

Toritrombicula lerdthusneei (Acari, Trombiculidae): A New Species of Chigger Mite Collected by Suzuki's Method from Iriomotejima Island, Okinawa, Japan, with Host and Distribution Records of the Genus *Toritrombicula* Sasa, 1954

Mamoru Takahashi¹, Hitoko Misumi¹, and Yumi Takahashi²

¹Department of Anesthesiology, Saitama Medical University, Moroyama-machi, Iruma-gun, Saitama, 350–0495 Japan

²Faculty of Medicine, Saitama Medical University, Moroyama-machi, Iruma-gun, Saitama, 350–0495 Japan
E-mail: m.takahashi@wish.ocn.ne.jp

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Abstract We describe and illustrate a new species, *Toritrombicula lerdthusneei* (Acari, Trombiculidae) and summarize the host and distribution records of the chiggers of the genus *Toritrombicula* Sasa, 1954. The type material was collected by Suzuki's method using black cloth from the coral reef of Iriomotejima Island, southwestern Okinawa, Japan. The new species is closely related to *T. nihoaensis* and *T. gygis*, but may be distinguished by the shape and size of the scutum, and the arrangement of the dorsal setae. Our description of a new species increases the total number of *Toritrombicula* species to 18 (15 from Asia and Australia, 2 from the Hawaiian Islands, and 1 from Russia).

Key words: Trombiculidae, chigger, Suzuki's method, black cloth, *Toritrombicula lerdthusneei*.

Introduction

Chiggers of the genus *Toritrombicula* Sasa, 1954 are mainly ectoparasites of birds, and are mainly distributed in tropical and subtropical zones. Prior to the present study, they comprised 14 species from Asia and Australia, 2 species from the Hawaiian Islands, and 1 species from Russia.

Here, we investigated the chigger fauna and ecology of scrub typhus vectors in Japan. We collected chiggers by Suzuki's method (Mitori-ho) using black cloth (Uchikawa *et al.*, 1993), from the coral reef of Iriomotejima Island, southwestern Okinawa, Japan. This coral reef is believed to be a breeding site of the Asiatic little tern (*Sterna albifrons*) and the black-naped tern (*S. sumatrana*).

The collected chiggers were mounted in Gum Chloral solution, and identified under the photo-

microscope. One of the species was identified as belonging to the genus *Toritrombicula* Sasa, 1954, and was proven to be distinct.

The following description of new species is based on the holotype and 2 paratypes. Abbreviations and terminology are those used by 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), postanal seta or caudal seta (CS), dorsal idiosomal seta (DS), dorsal setal formula (DSF), coxal setation formula (fCx), palpal setal formula (fPp), scutal formula (fSC), ventral setation formula (fV), humeral seta (H, HS), leg index (IP), nude seta (N), total number of of idiosomal setae, excluding coxal setae (NDV), posterolateral seta (PL), distance from sensillary bases to extreme

posterior margin (PSB), parasubterminala (pST), posterior width of scutum (PW), distance between sensillary bases (SB), length of sensilla (S), synthetic identification formula (SIF), sternal seta (StS), and true ventral seta or preanal seta (VS)

All measurements are in micrometers, with those for the holotype followed in parentheses by the mean and extremes of type series (holotype + 2 paratypes). The description of this new species increases the total number of species within the genus *Toritrombicula* to 18. We review the host and distribution records for all *Toritrombicula* species.

Type materials. Holotype (NSMT-Ac 13622) and paratype (NSMT-Ac 13623), collected from the coral reef at Hoshizuna-kaigan (24°26'16"N, 123°46'40"E), Iriomotejima Island, Taketomicho, Yaeyama-gun, Okinawa Prefecture, Japan, on 2-XI-2007 by M. Takahashi, by Suzuki's method using the black cloth, have been deposited in the collection of the Department of Zoology, National Museum of Nature and Science, Tokyo, Japan. Second paratype (NSMT-Ac 13624), collected from the same location as the holotype, on 23-VII-2008 by M. Takahashi, by the same method, has been deposited in the same museum.

Order Acari

Family Trombiculidae

Toritrombicula lerdthusnee Takahashi,
Misumi, and Takahashi, n. sp.

(Fig. 1)

Diagnosis of larva. SIF = 7B-N-3-2111.0000; fPp = B/B/NNN/7B; fCx = 1.1.1; IP = 848; pST = B; fSC = PL > AL ≥ AM; DSF = 2H-8(9)-6-6-4-4-2; DS = 32–33; fV = 30–31; NDV = 62–63.

Description of larva. Live unfed larvae, pale-

yellow in color.

