

***Leptotrombidium yoshiyukiae* (Acari, Trombiculidae) : A new species of chigger mite found on Japanese large-footed bat *Myotis macrodactylus* (Temminck, 1840) (Chiroptera, Vespertilionidae) in Tsushima Islands, Nagasaki Prefecture, Japan**

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長崎県対馬のモモジロコウモリに寄生するツツガムシの1新種、
ヨシユキツツガムシの記載

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抄録：大阪市立自然史博物館と国立科学博物館所蔵の対馬産モモジロコウモリの計7頭を調べた結果、3頭の耳介内に*Leptotrombidium*属のツツガムシ合計2種10個体の寄生がみられた。1種は1個体で、感覚毛が欠如していたので未同定種とした。別の1種は9個体得られ、約350種の既知種とは形態が異なり、新種（ヨシユキツツガムシ、*Leptotrombidium yoshiyukiae* Takahashi, Misumi and Baba sp. n.）として記載した。主な特徴は、背甲板はほぼ四角形で、感覚毛基根は後側毛基根を結ぶ線より明らかに上部にあり、感覚毛基部には微小な棘があった。胴背毛は第2列と3列、第4列と5列が融合した配列になっており、変異はあるが概ね2H-18-12-14-8-4-2であった。触肢附節毛はfPp = BB/NBB/7B、爪は3本に分岐し、ガレア毛も分岐していた。特に腹面に3対の胸板毛を有するのが、本種の大きな特徴の一つである。

Abstract: We described and illustrated a new species, *Leptotrombidium yoshiyukiae* Takahashi, Misumi and Baba sp. n. (Acari, Trombiculidae), parasitizing on the Japanese large-footed bat *Myotis macrodactylus* (Temminck, 1840) in Tsushima Islands, Nagasaki Prefecture, Japan. The new species was found to be closely related to *L. toshiokai* and *L. megatoshiokai* according to the arrangement of dorsal setae, but distinguished from them by scutum shape and palpal setal formula. Furthermore, the major difference among them was that *L. toshiokai* and *L. megatoshiokai* had two pairs of sternal setae, whereas *L. yoshiyukiae* sp. n. had three pairs.

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Key words: New species; chigger mite; taxonomy; description; bat

Introduction

Tsushima Islands, belonging to Nagasaki Prefecture, Japan, are located between Kyushu (Island) and Korean Peninsula. Different organisms from the Asian continent and Japan mainland have evolved separately from their mainland relatives, forming a unique ecosystem (Imaizumi, 1969; Urata and Yamaguchi, 1976). To date, few studies have reported chigger mites recovered from small mammals and soil samples in Tsushima Islands (Fujisaki, 1954; Uchikawa, 1976; Suzuki, 1978). Therefore, the chigger fauna of the study area is mostly unknown.

In the present study, during our investigation of the ectoparasites of the bat species *Myotis macrodactylus* (Temminck, 1840) collected from Tsushima Islands and preserved at the Osaka Museum of Natural History (OMNH)

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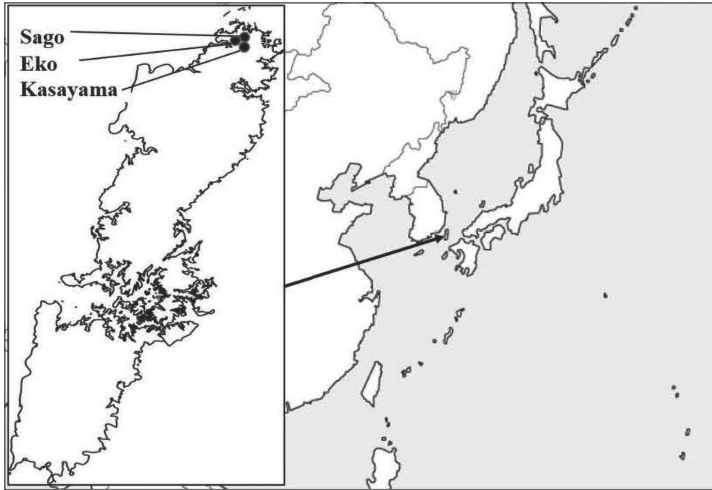


Fig.1. Map showing the three sites in Tsushima Islands, Nagasaki Prefecture, Japan, where *Myotis macrodactylus* were collected.

and National Museum of Nature and Science (NSMT), two species of chigger mites of the genus *Leptotrombidium* were collected, and one species was proven to be distinct.

