bear-

	Pedipalp	1st leg	2nd leg	3rd leg	4th leg
Coxa	0.53 (0.51)	0.56 (0.48)	0.42 (0.40)	0.38 (0.36)	0.32 (0.30)
Trochanter	0.48 (0.44)	0.31 (0.31)	0.21 (0.19)	0.20 (0.19)	0.32 (0.31)
Femur	0.58 (0.53)	1.10 (1.02)	0.83 (0.78)	0.74 (0.68)	1.19 (1.09)
Patella	0.55 (0.52)	1.28 (1.18)	0.49 (0.44)	0.31 (0.32)	0.55 (0.47)
Tibia	0.50 (0.44)	0.98 (0.89)	0.52 (0.47)	0.40 (0.35)	0.80 (0.75)
Metatarsi	—	0.32 (0.31)	0.50 (0.44)	0.50 (0.46)	0.71 (0.67)
Tarsus	0.34 (0.33)	0.49 (0.48)	0.41 (0.38)	0.39 (0.38)	0.51 (0.48)
Total	2.98 (2.77)	5.04 (4.68)	3.38 (3.09)	2.92 (2.75)	4.40 (4.06)

The values before parentheses are measurements in the largest individual, and the values in parentheses are the averages of measurements with three adults including the largest one.

ing ten long setae, five near base, one at middle, and four near blunt apex, and with two short spines on lateral spines near apex; length, 0.27–0.31 mm.

Localities. Amami-Oshima, Okinawa-hontô, Kumé-jima, Miyako-jima, Ishigaki-jima Islands, and Taiwan.

Notes. The present species is characterized by the unique shape of male flagellum and the small but robust body.

Though the shape of male flagellum illustrated by Kraepelin (1911) slightly differs from that in the specimens before the present authors, especially in dorsal view and in the size of protuberances on the dorsal surface, those differences may be attributed to geographical variation. The body length "3.3 mm" given by Kraepelin is not available for discussion, as the authors do not know how he measured it.

Takashima repeatedly discussed on this species, noticing that all the materials before him were females. However, it seems probable that he dealt only with larval individuals in view of the measurements given.

The present species is more frequently found in leaf mold in the vicinities of limestone caves than in shaded areas in woods (Shimojana, 1972).

Trithyreus siamensis Hansen, 1905

[Japanese name: Udenaga-sawada-mushi]

Trithyreus siamensis Hansen, 1905, in Hansen & Sörensen, Ark. f. Zool., **2**: 51, pl. 5 (2a–h). [Four specimens, Bangkok, Siam (in Berlin Museum)].

Trithyreus sp.: Shimojana, 1972, Idén, Tokyo, **26** (5): 101, figs. 4 and 5.

Hansen described in his original description that no eye-spots could be perceived in the present species, but in the specimens before the authors they exist though being weak. Because of damaged or exsiccated condition of his materials, Hansen could not examine the distal half of male first legs, the chaetotaxy of male flagellum and three posterior abdominal segments, female flagellum, and coloration. All these are described in the following lines.

Besides, it became clear by re-examination that only the male used and illustrated by Shimojana (1972) is an immature individual.

Material examined. 1 ♂ and 1 very young larval ♀, Muzuka-gaa Cave, Higashinaka, Hirara-shi, Miyako-jima Is., 3. viii. 1972, S. Uéno leg.; 2 ♀♀ and 2 larval ♀♀, Iza-gaa Cave, Higashinaka, Hirara-shi, Miyako-jima Is., 3. viii. 1972, S. Uéno leg.; 1 larval ♀, Mayaa-abu Cave, Mashiki, Ginowan-shi, Okinawa-hontô Is., 25. viii. 1972, M. Shimojana leg.; 1 larval ♂, Mayaa-abu Cave, Mashiki, Ginowan-shi, Okinawa-hontô Is., 8. vii. 1971, M. Shimojana leg.; 1 ♀, Yin-chuan-tsang-hsia-tung Cave, Kuei-chiao-liu, Ping-tung Hsien, Taiwan, 2. iv. 1965, S. Uéno leg.

