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Trombiculid Fauna in Nansei Islands and Their Characteristics (Prostigmata, Trombiculidae)

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Abstract : Surveys on trombiculid fauna in Nansei Islands (Tanegashima, Yakushima, Amamioshima, Tokunoshima, Okinoerabu, Yoron, Okinawa, Ishigaki and Iriomote Islands) were undertaken and their peculiar characteristics were studied. The surveys were performed especially for confirmation of the mites which could be a vector of scrub typhus in the area. As a collecting method, Tullgren apparatus was employed, that is, soil samples were collected from nest tunnels of various animals and unengorged larval mites were directly collected by the apparatus (described as "Direct Method" hereafter). From results of surveys reported here and those of past reports, trombiculid mites recorded in Nansei Islands were found to be 55 species of 21 genera in total (Table 8). They are 14 species of 7 genera in Tanegashima and Yakushima Islands (Table 1), 40 species of 17 genera in Amami Islands (Amamioshima, Tokunoshima, Okinoerabu and Yoron Islands) (Table 3), 17 species of 10 genera in Ryukyu Islands (Okinawa, Ishigaki and Iriomote Island) (Table 5). Of them, there were 2 species of genus unrecorded in Japan, 11 new species, 6 species newly recorded in Japan and 35 species newly recorded in Nansei Islands. As a result, the surveys fairly clarified trombiculid fauna of Nansei Islands, which were considerably unknown hitherto. In islands of Tanegashima and Yakushima located at southern end of palaearctic region, all trombiculid mites, except *Doloisia satoiana*, were found corresponding to those in Kyushu main−land. Only 7 species of them, however, corresponded to those in Amamioshima Island located at northern end of oriental region. Out of 48 species found in area south of Amamioshima Island, only 10 species corresponded to those in Japan main−land. It was seemed, from the above results, that Watase−Line, a biological distribution boundary linning at Tokara channel, could apply also to trombiculid fauna as well as many other animals and plants. Among trombiculid mites which previously confirmed as vectors of, three species were confirmed distributing in Nansei Islands; *Leptotrombidium pallidum pallidum* in Tanegashima, *L. deliense* and *L. scutellare* in Amamioshima Island. Furthermore, as to be suspected vectors of the infection, *L. kawamurai* in Yakushima, Amamioshima, Tokunoshima and Okinawa, re-

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semble species of *L. akamushi* and *L. p. burnsi* in Amamioshima were detected respectively. A new collecting method (the direct method) used in this survey had brought about 32 species of trombiculid mites in results. This indicates the new method can sufficiently substitute the usual host−collecting method. On the other hand, by the usual host−collecting method, peculiar trombiculid mites were collected such as *Eutrombicula (Siseca) haematocheiri* found in fresh water crabs, *Walchia (Walchia) pentalagi* and *Cordiseta (Kayella) nakayamai* specificaly found in Amami−Rabbit living only in Amamioshima and Tokunoshima Islands.

INTRODUCTION

Nansei Islands located between Kyushu and Taiwan are consists of very interesting islands in a view of biogeography. These islands are divided in palaearctic region and oriental region at Watase Line, a biological distribution boundary, which is linning at Tokara channel between Yakushima Island and Tokara Islands (Fig. 1). These islands are still maintainning exteremely specific fauna of biology by isolated environment of "Island", and geogrophical and historical age of the islands. In result of that, there are many uncommon animals still living in Nansei Islands, such as inherited species from ancient days or species peculiarly developed inside a particular island.

As types of scrub typhus and its vecor mites finding in Japan main-land, the followings are well at present;

Classical type scrub typhus in Niigata, Yamagata, Akita Pref. by *L. akamushi*.

Izu-seven islands type scrub typhus in Izu-seven islands and foot of Mt. Fuji by *L. scutellare*.

New type scrub typhus in Kanagawa, Shizuoka, Oita, Toyama, Niigata, Akita, Aomori Pref. by *L. pallidum*.