Materials and methods

Two and five individuals of *M. macrodactylus* collected by researchers in the period from 1966 to 1972 in caves located in the northern part of Tsushima Islands were stored in 70% ethanol in OMNH and NSMT, respectively (Fig. 1). Ectoparasites on the bats were searched under a stereomicroscope (SMZ-U ZOOM 1:10, Nikon Corporation, Tokyo, Japan). Chigger mites were removed from the intra-auricular skin surface using a sharp needle or/and sharp tweezers, after which they were placed in 70% ethanol. Each mite was mounted on a glass slide with Hoyer's solution and identified under a photomicroscope (Eclipse E600 DIC, Nikon Corporation, Tokyo, Japan).

The following description of new species was based on the holotype and six paratypes.

The abbreviations and terminology in the present study were obtained from Goff et al. (1982), with some modifications: anterolateral seta (AL); anteromedian seta (AM); distance from anterolateral setal base to posterolateral setal base on one side (AP); distance from sensillary bases to extreme anterior margin (ASB); anterior width of scutum (AW); branched seta (B); length of cheliceral base (CbL); width of cheliceral base (CbW); length of cheliceral blade (CsL); width of cheliceral blade (CsW); postanal or caudal seta (CS); dorsal medial seta of 1st post humeral row (D-med); dorsal terminal seta (D-ts); number of dorsal idiosomal setae including humeral setae (DS); dorsal setal formula (DSF); diameter of anterior eye (Eye-ant); diameter of posterior eye (Eye-post); coxal setation formula (fCx); palpal setal formula (fPp); scutal formula (fSC); sternal setal formula (fSt); ventral setation formula (fV) (referring to the number and arrangement of branched setae on the ventral surface of idiosoma, excluding coxal setae, beginning with the anterior sternal setae and indicating the position of the anus by "u"); gnathobase (Gn) (referring to the width at the level of the bases of the pair of branched setae); humeral seta (H); leg index (IP); nude seta (N); total number of idiosomal setae, excluding coxal setae (NDV); length of axial prong of palpal claw (PC-axial); length of accessory prong of palpal claw (PC-prong); length of palpal claw (PCL); width of palpal claw (PCW); posterolateral seta (PL); distance from PL base to posterior-most scutal margin (P-PL); distance from sensillary bases to extreme posterior margin (PSB); length of leg I (pa); length of leg II (pm); length of leg III (pp); parasubterminala (pST); posterior width of scutum (PW); length of sensilla (S); leg talsala I (S_1); leg talsala II (S_2); distance between sensillary bases (SB); scutal depth (SD); $SD = ASB + PSB$; synthetic identification formula (SIF); anterior sternal seta (StS_1); medial sternal seta (StS_2); posterior sternal seta (StS_3); length of leg tarsus I (Ta-IL); width of leg tarsus I (Ta-IW); length of tarsus II (Ta-IIL); width of leg tarsus II (Ta-IIW); length of leg tarsus III (Ta-IIIL); width of leg tarsus III (Ta-IIIW);

Table 1. Collection record of chigger mites recovered from Japanese large-footed bat *Myotis macrodactylus* (Temminck, 1840) in Tsushima Islands and preserved at the Osaka Museum of Natural History (OMNH) and National Museum of Nature and Science (NSMT), Japan.

Individual number	Collection date	Locality	Chigger mites collected	
			<i>Leptotrombidium yoshiyukii</i> sp. n.	<i>Leptotrombidium</i> sp.
14009 (NSMT)	VII.7.1969	Sago abandoned mine, Sago, Kamiagata-machi	5	0
14010 (NSMT)	VII.7.1969	Sago abandoned mine, Sago, Kamiagata-machi	1	0
14011 (NSMT)	VII.7.1969	Sago abandoned mine, Sago, Kamiagata-machi	0	0
14020 (NSMT)	VII.10.1966	Kasayama-do Cave, Izuhara-machi,	0	0
22547 (NSMT)	III 18.1972	Eko abandoned mine, Sago, Kamiagata-machi	0	1
R-69 (OMNH)	XII.2.1966	Sago abandoned mine, Sago, Kamiagata-machi	3	0
R-69 (OMNH)	XII.2.1966	Sago abandoned mine, Sago, Kamiagata-machi	0	0

0: not collected

setae on the ventral surface of the idiosoma excluding the coxal setae (V); ventral medial seta in 1st postanal setal row (V-cs); ventral medial seta in 1st preanal setal row (V-ps); true ventral or preanal setae, excluding coxal and sternal setae (VS).