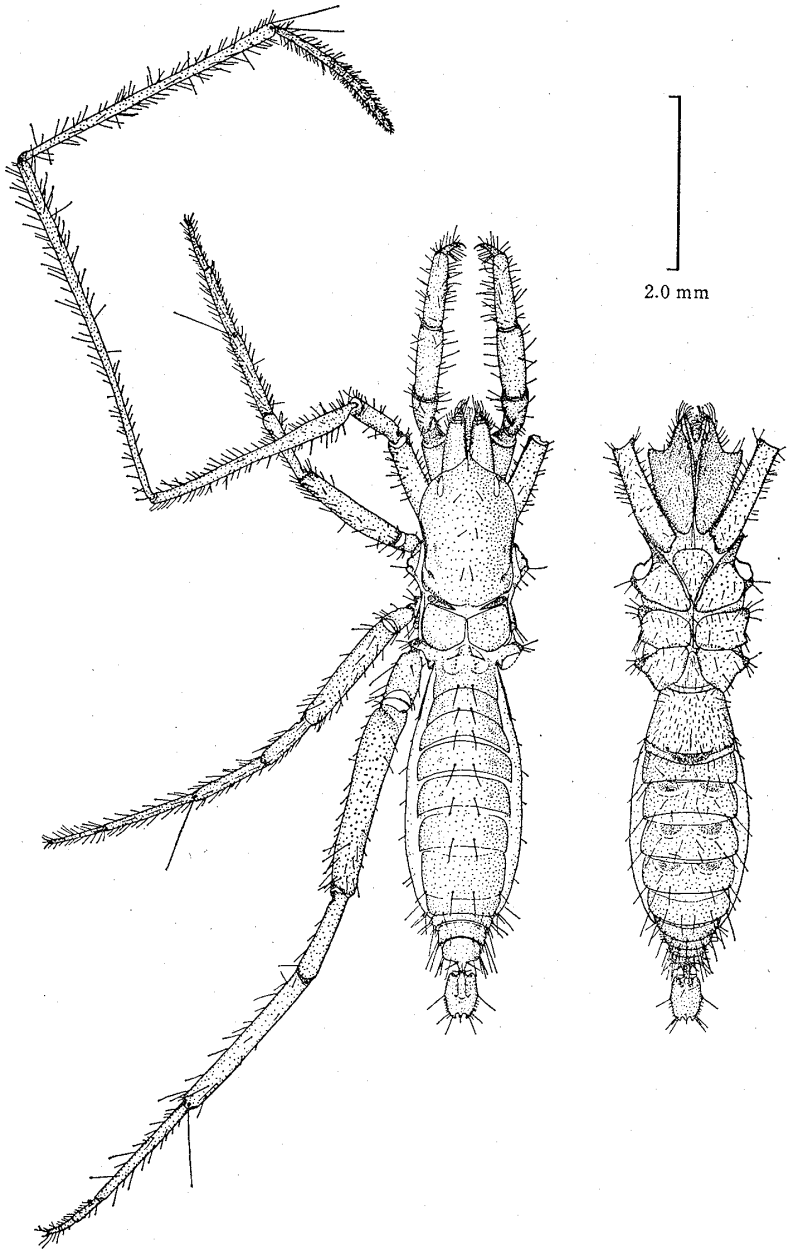


Fig. 12. *Trithyreus siamensis*, male, of Muzuka-gaa Cave, Miyako-jima Island. Left, dorsal side; right, ventral side.