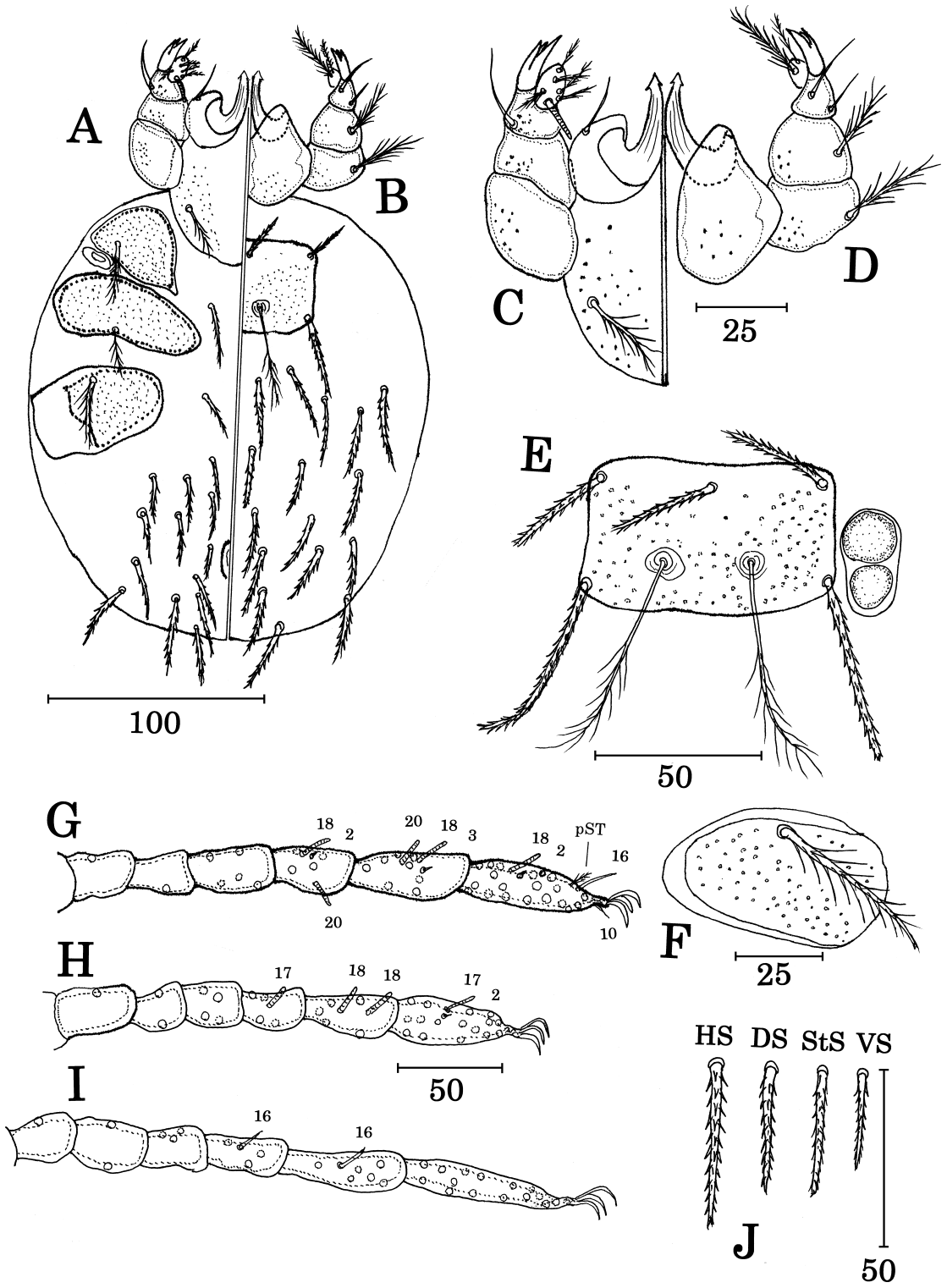
Idiosoma: Body longer than wide, measuring 220 (214, 205–220) long by 183 (188, 183–193) wide. Two pair of eyes on ocular plate, located by scutum at level of PL; diameter of anterior and posterior eyes 12 (12, 12) and 10 (10, 10), respectively.

Gnathosoma: Gnathosomal base moderately punctated, 55 (62, 55–66) wide, bearing a pair of branched setae; cheliceral bases rounded, 40 (40, 38–41) long by 30 (30, 29–31) wide, with moderate punctations; cheliceral blade 33 (32, 31–33) long by 21 (20, 19–21) wide, with tricuspid cap. Galeal seta nude. fPp = B/B/NNN/7B; palpal claw stout, 20 (20, 19–21) long, 3-pronged, with axial prong 9 (9, 9–10), 2 accessory prongs of unequal length and shorter than axial prong.

Scutum: Shape rectangular; anterior margin shallowly concave; lateral margins slightly indented between AL and PL; posterior margin slightly biconvex below sensillary bases; lateral margins weakly rounded at PL bases; AM base slightly below AL seta bases; SB distinctly anterior to level of PL bases; PL > AL ≥ AM; sensillae flagelliform with 11–13 long setules on distal half of shaft, proximal half finely nude. Other scutal setae with a moderate number of short and thick setules for almost their entire length. Large punctations distinctly distributed on scutum, except around seta AM and posterior portions of sensillary bases. Scutal measurements: AW, 67 (68, 67–68); PW, 74 (73, 70–74); SB, 27 (26, 25–27); ASB, 30 (29, 28–30); PSB, 14 (13, 12–14); AP, 28 (28, 27–28); AM, 28 (31, 28–33); AL, 31 (33, 31–36); PL, 47 (51, 47–55); S, 62 (59, 53–62).

Idiosomal setae: One pair HS, measuring 47 (49, 47–51); 32–33 DS arranged 2, 8 (9), 6, 6, 4, 4, 2; dorsal setae covered with a moderate number of thick and short setules for almost their entire length. HS and DS similar to scutal setae.

Fig. 1. *Toritrombicula lerdthusnee* n. sp., larva. A and B, ventral and dorsal aspects of larva; C and D, ventral and dorsal aspects of gnathosoma; E, scutum and eyes on ocular plate; F, coxa III; G, H, I, legs I, II, and III; pST, parasubterminala; J, details on setae; abbreviations: HS, humeral seta; DS, dorsal medial seta of first post-humeral row; StS, anterior sternal seta; VS, ventral medial seta of first post-sternal row. The length of the scale bar for each structure is in micrometers.