Besides the above typical types, scrub typhus-infections among cases of so-called local disease or unknown eruptive fever have been reported from various area. In these days, the scrub typhus is no longer the endemic disease infesting only in a specific area but is rather pandemic group-infection throughout the country. Moreover, the disease is seen not only in Japan but also in Taiwan, Philippines, Thailand, India and many other parts of south east Asia, or in south west Pacific islands and a part of Australia.

As to typhus in Nansei Islands, however, there had been no surveys performed in the past except a report by Tamiya (1962). The author had been conducted surveys on trombiculid fauna in Nansei Islands during period from 1971 to 1975 (partial additions at 1978, 1979 and 1980). Studies were especially carried out on the biogeographic and specific characteristics of the fauna and on confirmation of proven vetor for the disease. Together with usual host-collecting method, a direct collecting method which developed by the author at Mt. Fuji area was also employed in this survey (even though natural environments were quite different from Fuji area).

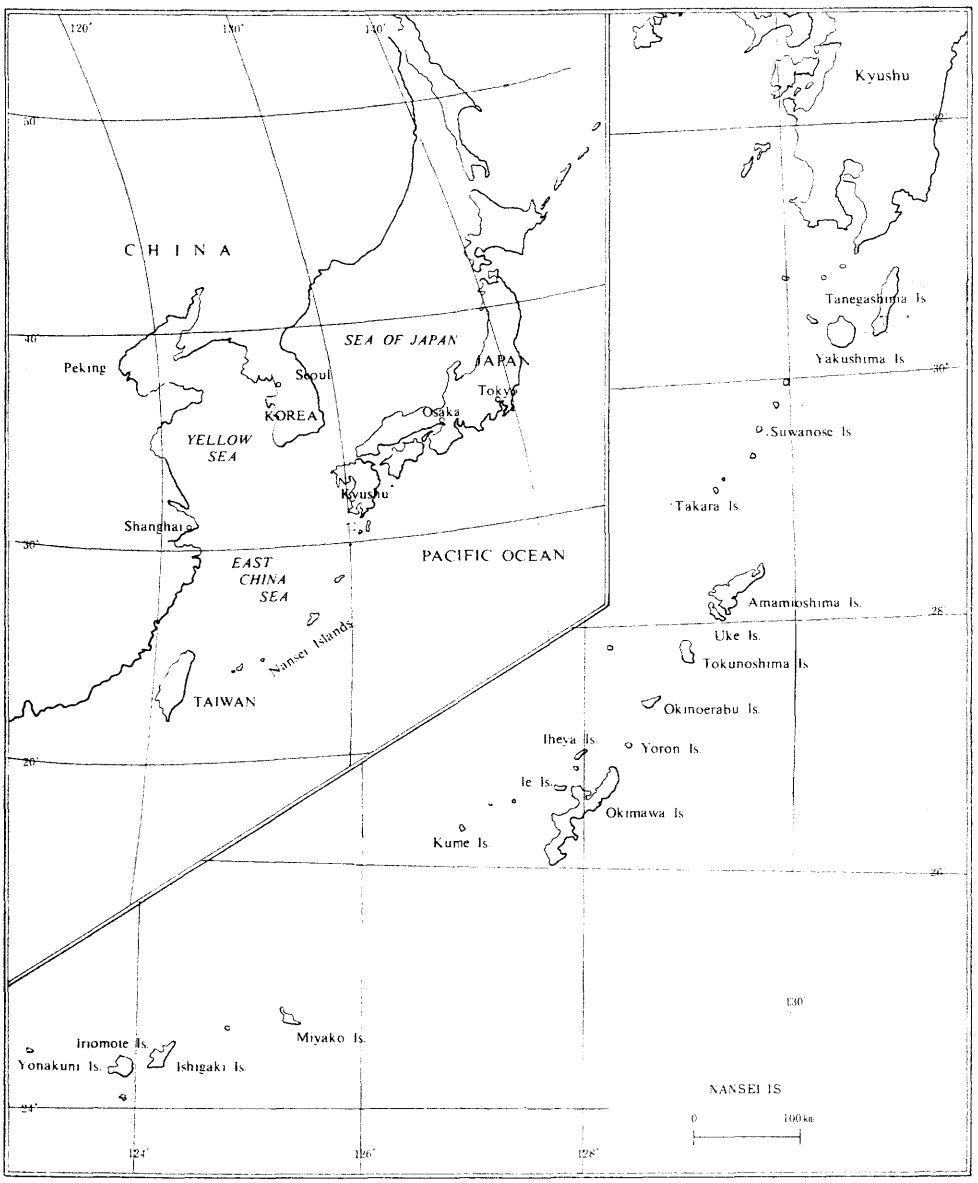

Fig. 1. Map of Nansei Islands.

METHODS AND PLACES

The hanging method was used for usual host-collecting method. Among various hosts examined, Amami-Rabbit, *Pentalagus furnessi* (Special Natural Monument) were captured alive and bred in a cage. The mites were collected everyday from a pan plac-

ed under the cage, with water filled inside in the pan. The rabbits were released after a week at places they were captured.

A direct collecting method was also used for collecting unengorged larval mites. It was a method to recover the larva in soils from nest-tunnels of host animals by employing Tullgren apparatus, which was reported in 1971 and 1973 (Fig. 2).

A monthly collection of the larval mites was undertaken at area around Mt. Yuwan (694.7m. high) of southern Amamioshima Island, throughout a year.