All measurements are shown in micrometers (μm), with measurements for the holotype followed by means and ranges for the type series in parentheses (holotype+six paratypes).

The type materials, including holotype (OMNH-TAc-001) and three paratypes, have been deposited in the acari collection of the Osaka Museum of Natural History, Osaka, Japan. Another three paratypes have been deposited in the acari collection of the National Museum of Nature and Science, Tsukuba, Ibaraki, Japan.

Results

We examined seven *M. macrodactylus* collected from one cave and two abandoned mines. A total of 10 chigger mites consisting of two species belonged to the genus *Leptotrombidium* were removed from the intra-auricular skin surface of three bats. One species was an individual and was unidentified because of lacked sensory setae.

Another species (nine individuals) was morphologically different from that of known species of the genus *Leptotrombidium* (Table 1). We described it as a new species here.

SYSTEMATICS

Order Trombidiformes

Family Trombiculidae

Genus *Leptotrombidium* Nagayo, Miyagawa, Mitamura and Imamura, 1916

Leptotrombidium yoshiyukiae Takahashi, Misumi and Baba sp. n.

[New Japanese name: Yoshiyuki tsutsugamushi]

(Figs. 2–5)

Diagnosis of larvae.

SIF = 7B-B-3-2111.0000; fPp = BB/NBB/7B; fCx = 1. 1. 1; fSt = 2. 2. 2; fSC: PL > AL \geq AM; IP = 844 (864, 845–900); pST = N; one humeral setae; DSF = 2H, 16, 18, 14, 8, 4, 2 = 64 (holotype); 2H, 18 (16), 16 (12), 14 (12), 8, 6 (4), 2 = 58–64; DS = 58–64; fV = 2, 2, 2, 26 u 30 = 32 + 30 = 62 (holotype), 62–66; NDV = 122–130 (126 in the holotype). Standard measurements of examined specimens given in Table 2.

Type materials. Holotype (OMNH-TAc-001) is an engorged larva parasitizing on *M. macrodactylus* (Temminck,

Table 2. *Leptotrombidium yoshiyukiae* sp. n., standard measurements of the type series (n = 7).

Character*	Holotype	Mean	Range
Eye-ant	10	14	10-16
Eye-post	7	8	7-10
Gn	72	72	68-75
CbL	43	39	33-43
CbW	33	35	33-36
CsL	33	35	33-39
CsW	8	8	7-10
PCL	16	20	16-24
PCW	4	4	4-5
PC-axial	5	5	5-6
PC-prong	3	3	2-3
AW	61	62	62-63
PW	85	90	85-101
SB	31	33	31-34
ASB	32	35	32-37
PSB	18	18	17-18
SD	50	52	49-54
P-PL	5	5	5-6
PW/SD	1.7	1.7	1.6-1.9
AP	44	43	41-46
AM	42	47	42-51
AL	54	55	53-57
PL	62	63	62-64
S	74	73	72-75
H	52	55	52-58
StS ₁	33	35	33-42
StS ₂	30	31	28-34
StS ₃	29	33	29-36
D-med	47	49	46-51
D-ts	44	45	41-50
V-ps	33	33	32-33
V-cs	35	38	35-40
pa	297	298	283-321
pm	233	261	233-263
pp	315	307	302-317
IP	845	866	844-868
Ta-IL	229	257	229-259
Ta-IW	20	21	20-22
Ta-IIL	22	22	20-24
Ta-IIW	18	18	17-19
Ta-III L	84	83	81-84
Ta-III W	17	17	16-20
S ₁	22	21	21-22
S ₂	22	21	20-22
VS	26	28	26-32
CS	30	29	28-30
V	62	63	60-65
DS	64	62	58-64
NDV	126	128	126-130

*Morphometric (Eye-ant to S₂, µm) and meristic (VS to NDV) traits

Abbreviations were described in materials and methods.