Length of dorsal setae as follows: medial seta of first posthumeral row 43 (41, 40–43); dorsal medial seta in central position 42 (41, 40–42); posterodorsal medial seta 36 (34, 32–36); dorsal terminal seta 33 (33, 32–33); StS 2-2 [anterior 36 (34, 32–36), posterior 26 (28, 26–30)], covered with a moderate number of long setules on the surface of their entire length, more pliant than preanal setae; 12–13 VS similar in nature to StS but shorter; length of medial seta in first preanal setal row 25 (28, 25–30); 14 CS similar in nature to DS but shorter and more slender; length of medial seta in first postanal row 38 (35, 32–38).

Leg: IP = 883 (mean 848, range 822–883). All 7-segmented, terminating in a pair of claws and a slender claw-like empodium. Onychotriches lacking. Conspicuous small punctations on coxae and free leg segments. No modified leg segments.

Leg I: 300 (276, 262–300) long; tarsus 70 (70, 68–72) long by 25 (25, 24–26) wide; coxa with 1 B; trochanter 1B; basifemur 1B; telofemur 5B; genu 4B, 2 genualae [dorsal genuala 18 (20, 18–22), distal genuala 20 (19, 18–20)], microgenuala 2; tibia 8B, 2 tibialae [proximal tibiala 20 (20, 20–21), distal tibiala 18 (18, 17–18)], microtibiala 3; tarsus 21B, tarsala 18 (19, 18–22), microtarsala 2, subterminala 16 (20, 16–23), pretarsala 10 (10, 9–11).

Leg II: 270 (268, 265–270) long; tarsus 65 (63, 60–65) long by 23 (22, 20–23) wide; coxa 1B; trochanter 1B; basifemur 2B; telofemur 4B; genu 4B, genuala 17 (18, 17–19); tibia 5B, 2 tibialae [proximal tibiala 18 (18, 17–18), distal tibiala 18 (17, 17–18)]; tarsus 16B, tarsala 17 (16, 16–17), microtarsala 2.

Leg III: 313 (304, 295–313) long; tarsus 83 (81, 78–83) long by 20 (19, 18–20) wide; coxa 1B; trochanter 1B; basifemur 2B; telofemur 3B; genu 3B, genuala 16 (17, 16–17); tibia 6B, tibiala 16 (17, 16–17); tarsus 15B.

Etymology. This species is dedicated in honor of Dr. Kriangkrai Lerdtthusnee, formerly of the Department of Entomology, US Army Medical Component, Armed Forces Research Institute of Medical Sciences, Bangkok, Thailand, in recog-

nition of his substantial contribution to our knowledge of the ecology of scrub typhus vectors.

Remarks

Brief systematic history

The genus *Toritrombicula* has a complicated taxonomy and confusing authorship: *Toritrombicula* Sasa *et al.*, 1953 (Loomis, 1966; Vercammen-Grandjean, 1960; Vercammen-Grandjean and Langston, 1976); *Toritrombicula* Sasa, Hayashi and Kawashima, 1953 (Vercammen-Grandjean, 1968); and *Toritrombicula* Sasa, 1954 (Nadchatram and Dohany, 1974). Sasa *et al.* (1953a) described a new species *Trombicula hasegawai* Sasa, Hayashi and Kawashima, 1953. Thereafter, Sasa (1954) erected a subgenus *Toritrombicula* of the genus *Trombicula*. Vercammen-Grandjean (1960) subsequently erected *Toritrombicula* as a full genus. Loomis (1966) incorporated the members of the genus *Neacariscus* as a synonymy of the genus *Toritrombicula*. Vercammen-Grandjean (1968) divided the genus *Toritrombicula* into 3 subgenera: *Toritrombicula*, *Cotrombidium*, and *Whartonacarus*. Vercammen-Grandjean and Langston (1976) rejected the proposal of Loomis (1966), based on the fact that many species within *Toritrombicula* and *Neacariscus* exhibited respective characters of each group. Thus, species belonging to the subgenera *Toritrombicula* and *Cotrombidium* were included in a full genus *Toritrombicula*. *Whartonacarus* originally was named as a subgenus of the genus *Necariscus* (Vercammen-Grandjean, 1960). Brennan and Goff (1977) subsequently promoted the subgenus *Whartonacarus* Vercammen-Grandjean, 1960 to a full genus *Whartonacarus*. Table 1 shows the pertinent differences between the genera *Toritrombicula*, *Neacariscus*, and *Whartonacarus*. Clearly, the 3 genera are very closely related to one another. In particular, *Whartonacarus* is separated from *Neacariscus* by a single characteristic (the possession of a few posterior epiostracal striae). Kudryashova (1998) cautioned that such taxo-

Table 1. Pertinent differences of each three genera *Toritrombicula*, *Neacariscus* and *Whartonacarus*.

genus	<i>Toritrombicula</i>	<i>Neacariscus</i>	<i>Whartonacarus</i>
SIF	7B-N-3-2111.0000	7B/7B.S-N-2-3/2111. 1000	7B.S-N-2- 3111.1000
fT	7B	7B.S	7B.S
tibial claw	trifurcate	bifurcate	bifurcate
fPp	B-B-N-N-N/B	B-B/N-N-N-N	B-B/N-N-N-N
Parasubterminala of leg I	branched	nude	nude
Scutum with prominent anterolateral shoulders	no	yes	yes
possibly a few posterior epiostracal striae	no	no	yes
genualae I	2	2, 3	3–4 (typically 3)
genualaeII	1	1	1–5 (typically 1)
genualae III	1	1	1–8 (typically 1)
tibiala III	1	1	1
mastitalsala III	none	long, nude	1 nude

onomic decisions may increase the artificial nature of the genus.