The islands surveyed in this study were Yakushima and Tanegashima Islands of palaearctic region, and Amamioshima, Tokunoshima, Okinoerabu, Yoron, Okinawa, Ishigaki and Iriomote Islands of oriental region.

Fig. 2. Tullgren apparatus for collection of unengorged larvae from soil sumples.

RESULTS AND DISCUSSION

1. Yakushima and Tanegashima Islands.

The two islands located at southern end of palaearctic region are quite important as in comparing trombiculid fauna of Japan mainland with that of oriental region, south of Amamioshima Island.

a) Yakushima Island.

There was a report for the mites at this island by Kaneko *et al.* (1961). They collected 5 species of 3 genera from wild rodents of 21 individuals of *Apodemus speciosus dorsalis* and 5 individuals of *Apodemus argenteus yakui*.

Suzuki *et al.* (1980) collected 7 species of 4 genera of unengorged larva from soil *A. S. dorsalis*, an individual of *A. a. yakui*, 2 individuals of *Mogera wogura kanai*, 2 individuals of *Mustella sibirica sho* and an individual of *Rhinolophus ferrumequinum nippon*.

b) Tanegashima Island.

Kaneko *et al.* reported (1961) collections of 6 species of 5 genera of trombiculid mites obtained from 43 individuals of *A. s. dorsalis*, 5 individuals of *A. a. tanei* and an individual of *Mus muscalus orii*.

Suzuki *et al.* (1980) collected 7 species of 4 genera of unengorged larval mites from soil samples and 3 species of 2 genera of trombiculid mites from 7 rodents of *A. S. dorsalis*.

As shown in Table 1, trombiculid mites collected in the two islands were 14 species of 7 genera in total; including newly added 8 species of 5 genera, namely, *L. kawamurai*, *L. miyajimai*, *L. pallidum*, *L. (T.) kansai*, *Neotrombicula mitamurai*, *Sasatrombicula koomori*, *Walchia ogatai* and *Doloisia satoiana*. Comparing those results with the fauna of Japan main-land, it was obvious that the fauna in the two islands was almost same as that in Japan main-land (Honshu and Kyushu). Namely, *L. fuji* was found to be most dominant both in the two areas, with only uncommon species *D. satoiana* collected in Yakushima Island.