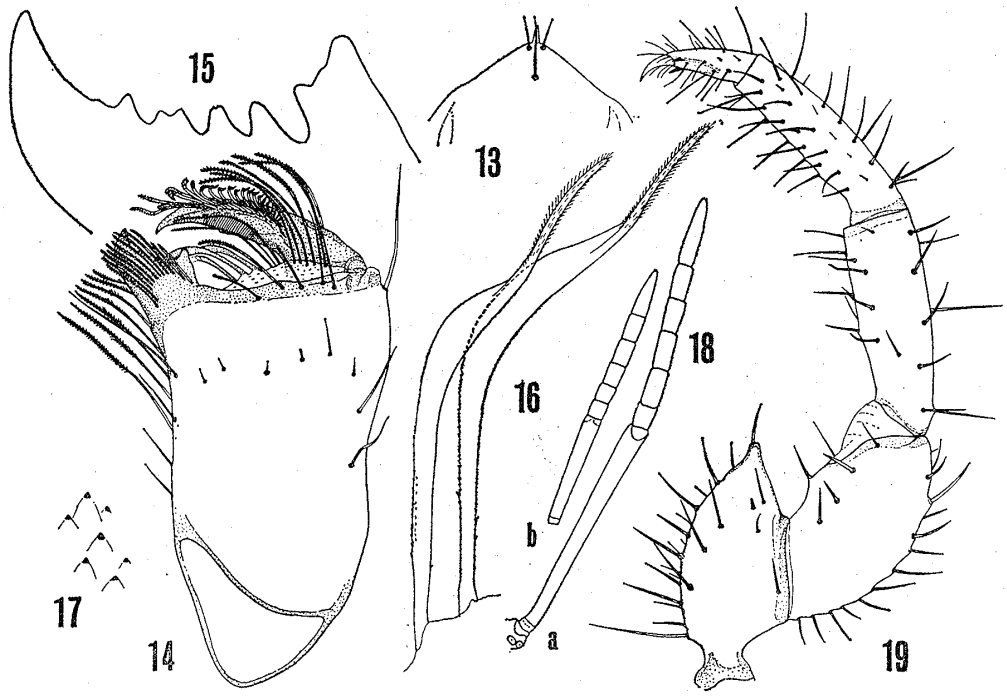
Male. Body length (from apex of propeltidium to tip of flagellum), 6.70 mm. Propeltidial length, 1.89 mm.

Coloration. Body light brownish grey in general view. Chelicerae, pedipalpi, and trochanter to tarsus of first legs brownish. Ventral side of body paler. Antero-distal part of each of second to fourth coxae light brown. Flagellum brown. Membraneous parts white.

Cephalothorax. Propeltidium protruded in the anterior margin as shown in Figs. 12 and 13; projecting antero-median portion with a pair of setae followed by a single longer one (Fig. 13); behind these there are three successive pairs of setae; a pair of whitish eye-spots weakly defined. Second thoracic tergite (metapeltidium) distinctly separated into two plates by a well-defined longitudinal narrow strip of membraneous skin; plates without spine; anterior margin of each plate straight, latero-posterior margin round, and postero-medial margins straight. Cephalic sternum subtriangular and longer than wide; anterior margin round.

Chelicerae. The length of first segment (between tip of proximal margin and tip of immovable digit), 1.40 mm; second segment, 0.58 mm.

Inner surface as shown in Fig. 14. First segment bearing a long seta at the apex



Figs. 13–19. *Trithyreus siamensis*, male. —— 13. Anterior margin of cephalothorax. —— 14. Inner aspect of right chelicera. —— 15. Distal end of immovable digit of chelicera. —— 16. Long modified expanded setae of distal margin of first segment of chelicera. —— 17. The stridulatory area of chelicera (with some of the spicules enlarged). —— 18 a. Metatarsus-tarsus of first leg. —— 19. Inner aspect of pedipalp.

Fig. 18 b. *Trithyreus siamensis*, female. Metatarsus-tarsus of first leg.

(These figures have been drawn with the same degree of enlargement for the corresponding body parts of respective species.)

on dorsum, two medium-sized setae dorsally and six shorter setae at distal two-ninths on the inner surface, seven long feathered setae and three short and one long simple setae on the venter, two feathered setae and two or three short setae on both the surfaces of distal margin, three long modified expanded setae (Fig. 16) on the external distal margin, and five feathered long setae on each side of membraneous part of distal margin; immovable digit with twelve short feathered setae lined closely on the inner surface and distal end of digit as shown in Fig. 15. Second segment or movable digit with a row of 25 short distally feathered and curled setae; there are also 23 hyaline teeth of serrula and a guard tooth on the distal half on inner surface.