Many *Toritrombicula* species described after *Toritrombicula* Sasa, 1954 were moved to other genera as follows: *Toritrombicula* (*Toritrombicula*) *plubius* and *T. (Whartonacarus)* *chaetosa* to the genus *Neacariscus*; *T. anous*, *T. (W.) nativatis*, *T. oceanica*, *T. (W.) shiraii*, *T. (W.) thompsoni*, and *T. (W.) dupliseta* to the genus *Whartonacarus*; and *T. thalassa* to the genus *Eutrombicula*.

In summary, the authorship of the genus *Toritrombicula* is as follows: Sasa (1954) originally erected the subgenus *Toritrombicula* of the genus *Trombicula*, to accommodate the species *Trombicula hasegawai* Sasa, Hayashi, and Kawashima, 1953. According to the Chapter 9, Article 43 (Principle of Coordination) of the International Code of Zoological Nomenclature, Fourth Edition, the genus name is *Toritrombicula* Sasa, 1954, and the type species is *Trombicula hasegawai* Sasa, Hayashi, and Kawashima, 1953.

Host and distribution records of the genus Toritrombicula

The new species described here was collected by Suzuki's method using black cloth, from the coral reef of Iriomotejima Island, southwestern Okinawa, Japan. This coral reef is believed to be a breeding site of the Asiatic little tern (*S. albifrons*) and the black-naped tern (*S. sumatrana*). Given that almost all known species of *Toritrombicula* are bird-infesting parasites, the

present new species of chigger may be parasitic on these terns.

Table 2 lists the global distribution of *Toritrombicula* species. The newly identified species increases the total number of *Toritrombicula* species to 18 (15 from Asia and Australia, 2 from the Hawaiian Islands, and 1 from Russia). The species are mainly parasitic on birds, but some (*T. densipiliata*, *T. dumbletoni*, and *T. nissani*) have been recorded on mammalian hosts (rats and cuscus). However, these may have been accidental hosts.

Traub and Wisseman (1974) stated that virtually every species of mammal or bird coming into contact with the microhabitat of respective chiggers may become infested with the trombiculids in that particular niche. In general, these foci are at ground level, or within a few centimeters thereof. However, they may also be found within an arboreal nest or a rodent burrow. The host records of *Toritrombicula* listed in Table 2 demonstrate that 10 of the 18 chigger species were recovered from a single or several host species. Nevertheless, it is unclear whether each larva of chigger species is strictly monoxenic. With the exception of the present new species, the remaining 7 species are recorded as having been isolated from 4–58 bird species. Among these, *T. nissani*, *T. densipiliata*, and *T. hasegawai* have been recovered from a wide variety of birds.

Birds play an important role in the widespread distribution of ectoparasites. However, none of

Table 2. Global distribution of *Toritrombicula*: hosts, locality, and source.

No.	Species	Hosts	Locality	Source
1	<i>Toritrombicula asa</i> Nadchatram, 1967	Chesnut-breasted malcoha, <i>Phoenicophaeus curvirostris</i>	Philippines (Culion Island)	Nadchatram (1967)
2	<i>Toritrombicula asiatica</i> (Schluger and Belskaja, 1966)	Mourning chat, <i>Oenanthe picata</i> Black-eared wheateater, <i>Oenanthe hispanica pleshanka</i>	Russia (Turkmen) Russia (Turkmen)	Schluger and Belskaja (1966, 1967) Schluger and Belskaja (1966, 1967)
3	<i>Toritrombicula blumbergi</i> (Asanuma 1959)	Japanese wren, <i>Troglodytes troglodytes fumigatus</i>	Japan (Chichibu, Saitama Prefecture)	Asanuma (1959)
4	<i>Toritrombicula corvi</i> (Hatori, 1920)	Crow, <i>Corvus macrorhynchus</i> Vogel (fowl) Fowls Birds House crow, <i>Corvus splendens</i> Chicken, <i>Centropus javanicus</i> <i>Gallus</i> sp. Domestic fowl, <i>Corvus macrorhynchus colonorum</i> Domestic fowl, <i>Centropus bengaliensis javanicus</i>	Taiwan (Yoshinomura) Taiwan Taiwan Taiwan Taiwan Taiwan Taiwan	Hatori (1920) Kawamura and Yamaguchi (1921) Walch and Keukenschrijver (1924) Womersley and Heaslip (1943) Womersley (1952) Philip and Woodward (1946) Gunther (1952) Wharton and Fuller (1952) Radford (1954) Audy (1956) Chen and Hsu (1958) Chen and Hsu (1958)
5	<i>Toritrombicula densipiliata</i> (Walch, 1922)	Unspecified Green-breasted pitta, <i>Pitta sordida</i> Black-necked Tailor Bird, <i>Orthotomus atrogularis</i> Diard's Trogon, <i>Harpactes diardii</i> Kingfisher, <i>Halcyon concreta</i> Owl, <i>Otus bakkamoena</i> Orange-headed thrush, <i>Zoothera citrina</i> White-throated jungle flycatcher, <i>Anthipes solitaries malayana</i> Chestnut-winged flycatcher, <i>Drymophila pyrhoptera</i> Grey-headed tree-babbler, <i>Stachyris poliocephala</i> Chestnut-headed nun-babbler, <i>Alcippe castaneiceps</i> Birds, <i>macronous ptilosus</i> Green broadbill, <i>Calyptamena viridis</i> Crow pheasants, <i>Centropus</i> sp. Pheasants, <i>Centropus</i> sp. <i>Pitta sordida</i> Black plate <i>Macronus flavicollis</i> <i>Pachycephala whiteheadi</i>	Indonesia (Deli, Sumatera) West Malaysia (Gunong, Brinchang, Pahang) Philippines (Minagas Point) West Malaysia (Paka River, Trengganu) West Malaysia (Selangor) West Malaysia (Selangor) West Malaysia (Selangor) West Malaysia (Perak) West Malaysia (Gunong Brinchang) West Malaysia (Subang, Selangor) West Malaysia (Subang, Selangor) West Malaysia (Selangor) West Malaysia (Cameron Highlands) East Malaysia (Semango Forest, Sarawak) East Malaysia (Semango Forest, Sarawak) East Malaysia [Beaufort, Sabah (North Borneo)] Philippines (Palawan Bay, Balabac Island) Philippines (Palawan Bay, Balabac Island) Thailand (Wang Ta-khrai) Philippines (Brooke's Point, Palawan Island) Philippines (Mantalingajan Range, Brooke's Point, Sharma) Philippines (Pinigisan)	Walch (1922) Nadchatram (1967) Vercammen-Grandjean and Langston (1976) Nadchatram (1967) Vercammen-Grandjean and Langston (1976) Nadchatram (1967) Vercammen-Grandjean and Langston (1976) Nadchatram (1967) Vercammen-Grandjean and Langston (1976) Nadchatram (1967) Nadchatram (1967) Vercammen-Grandjean and Langston (1976) Nadchatram (1967) Nadchatram (1967) Nadchatram (1967) Nadchatram (1967) Nadchatram (1967) Nadchatram (1967) Nadchatram (1967) Vercammen-Grandjean and Langston (1976) Nadchatram (1967) Nadchatram (1967) Nadchatram (1967) Nadchatram (1967) Vercammen-Grandjean and Langston (1976)