1840) (Chiroptera, Vespertilionidae). It was collected on July 7, 1969 in the Sago abandoned mine, Sago, Kamiagata-machi, Kamiagata-gun, Tsushima Islands, Nagasaki Prefecture, Japan.

Three paratypes deposited in the Osaka Museum of Natural History, Osaka, Japan are engorged larvae parasitizing on *M. macrodactylus*. They were collected on December 2, 1966 in the Sago abandoned mine, Sago, Kamiagata-machi, Kamiagata-gun, Tsushima Islands, Nagasaki Prefecture, Japan. Three paratypes deposited in the National Museum of Nature and Science are engorged larvae, with the same as host, location, and collection date as those of the holotype.

Description of larvae.

Color: Unclear because the specimen was preserved in alcohol (Fig. 2).

Idiosoma: Engorged larval body with greater length than width, measuring 479 (465, 425–490) in length and 345 (325, 300–350) in width. Two pairs of eyes on the ocular plates, located by the scutum at the level of the slightly upper part of PL bases (Fig. 3).

One pair of humeral setae, dorsal setae 58–64, arranged in irregular rows; DSF: 2H, 16, 18, 14, 8, 4, 2 = 64 (holotype); 2H, 18 (16), 16 (12), 14 (12), 8, 4, 2 = 58–64 (paratype). Humeral and dorsal idiosomal setae covered with a moderate number of thick and short setules for almost their entire length, similar to PL setae. Three pairs of sternal setae (fSt = 2-2-2), covered with a moderate number of fine setules over their entire length, more pliant than the preanal setae; 26–32 ventral (preanal) setae (VS) and 28–30 caudal or postanal setae (CS) (26 and 30 setae in the holotype, respectively), similar in nature to sternal setae (StS) but shorter; preanal and postanal setae are different in nature from dorsal idiosomal setae, and shorter; total number of idiosomal setae, excluding coxal setae, 126–130 (126 in the holotype) (Figs. 4 and 5).

Gnathosoma: Gnathosomal base without punctation, cheliceral bases triangular and posterior margin slightly rounded, cheliceral blade with a tricuspid cap; Galeal seta branched. fPp = BB/NBB/7B; palpal claw stout and three pronged, with axial prong and two accessory prongs of almost equal or slightly different length.

Scutum: Shape rectangular, greater in width than in length, PW/SD ratio 1.7 (1.7, 1.6–1.9) with anterior margin slightly concave; anterior corners with slight AL shoulders; posterior margin almost straight; lateral margins slanting outwards with slight concavity; posterior corners somewhat extended; width of scutum greatest at PL corners; AL setae situated on the anterior corners; PL setae situated on the posterior corners; AM seta base slightly above AL seta bases;



Fig. 2. Two larvae of *Leptotrombidium yoshiyukiae* sp. n. parasitizing in the cavum of the auricle of *Myotis macrodactylus* preserved in an ethanol solution. The body color is whitish because of discoloration in ethanol.