On the other hand, comparing the fauna of the two islands with that of Amami-

Table 1. Summarized list of larval trombiculid mites collected on Yakushima and Tanegashima Island

Trombiculid mites \ Place	Yakushima Island	Tanegashima Island
Leptotrombidium [*L.*] *fuji*	1081	905
L. [*L.*] *kawamurai*	20	0
L. [*L.*] *kuroshio*	93	13
L. [*L.*] *miyajimai*	21	6
L. [*L.*] *pallidum*	0	2
L. [*T.*] *kansai*	16	1
Neotrombicula [*N.*] *mitamurai*	0	3
N. [*N.*] *tamiyai*	0	1
Miyatrombicula [*M.*] *kochiensis*	0	24
Doloisia[*D.*] *okabei*	44	1
D. [*D.*] *satoiana*	4	0
Gahrliepia [*G.*]*saduski*	42	47
Walchia [*W.*] *ogatai*	2	0
Sasatrombicula [*S.*] *koomori*	7	0

Table 2. Geographic distribution of trombiculid mites of Yakushima & Tanegashima Island in Amami Island and the Mainland of Japan

Trombiculid mites \ Area	Mainland of Japan	Yakushima and Tanegashima Island	Amamioshima Island
Leptotrombidium [*L.*] *fuji*	+	+	+
L. [*L.*] *kawamurai*	+	+	+
L. [*L.*] *kuroshio*	+	+	+
L. [*L.*] *miyajimai*	+	+	
L. [*L.*] *pallidum*	+	+	
L. [*L.*] *kansai*	+	+	
Neotrombicula [*N.*] *mitamurai*	+	+	
N. [*N.*] *tamiyai*	+	+	+
Miyatrombicula [*M.*] *kochiensis*	+	+	+
Doloisia [*D.*] *okabei*	+	+	+
D. [*D.*] *satoiana*		+	+
Gahrliepia [*G.*] *saduski*	+	+	
Walchia [*W.*] *ogatai*	+	+	
Sasatrombicula [*S.*] *koomori*	+		

oshima Island just other side of Tokara Channel, 7 species of 4 genera (*L. kawamurai*, *L. kuroshio*, *L. miyajimai*, *Miyatrombicula kochiensis*, *Gahrliepia saduski*, *D. okabei* and *D. satoiana*) were found commonly in Amamioshima Island but other 7 species of 5 genera were not found in Amamioshima at all. Since trombiculid fauna of the two islands were found to be almost corresponding to that of Kyushu, Watase Line (biological distribution boundary) should apply also to trombiculid fauna as well as it was proved in many other animals and plants.

Tamiya *et al.* reported (1962) positive cases of finding scrub-typhus rickettsia in *M. m. orii* and *A. s. dorsalis* collected in Tanegashima Island. This result evidenced the existence of vector mites in the island. Taking results of the past reports into the consideration, *L. pallidum*, collected by the auther in this survey, may very well be a key vector of the infection.

Tamiya *et al.* also studied to isolate the rickettsia from *A. a. yakui*, *A. s. dorsalis*, *R. rattus* and *R. norvegicus* collected in Yakushima Island, but results were negative (1962). However, *L. kawamurai* collected by Suzuki *et al.* in this island (1980) was also known to be infected with the rickettsia in high ratio at Hokkaido. Therefore, there is a possibility of existence of scrub typhus in Yakushima Island.

2. Amami Island (Amamioshima, Tokunoshima, Okinoerabu and Yoron Islands).

In these islands, the natural environment is maintained much better than in any other parts of Nansei Islands. In Amamioshima Island, especially, where great virgin forests are still remained, there are quite peculiar mammals living in the forest. They are, such as, Amami-Rabbit, *Pentalagus furnessi* remainning in a premitive form of ancient rabbit (Fig. 3-A) ; Amami spinous country rat, *Tokudaia osimensis osimensis*

(Fig. 3−B); Okinawa long−haired rat, *Diplothrix legata* (Fig. 3−C) or Orii's shrew, *Crocidura orii*. Therefore, these islands are quite interesting areas not only for trombiculid mites but also for the host animals of the mites. Table 3 shows trombiculid mites of 40 species of 17 genera found in Amami Islands.

a) Amamioshima Island.