Table 2. Continued.

No.	Species	Hosts	Locality	Source
5	<i>Toritrombicula densipiliata</i> (Walch, 1922)	<i>Copsychus niger</i>	Philippines (Palawan Bay, Balabac Island)	Nadchatram (1967)
		Flycatcher, <i>Muscicapa rufigastra</i>	Brooke's Point, Palawan Island	Nadchatram (1967)
		<i>Muscicapa</i> sp.	Philippines (Mantalingajan Range, Brooke's Point, Palawan)	Nadchatram (1967)
		<i>Centropus sineuiois</i>	Philippines (Palawan Bay, Balabac Island)	Nadchatram (1967)
		Rat	Territory of New Guinea (Nissan Island, Green Islands)	Vercammen-Grandjean and Langston (1976)
		Tree	Indonesia (Morotai Island, Molucca Islands)	Vercammen-Grandjean and Langston (1976)
6	<i>Toritrombicula dicrula</i> Chau, 2005	Collared Scops owl, <i>Otus bakkamoena lempiji</i>	West Malaysia (Tanjong Malim)	Vercammen-Grandjean and Langston (1976)
		<i>Dicrula</i> sp.	Vietnam	Chau (2005)
7	<i>Toritrombicula dumbletoni</i> (Womersley and Audy, 1957)	Tree log	Indonesia (Molucca Islands, Morotai)	Dumbleton (1947)
		Rat	New Guinea (Nissan, Green Island)	Nadchatram (1967) Dumbleton (1947)
8	<i>Toritrombicula gygis</i> Brennan and Amerson, 1971	<i>Gygis alba</i>	Phoenix Island	Nadchatram (1967) Brennan and Amerson (1971)
9	<i>Toritrombicula hasegawai</i> (Sasa, Hayashi and Kawashima, 1953)	<i>Monticola solitarius magnus</i>	Japan (Amamioshima)	Suzuki (1980)
		<i>Turdus celaenops celaenops</i>	Japan (Hachijo-koshima, Tokyo)	Sasa <i>et al.</i> (1953a, b)
			Japan (Hachijo Island, Tokyo)	Sasa <i>et al.</i> (1953b)
			Japan (Hachijo Island, Tokyo)	Sasa (1956)
		<i>Streptopelia orientalis orientalis</i>	Japan (Hachijo-koshima, Tokyo)	Sasa <i>et al.</i> (1953b)
			Japan (Hachijo Island, Tokyo)	Sasa <i>et al.</i> (1953b)
			Japan (Hachijo Island, Tokyo)	Sasa (1956)
			Japan (Hachijo Island, Tokyo)	Sasa (1956)
			Japan (Hachijo Island, Tokyo)	Sasa (1956)
		<i>Columba janthina janthina</i>	Japan (Hachijo-koshima, Tokyo)	Sasa <i>et al.</i> (1953b)
		<i>Passer montanus saturatus</i>	Japan (Hachijo-koshima, Tokyo)	Sasa <i>et al.</i> (1953b)
		<i>Monticola solitarius magnus</i>	Japan (Hachijo-koshima, Tokyo)	Sasa <i>et al.</i> (1953b)
			Japan (Hachijo Island, Tokyo)	Sasa <i>et al.</i> (1953b)
			Japan (Hachijo Island, Tokyo)	Sasa <i>et al.</i> (1958)
	Japan (Hachijo Island, Tokyo)	Sasa <i>et al.</i> (1958)		
	Japan (Hachijo-koshima, Tokyo)	Sasa <i>et al.</i> (1958)		
	<i>Aplonis opacus</i>	Palau Island	Loomis (1966)	
	<i>Colluricincla tenebrosa</i>	Palau Island	Loomis (1966)	
	<i>Corvus macrorhyncus connectens</i>	Japan (Amamioshima)	Suzuki (1980)	
	<i>Cissa erythrorhyncha</i>	China (Zhejiang Province)	Li (1997)	
	<i>Pica pica sericea</i>	China (Zhejiang Province)	Li (1997)	
	<i>Copsychus saularis prosthopellus</i>	China (Zhejiang Province)	Li (1997)	
10	<i>Toritrombicula kirhocephales</i> Goff, 1982	<i>Pitohui kirhocephalus</i>	New Guinea (East Sepik)	Goff (1982)
11	<i>Toritrombicula nihoaensis</i> Goff, 1984	<i>Telespyza ultima</i>	Hawaiian Island (Nihoa)	Goff (1984)
12	<i>Toritrombicula nissani</i> (Dumbleton, 1947) Syn. <i>Trombicula</i> (Leptotrombidium) <i>myzantha</i> Womersley, 1952	<i>Cuscus</i> (phalanger or possum)	New Guinea (Nissan Island, Green Islands)	Dumbleton (1947)
		<i>Pallida cuckoo</i> , <i>Cuculus pallidus</i>	Australia (Clermont, Queensland)	Gill <i>et al.</i> (1945)
		Lousy jack, <i>Cracticus torquatus</i>	Australia (Clermont, Queensland)	Gill <i>et al.</i> (1945)
		Fruit pigeon	New Guinea (Owi Island)	Gill <i>et al.</i> (1945)
		Pigeon	Australia (Solomon Archipelago)	Gill <i>et al.</i> (1945)
		Pallid cuckoo or Lousy jack	Australia (Yerongpilly, Queensland)	Gill <i>et al.</i> (1945)
		Tree kangaroo	New Guinea (Nissan Island)	Gunther (1952)