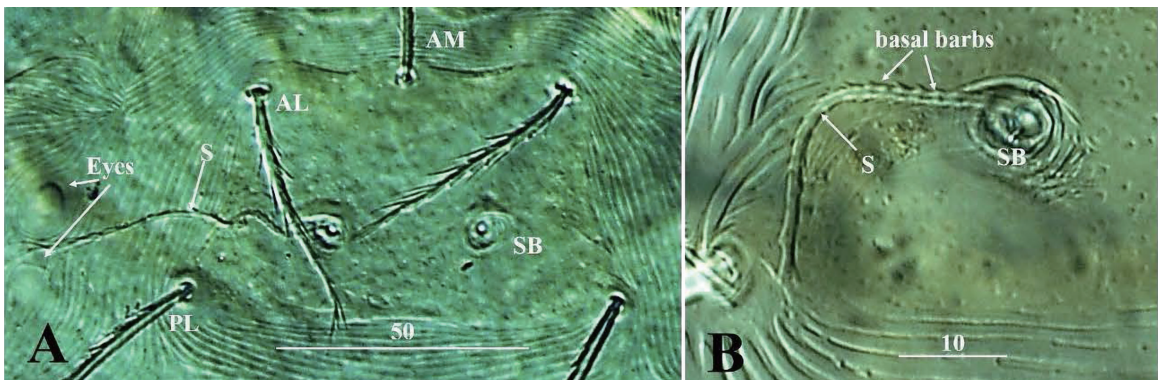


Fig. 3. *Leptotrombidium yoshiyukiae* sp. n., larval specimen. A, scutum; B, enlarged view of sensilla with small basal barbs. Abbreviations: AL, anterolateral scutal seta; AM, anteromedian scutal seta; PL, posterolateral scutal seta; S, sensilla; SB, sensillary base

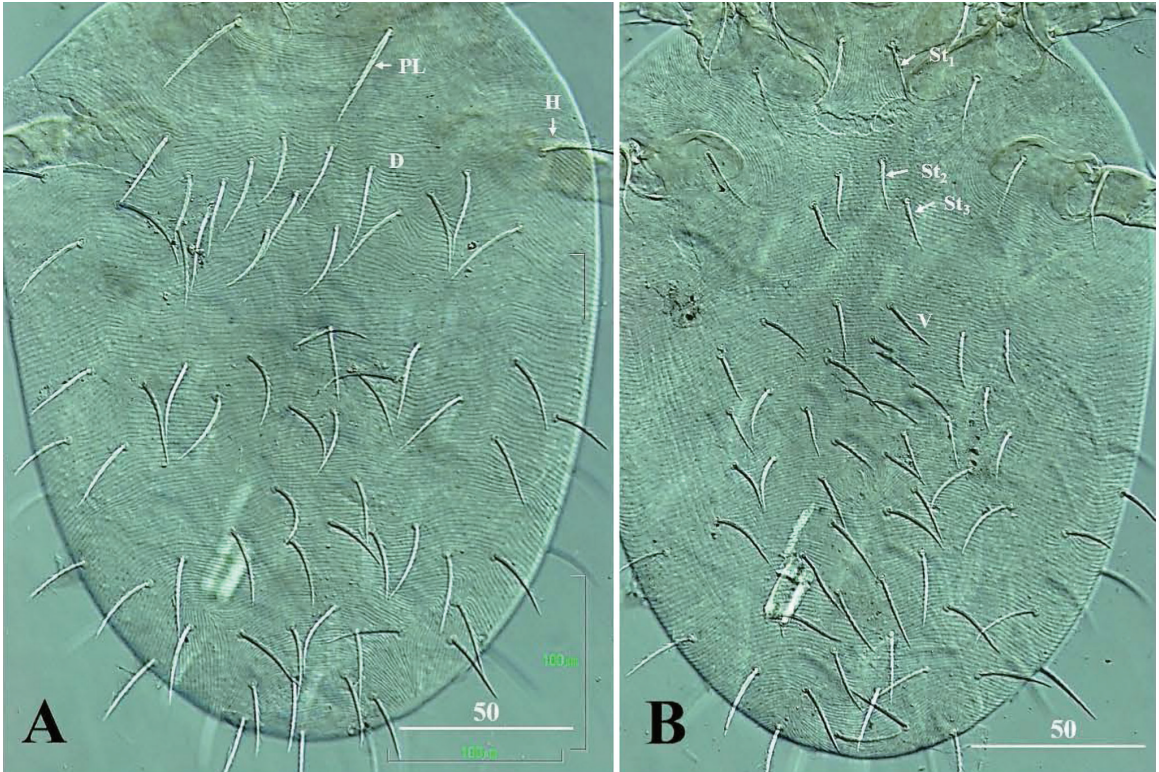


Fig. 4. *Leptotrombidium yoshiyukiae* sp. n., larval specimen. A, dorsal idiosomal setae; B, sternal area and ventral setae of idiosoma. Abbreviations: D, dorsal idiosomal setae; H, humeral seta; PL, posterolateral scutal seta; St1, anterior sternal seta; St2, medial sternal seta; St3, posterior sternal seta; V, ventral setae.

relative length of the scutal setae, $PL > AL \geq AM$; AL and AM setae with a moderate number of slightly fine setules over almost their entire length; PL setae barbed with a moderate number of stouts and short setules over almost their entire length, resembling humeral setae and dorsal idiosomal setae in appearance; each sensillary base round with several small ridges; sensillary bases distinctly anterior to level of PL bases [$PSB - (P-PL) = 9-12$, mean value 11]; sensillae flagelliform, densely covered with scale-like barbs in proximal half, and with about 6–8 branches of moderate length in distal quarter; small granular punctations distinctly distributed on scutum except around AM base, especially dense around sensillary bases.