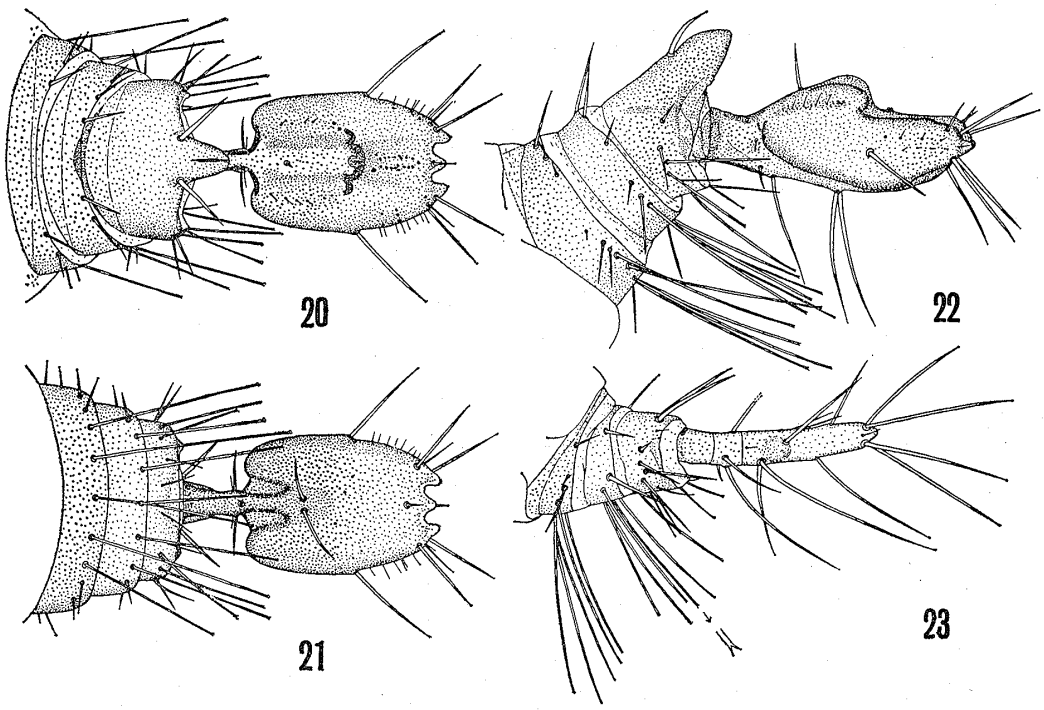
Pedipalpi. Total length, 5.28 mm. Trochanter almost the same as the length of femur, strongly protruding distally; tip of distal process blunt, ventro-distal angle of this process being about 60°; ventral margin roundly convex, with eight strong and nine short setae; internal surface with a single short tooth at about distal fourth, and with six setae. Femur curved and roundly convex dorsally; dorsal margin with 13 setae; ventral margin moderately protruding and the angle itself adorned with a seta; internal surface with three setae and one thick seta. Patella nearly of equal length to femur and longer than tibia; tibia with a larger number of setae than patella. Tarsus with two immovable short spurs and many setae; claw half the length of tarsus.

Legs. First leg slender and longer than twice the body length; trochanter shorter than coxa; femur shorter and stouter than patella and tibia; patella longest in all segments and nearly equal to the abdominal length; tibia almost equal to femoral length; combined metatarsi and tarsus shorter than femur; second metatarsus a little shorter than tarsus; terminal segment of tarsus one-third the length of second metatarsus (Fig. 18 a). Second coxae with an antero-distal long process. Fourth leg remarkably long and relatively slender, and longer than the body; greatest depth of femur about one-fourth its length.

Measurements (in mm) of each of right legs, showing the linear distance between midpoints of joints, are as follows. The measurement of tarsus includes the length of claw.

	Pedipalp	1st leg	2nd leg	3rd leg	4th leg
Coxa	1.02	1.35	0.63	0.50	0.48
Trochanter	1.00	0.80	0.35	0.35	0.70
Femur	0.98	3.18	1.60	1.45	2.45
Patella	0.95	4.40	0.95	0.65	1.10
Tibia	0.82	3.20	1.35	0.95	2.10
Matatarsi	—	0.85	1.00	1.10	1.70
Tarsus	0.51	1.02	0.70	0.77	1.00
Total	5.28	14.80	6.58	5.77	9.53

Abdomen. First abdominal tergite small, poorly sclerotized, triangular with wide base, and with two pairs of very short spines and also with a pair of mesal setae



Figs. 20–22. *Trithyreus siamensis*, male. Dorsal, ventral, and lateral aspects of flagellum and three posterior abdominal segments.

Fig. 23. *Trithyreus siamensis*, female. Lateral aspect of flagellum and three posterior abdominal segments.