Table 2. Continued.

No.	Species	Hosts	Locality	Source
12	Syn. <i>Trombicula</i> (<i>Leptotrombidium</i>) <i>myzantha</i> Womersley, 1952	Green-winged pigeon, <i>Chalcophaps chrysochlora</i>	Australia (Mount Jukes, Mackay, Queensland)	Domrow (1966)
		Pale-yellow robin, <i>Eopsaltria capito</i>	Australia (Innisfail-Palmerston Highway, Queensland)	Domrow (1966)
		<i>Falco cenchroides</i>	Australia (Kowanyama, Queensland)	Domrow (1974)
		<i>Ninox novaeseelandiae</i>	Australia (Kowanyama, Queensland)	Domrow (1974)
		<i>Ninox connivens</i>	Australia (Kowanyama, Queensland)	Domrow (1974)
		<i>Tyto alba</i>	Australia (Kowanyama, Queensland)	Domrow (1974)
		<i>Podargus strigoides</i>	Australia (Kowanyama, Queensland)	Domrow (1974)
			Australia (Mudginberri, Queensland)	Domrow (1974)
		<i>Podargus papuensis</i>	Australia (Kowanyama, Queensland)	Domrow (1974)
		<i>Pomatostomus temporalis</i>	Australia (Condamine, Queensland)	Domrow (1974)
		<i>Pachycephala rufiventris</i>	Australia (Charleville, Queensland)	Domrow (1974)
		<i>Meliphaga flava</i>	Australia (Kowanyama, Queensland)	Domrow (1974)
		<i>Myzantha melanocephala</i>	Australia (Condamine, Queensland)	Domrow (1974)
		<i>Struthidea cinerea</i>	Australia (Condamine, Queensland)	Domrow (1974)
		<i>Arses lorealis</i>	Australia (Queensland)	Domrow and Lester (1985)
		<i>Chalcophaps chrysochlora</i>	Australia (Queensland)	Domrow and Lester (1985)
		<i>Colluricincla harmonica</i>	Australia (Queensland)	Domrow and Lester (1985)
		<i>Colluricincla megarhyncha</i>	Australia (Queensland)	Domrow and Lester (1985)
		<i>Coracina novaehollandiae</i>	Australia (Queensland)	Domrow and Lester (1985)
		<i>C. papuensis</i>	Australia (Queensland)	Domrow and Lester (1985)
		<i>Cracticus quoyi</i>	Australia (Queensland)	Domrow and Lester (1985)
		<i>Cuculus pallidus</i>	Australia (Queensland)	Domrow and Lester (1985)
		<i>Eopsaltria capito</i>	Australia (Queensland)	Domrow and Lester (1985)
		<i>E. leucops</i>	Australia (Queensland)	Domrow and Lester (1985)
		<i>Eurystomus orientalis</i>	Australia (Queensland)	Domrow and Lester (1985)
		<i>Falco berigora</i>	Australia (Queensland)	Domrow and Lester (1985)
		<i>F. cenchroides</i>	Australia (Queensland)	Domrow and Lester (1985)
		<i>Geopelia humeralis</i>	Australia (Queensland)	Domrow and Lester (1985)
		<i>Halcyon sanctus</i>	Australia (Queensland)	Domrow and Lester (1985)
		<i>Meliphaga flava</i> ,	Australia (Queensland)	Domrow and Lester (1985)
		<i>M. notata</i> ,	Australia (Queensland)	Domrow and Lester (1985)
		<i>Melithreptus albogularis</i>	Australia (Queensland)	Domrow and Lester (1985)
		<i>Monarcha trivirgata</i>	Australia (Queensland)	Domrow and Lester (1985)
		<i>Myiagra rubecula</i>	Australia (Queensland)	Domrow and Lester (1985)
		<i>Myzomela obscura</i>	Australia (Queensland)	Domrow and Lester (1985)
		<i>Myzantha melanocephala</i>	Australia (Queensland)	Domrow and Lester (1985)
		<i>Ninox connivens</i>	Australia (Queensland)	Domrow and Lester (1985)
		<i>N. novaeseelandiae</i>	Australia (Queensland)	Domrow and Lester (1985)
		<i>Oriolus flavocinctus</i>	Australia (Queensland)	Domrow and Lester (1985)
		<i>Pachycephala rufiventris</i>	Australia (Queensland)	Domrow and Lester (1985)
		<i>Pavo cristatus</i>	Australia (Queensland)	Domrow and Lester (1985)
		<i>Philemon argenticeps</i>	Australia (Queensland)	Domrow and Lester (1985)
		<i>P. citreogularis</i>	Australia (Queensland)	Domrow and Lester (1985)
		<i>Phonygamus keraudrenii</i>	Australia (Queensland)	Domrow and Lester (1985)
		<i>Platycercus adscitus</i>	Australia (Queensland)	Domrow and Lester (1985)
		<i>Podargus papuensis</i>	Australia (Queensland)	Domrow and Lester (1985)
		<i>P. strigoides</i>	Australia (Queensland)	Domrow and Lester (1985)
		<i>Pomatostomus temporalis</i>	Australia (Queensland)	Domrow and Lester (1985)
		<i>Ptiloris magnificus</i>	Australia (Queensland)	Domrow and Lester (1985)
		<i>Struthidea cinerea</i>	Australia (Queensland)	Domrow and Lester (1985)
		<i>Tyto alba</i>	Australia (Queensland)	Domrow and Lester (1985)
		<i>Xanthotis flaviventer</i>	Australia (Queensland)	Domrow and Lester (1985)
13	<i>Toritrombicula oahuensis</i> Goff, 1977	<i>Pluvialis dominica fulva</i>	Hawaiian Island (Oahu)	Goff (1977)
14	<i>Toritrombicula robusta</i> (Gunther, 1941)	Pitta, <i>Pitta mackloti</i>	New Guinea (Baiune)	Gunther (1941)
		Bird, <i>Microeca</i> sp	New Guinea (Bulolo)	Gunther (1941)