Leg: IP = 844 (864, 844–900). All 7-segmented, terminating in a pair of claws and a slender clawlike empodium. Onychotriches lacking. Small conspicuous punctations on coxae and free leg segments. No modified leg segments. Leg I: coxa with 1B; trochanter 1B; basifemur 1B; telofemur 5B; genu 4B, 2 genualae [dorsal genuala 21 (20, 18–22), distal genuala 22 (21, 19–23)], microgenuala 4 (3, 4–5); tibia 8B, 2 tibialae [proximal tibiala 21 (21, 20–21), distal tibiala 22 (20, 19–22)], microtibiala 4 (4, 2–4); tarsus 24B, tarsala 22 (23, 22–24) located on distal 1/3 of segment, microtarsala 3 (2, 2–3), a nude subterminala 24 (24, 23–25), a short parasubterminala 12 (9, 7–12), pretarsala 13 (16, 13–19). Leg II: coxa 1B; trochanter 1B; basifemur 2B; telofemur 3B; genu 3B, one genuala 16 (16, 15–21); tibia 5B, 2 tibialae [proximal tibiala 19 (18, 16–21), distal tibiala 21 (21, 18–22)]; tarsus 16B, tarsala 22 (22, 20–24), microtarsala 4 (3, 2–4). Leg III: coxa 1B; trochanter 1B; basifemur 2B; telofemur 3B; genu 3B, one genuala 21 (24, 20–28); tibia 5B, one tibiala 30 (25, 21–31); tarsus 15B.

Distribution and host.

This species has only been collected from the *M. macrodactylus* that inhabits the Sago abandoned mine, Sago, Kamiagata-machi, Kamiagata-gun, Tsushima Islands, Nagasaki Prefecture, Japan. However, in future investigations, it