(These figures have been drawn with the same degree of enlargement as Figs. 8–11.)

on posterior margin; posterior margin roundly concave. Second to ninth abdominal segments with pleural membrane; each tergite with a pair of mesal setae posteriorly. Anterior part of second abdominal tergite either weakly sclerotized or not, and with three pairs of very short spines. Tergites third to ninth simply shaped. Segments tenth to twelfth making complete ring encircling abdomen (Figs. 20–22), and with short setae on dorsal and lateral surfaces and long setae on the most part of ventral surface; tip of the long setae bifurcate; postero-mesal part of twelfth segment conical, strongly projecting backwards, and the basal part of this projection with a pair of strong and curved setae.

Flagellum. Main piece longer than wide, hexagonally extending (or in a shape like a racket of ping-pong) in dorsal view, but with three protuberances at the posterior end, as shown in Fig. 20; in lateral view (Fig. 22), the maximum height is at the central part, with three risings, and posterior half approximately flat; length (including stalk): 0.70 mm, width: 0.36 mm, height: 0.32 mm. Stalk rather compressed. Adding to these, there are irregular rows of dots in posterior half of the dorsal surface of main piece, which probably bear minute setae as was already surmised by Hansen.

Female. Body length (from apex of propeltidium to tip of flagellum), 5.62–6.15 mm. Propeltidial length, 1.69–1.83 mm.

Coloration. The same as the male, but paler; flagellum also paler.

Cephalothorax. Eye-spots perceived though indistinct. Behind three spines at the apical part, there are four successive pairs of setae.

Pedipalpi. Similar to those in the male but shorter. Tip of distal process of trochanter not so strongly protruding; ventro-distal angle of this process being about 85°. Measurements are shown together with those of legs.

Legs. First leg comparatively short, about three-fifths as long as that in the male; second metatarsus shorter than tarsus; terminal segment of tarsus about a half the length of the second metatarsus (Fig. 18 b). Fourth leg not so remarkably long, but slightly longer than body; greatest depth of femur about one-third its length.

Measurements (in mm) of each of right legs are given below in the same method as in the case of male.

	Pedipalp	1st leg	2nd leg	3rd leg	4th leg
Coxa	0.89 [0.96]	0.92 [0.80]	0.60 [0.52]	0.48 [0.53]	0.53 [0.45]
Trochanter	0.82 [0.75]	0.55 [0.55]	0.22 [0.25]	0.28 [0.30]	0.40 [0.40]
Femur	0.89 [0.80]	1.90 [1.82]	1.40 [1.25]	1.12 [1.00]	1.85 [1.72]
Patella	0.78 [0.75]	2.50 [2.15]	0.80 [0.70]	0.50 [0.50]	0.80 [0.76]
Tibia	0.72 [0.73]	1.85 [1.60]	1.00 [0.88]	0.70 [0.62]	1.25 [1.18]
Metatarsi	—	0.52 [0.45]	0.80 [0.70]	0.86 [0.72]	1.20 [1.10]
Tarsus	0.52 [0.43]	0.65 [0.60]	0.65 [0.52]	0.64 [0.62]	0.81 [0.80]
Total	4.62 [4.42]	8.89 [7.92]	5.47 [4.82]	4.58 [4.29]	6.84 [6.41]

The values in brackets are of another specimen.

Flagellum. Elongate, cylindrical, and divided into three sections by sutures (Fig. 23); distal section longer than two proximal sections combined; first section without spine; second section bearing long and medium-sized setae; last section bearing ten long and two medium-sized setae and some short spines; tip of last section blunt; length, 0.55 mm.

Localities. Okinawa-hontô and Miyako-jima Islands, Taiwan, and Thailand (Bangkok).

Notes. The male of the present species is characterized by the shape of flagellum and of the backward process of last abdominal segment, while the female can be separated from those of all the other described forms by the shape of the trochanter of pedipalp together with the dimensions of each segment of tarsal part of the first leg.

At the present time it is difficult to decide to which species *siamensis* is closely related, but the species is doubtless the most specialized form of the Asian species.

In the Ryukyus and Taiwan, *T. siamensis* has been found only in limestone caves, but it may be a troglophile as in the case of *S. sauteri.* It is, however, worthy of noticing that the species dwells in subterranean habitats at the northernmost part of its range of distribution.

ACKNOWLEDGEMENT

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