Table 2. Continued.

No.	Species	Hosts	Locality	Source
14	<i>Toritrombicula robusta</i> (Gunther, 1941)	Cat bird, <i>Ailuroedus melanocephalus</i>	New Guinea	Gunther (1952)
		Thrush-like bird	Indonesia (Irian)	Vercammen-Grandjean and Langston (1976)
		<i>Crateroscelis murina</i>	New Guinea (Wanuma)	Vercammen-Grandjean and Langston (1976)
		Unknown kingfisher	New Guinea (Wanuma)	Vercammen-Grandjean and Langston (1976)
		<i>Colluricincha harmonica</i>	Australia (Queensland)	Domrow and Lester (1985)
		<i>C. megarhyncha</i>	Australia (Queensland)	Domrow and Lester (1985)
		<i>Eopsaltria leucops</i>	Australia (Queensland)	Domrow and Lester (1985)
		<i>Meliphaga flava</i>	Australia (Queensland)	Domrow and Lester (1985)
		<i>M. notata</i>	Australia (Queensland)	Domrow and Lester (1985)
		<i>Myzomela obscura</i>	Australia (Queensland)	Domrow and Lester (1985)
		<i>Oriolus flavocinctus</i>	Australia (Queensland)	Domrow and Lester (1985)
		<i>Podargus strigoides</i>	Australia (Queensland)	Domrow and Lester (1985)
		<i>Xanthotis flaviventer</i>	Australia (Queensland)	Domrow and Lester (1985)
		15	<i>Toritrombicula samara</i> (Radford, 1953b)	Cuckoo, <i>Centropus melanops</i>
<i>Centropus</i> sp.	Philippines (Leyte Island)			Brown and Goff (1988)
<i>Oriolus</i> sp.	Philippines (Leyte Island)			Brown and Goff (1988)
<i>Chrysocalyptis</i> sp.	Philippines (Leyte Island)			Brown and Goff (1988)
<i>Halcyon</i> sp.	Philippines (Leyte Island)			Brown and Goff (1988)
16	<i>Toritrombicula uphami</i> Nadchatram, 1967	<i>Irena</i> sp.	Philippines (Leyte Island)	Brown and Goff (1988)
17	<i>Toritrombicula vorca</i> (Traub and Audy, 1953)	Green-breasted pitta, <i>Pitta sordida</i>	West Malaysia (Pahang)	Nadchatram (1967)
Unidentified bird		East Malaysia (Mount Kinabalu, Tenompok, Sabah)	Traub and Audy (1953)	
Crow pheasant, <i>Centropus</i> sp.		East Malaysia (Beaufort, Sabah)	Traub and Audy (1953)	
Chestnut-collared kingfisher, <i>Halcyon concreta concreta</i>		West Malaysia (Selangor)	Audy (1956)	
18	<i>Toritrombicula lerdthusneei</i> n. sp. (this study)	Collared Scops owl, <i>Otus bakkamoena lempiji</i>	West Malaysia (Bukit Lagong Forest Reserve)	Audy (1956)
	On rock	Japan (Iriomotejima Island, Okinawa)	Takahashi <i>et al.</i> (this study)	

the Southeast Asian species of *Toritrombicula* occur in Australian bird species and vice versa (Table 2). Moreover, the distribution of *Toritrombicula* species is mainly restricted to the tropical

and subtropical zones of Asia and Australia (Fig. 2). Thus, it appears that many *Toritrombicula* species may be considered to be habitat specific rather than host specific.