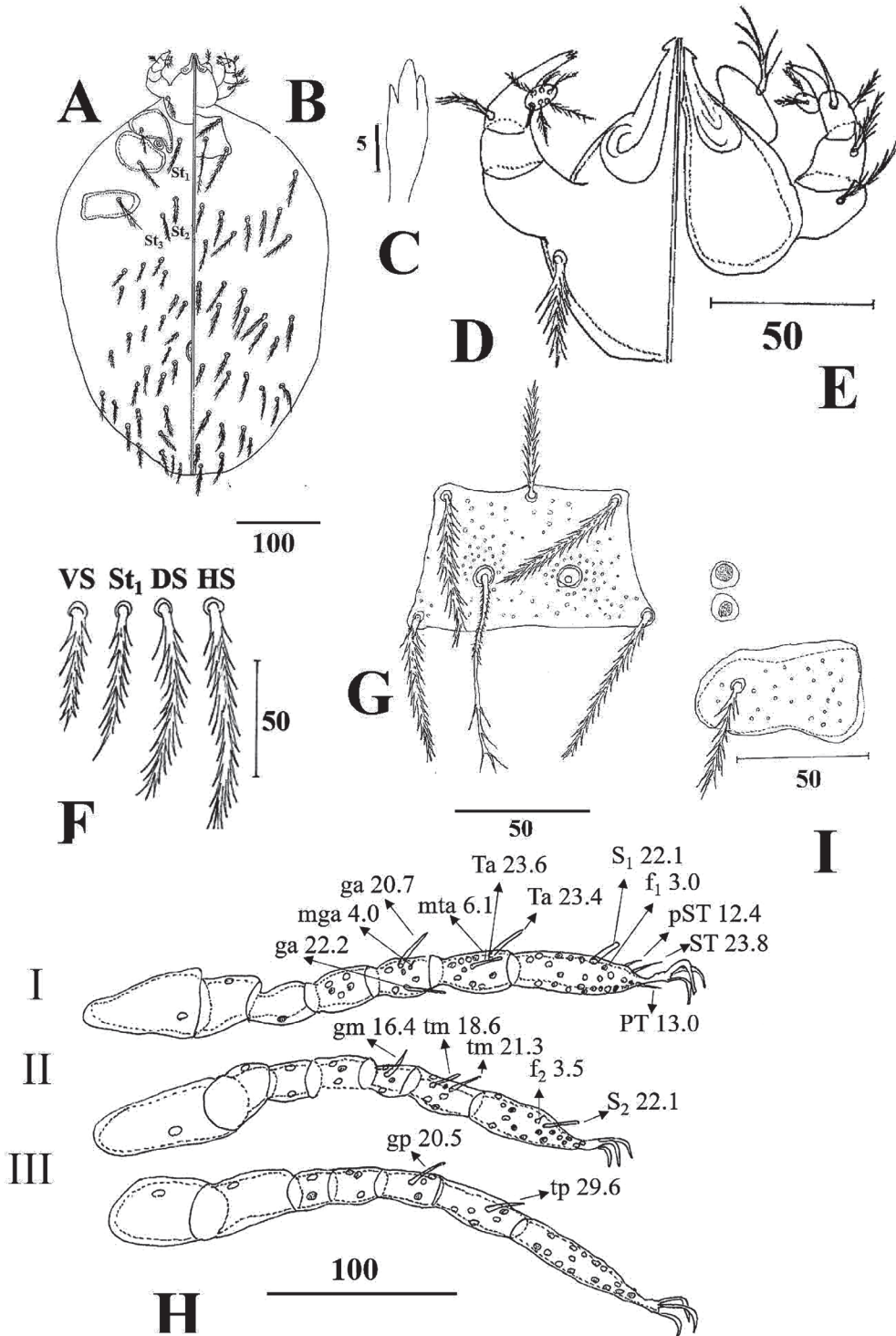


Fig. 5. *Leptotrombidium yoshiyukiae* sp. n., larva. A and B, ventral and dorsal aspects of larva, respectively; C, palpal claw; D and E, ventral and dorsal aspects of gnathosoma; F, details on setae: HS, humeral seta; DS, dorsal medial seta of the first post-humeral row; St_1 , anterior sternal seta; VS, ventral medial seta of the first post-sternal row; G, scutum and eyes on the ocular plate; H, legs I, II, and III; I, coxa III. Abbreviations: f₁, famulus I; f₂, famulus II; ga, genuala I; gm, genuala II; gp, genuala III; mga, microgenuala; mta, microtibiala; pST, parasubterminala; PT, pretalsala; ST, subterminala; S₁, talsala I; S₂, talsala II; tm, tibiala II; tp, tibiala III. The scale bar for each structure is shown in micrometers.

could also be found on other species of bats, which is why further investigation is required.

Etymology.

This species is named after Dr. Mizuko Yoshiyuki, a former employee of the National Museum of Nature and Science, Tokyo, Japan, in recognition of her findings on the bat fauna of Tsushima Islands, Nagasaki Prefecture, Japan as well as of her substantial contribution to our knowledge of the systematic study of Japanese Chiroptera.

Discussion

Chiggers of the genus *Leptotrombidium* Nagayo, Miyagawa, Mitamura and Imamura, 1916 are distributed worldwide, and large numbers of species (> 350) have been recorded in various areas and a wide variety of hosts, mainly small mammals and birds (Womersley, 1952; Sasa, 1956; Vercammen-Grandjean and Langston, 1976; Domrow and Lester, 1985; Li, 1997; Kudryashova, 1998; Fernandes and Kulkarni, 2003; Stekolnikov, 2013). Because they closely resemble each other, identification of species belonging to this genus can be very difficult because of their considerable morphological variability.

In the present study, when the preparate specimen collected from *M. macrodactylus* was first observed, it was striking that the scutum was slightly trapezoidal or subquadrate. Sensillary bases were also distinctly anterior to the level of PL bases. Furthermore, Palpal tarsus formula was 7B, with 3-pronged palpal claw. These characteristics of scutum and gnathosoma implied that the species belonged to the genus *Trombigastia*. However, we decided that this species belonged to the genus *Leptotrombidium* instead, because the following morphological characteristics of this species were in accordance with those of the genus *Leptotrombidium*: galeal seta branched; PW/SD ratio 1.7 (range 1.6–1.9) [= PW at least 1.5× greater than SD (Nadchatram and Dohany, 1974)]; 2 genualae I; tarsala I 22 (range 22–24); tarsala II 22 (range 20–24) (almost the same length as that of tarsala I and II). In the genus *Trombigastia*, these characteristics are different: galeal seta nude, PW/SD ratio usually 1.4, 3 genualae I, and tarsala I approximately 2× as long as tarsala II (Nadchatram and Dohany, 1974).

Leptotrombidium yoshiyukiae sp. n. was found to be closely related to *L. toshiokai* and *L. megatoshiokai* according to the arrangement of dorsal setae, but it was distinguished by the shape of the scutum and location of sensillary bases. Another significant difference was that *L. toshiokai* and *L. megatoshiokai* had two pairs of sternal setae, whereas *L. yoshiyukiae* sp. n. had three pairs.

Chigger mites in Tsushima Islands.

Several studies have reported chigger mites recovered from small mammals (bats, rodents, insectivores) and soil samples in Tsushima Islands (Fujisaki, 1954; Uchikawa, 1976; Suzuki, 1978).

Fujisaki (1954) reported five chigger mite species recovered from small mammals such as *Apodemus speciosus*, *A. geisha* (= *A. argenteus*), and *Ulotricus talpoides*, while Uchikawa (1976) reported one unknown chigger mite species from the bat species *Rhinolophus ferrumequinum*. Moreover, Suzuki (1978) reported ten species of chigger mites from wild rodents and soil surface. According to these investigations, a total of six genera, including one unknown genus consisting of 16 species (including one unknown species), have been recorded to date (Table 3). Future investigations are expected to reported additional species of chigger mites.

Acknowledgements

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Table 3. A list of chigger mites collected from various small mammals in Tsushima Islands, Nagasaki Prefecture, Japan.

Species	Rhinolophus ferrumequinum	Rhinolophus cornutus	Miniopterus fuliginosus	Myotis macrodactylus	Nyctalus aviator	Apodemus geisha	A. spectosus	Uloricus talpoides	Rodents and insectivores	Soil samples
	Uchikawa (1976)	Uchikawa (1976)	Uchikawa (1976)	Uchikawa (1976)	Uchikawa (1976)	Fujisaki (1954)	Fujisaki (1954)	Fujisaki (1954)	Suzuki (1978)	Suzuki (1978)
<i>Leptotrombidium yoshiyukiae</i> sp. n.	— ¹⁾	—	—	—	—	—	—	—	—	—
<i>Leptotrombidium</i> sp.	—	—	—	—	—	—	—	—	—	—
<i>L. fuji</i>	—	—	—	—	—	—	—	—	—	—
<i>L. kuroshio</i>	—	—	—	—	—	—	—	—	—	—
<i>L. orientale</i>	—	—	—	—	—	—	—	—	—	—
<i>L. pallidum</i>	—	—	—	—	—	—	—	—	—	—
<i>L. scutellare</i>	—	—	—	—	—	—	—	—	—	—
<i>L. tanaka-ryoi</i>	—	—	—	—	—	—	—	—	—	—
<i>L. tsushimaense</i>	—	—	—	—	—	—	—	—	—	—
<i>Euschoengastia koreanaensis</i>	—	—	—	—	—	—	—	—	—	—
<i>Ethonella ichikawai</i>	—	—	—	—	—	—	—	—	—	—
<i>Gabrielepis saduski</i>	—	—	—	—	—	—	—	—	—	—
<i>Mackienia sugiharai</i>	—	—	—	—	—	—	—	—	—	—
<i>M. todai</i>	—	—	—	—	—	—	—	—	—	—
<i>Walchia ogatai</i>	—	—	—	—	—	—	—	—	—	—
Gen. sp.	—	—	—	—	—	—	—	—	—	—

—¹⁾: collected○²⁾: not collected

museum.

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