Key to 18 species of genus *Toritrombicula*

1. Sensillary bases on approximately halfway between anterior and posterior margins of scutum . . . 2
Sensillary bases on slightly or clearly anterior to a line with PL bases 3
2. Sensilla nude on distal half, proximal stem with barbs *T. corvi*
Sensilla with several barbs on distal half, proximal stem smooth *T. blumbergi*
3. Sensilla with many barbs on distal half 4
Sensilla filiform with 1 or 2 medial branches only *T. oahuensis*
4. Galeal seta branched 5
Galeal seta nude 7
5. Palpal formula BB/NNN 6
Palpal formula BB/NBB *T. asiatica*
6. DSF 2-8-6-6-4-2 (total 28) *T. nissani*
DSF 2-12-10-10-8-6-4-2 (total 54) *T. dumbletoni*
7. Number of dorsal setae ≤ 36 8

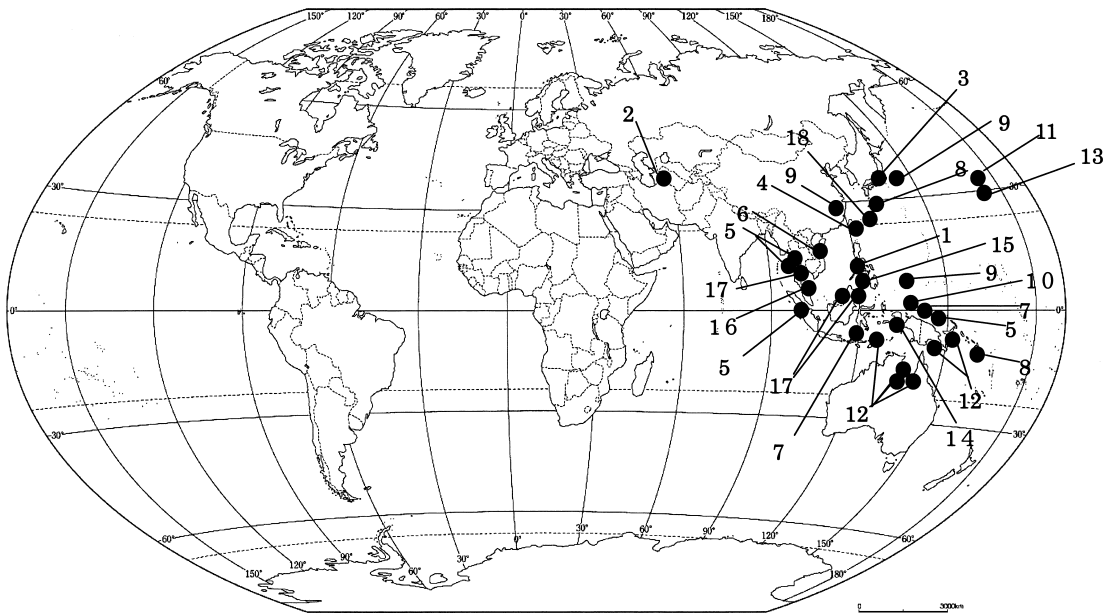


Fig. 2. Geographical distribution of the genus *Toritrombicula*, restricted to the Eastern Hemisphere. The numbers on the map correspond to the serial numbers shown in Table 2.

Number of dorsal setae 40–46	13
Number of dorsal setae > 50	15
8. First 3 rows of dorsal setae 2-8-6	9
First 3 rows of dorsal setae 2-10 (12)-8	11
9. PW/AP > 2.7	10
PW/AP < 2.7, DSF 2-8-6-6-4-2-2 (total 30)	<i>T. lerdthusneei</i> n. sp.
10. DSF 2-8-6-6-4-2 (total 28), PW/AP = 2.88	<i>T. nihoaensis</i>
DSF 2-8-6-8-6-4-2 (total 36), PW/AP = 2.73	<i>T. gygis</i>
11. Posterior corners of scutum angular, projecting laterally	12
Posterior corners of scutum rounded, not projecting laterally	<i>T. dicrula</i>
12. DSF 2-10-8-6-4-2 (total 32)	<i>T. kirhocephales</i>
DSF 2-12-8-8-4-2 (total 36)	<i>T. robusta</i>
13. Scutum strongly sclerotized, rectangular, posterior margin straight or shallow and slightly wavy	14
Scutum rectangular, posterior margin concave at mid-portion, weakly protruding laterally. DSF 2-(8, 4)-10-10-4-2-2 (total 42)	<i>T. asa</i>
14. Scutum posterior margin shallow and slightly wavy, lateral margin straight, DSF 2-(6, 4)-8-8-6-4-2 (total 40)	<i>T. uphami</i>
Scutum posterior margin straight, lateral margin slightly slanting. DSF 2-(8, 4)-10-8-6-4-2 (total 44)	<i>T. samara</i>
15. Scutum rectangular and strongly sclerotized, posterior margin straight, but sometimes weakly concave	16
Scutum subrectangular, posterior margin somewhat convex, opposite level of sensillary bases. DSF 4-(8, 10)-12-12-4-8-6-4-2 (total 70)	<i>T. vorca</i>

16. Scutal setae length $PL > AL > AM$, DSF 4-14-12-10-8-6-4-2 (total 60) *T. densipiliata*
 Scutal setae length $PL > AM > AL$, DSF 4-14-12-10-8-6-4 (total 58) *T. hasegawai*

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