Trombiculid mites recorded in the past from Amamioshima Island were 10 species of 6 genera ; 5 species of 4 genera of *Ascoschoengastia indica*, *Walchiella oudemansi*,

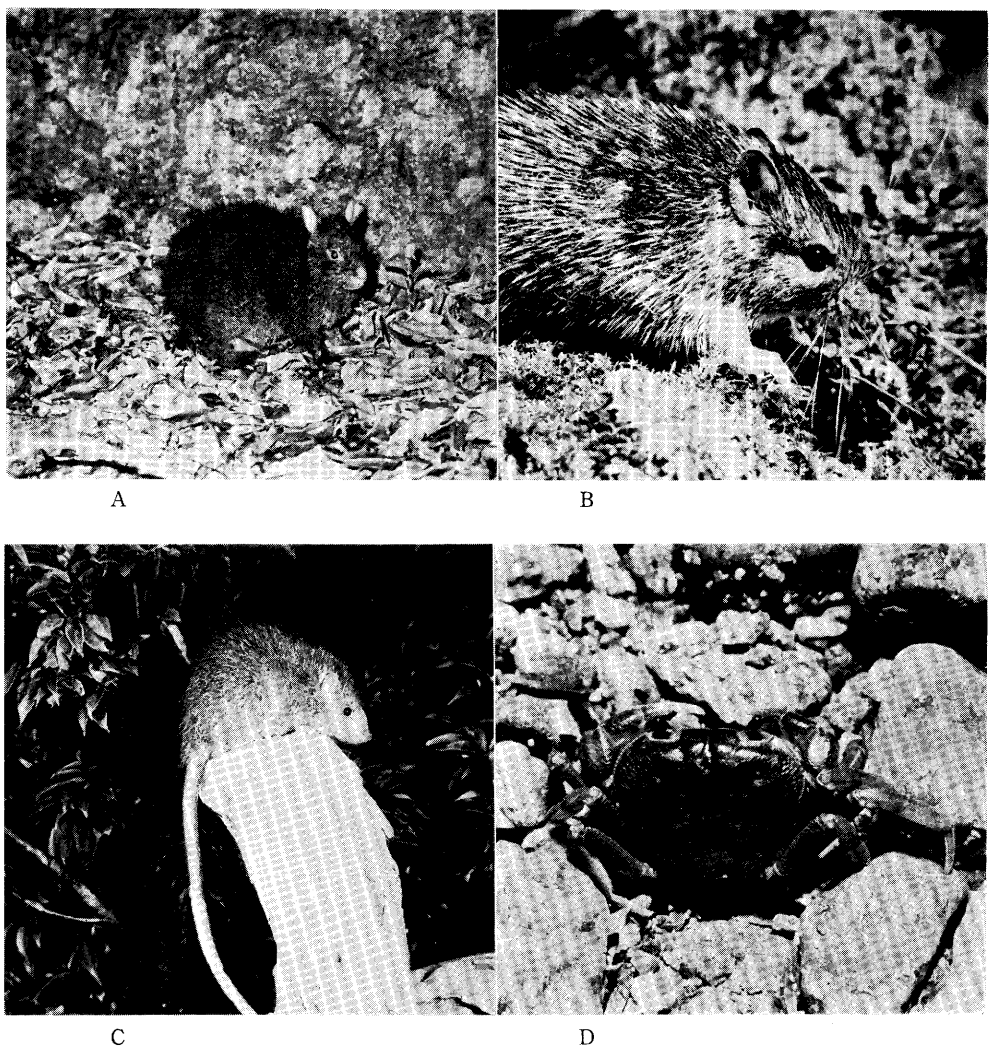

Fig. 3. Main hosts of trombiculid mites in Amami Island.
3-A. Amami rabbit, *Pentalagus furnessi* (Stone, 1900).
3-B. Amami spinous country rat, *Tokudaia osimensis osimensis* (Abe, 1933).
3-C. Okinawa long-haired rat, *Diplothrix legata* (Thomas, 1906).
3-D. Fresh water crab, *Potamon dehaani* (White, 1847).

Acomatacarus yosanoi, *L. deliense* and *L. scutellare* obtained from *D. legata* reported by Kano *et al.* (1961), and 5 species of 3 genera of *Doloisia synoti*, *L. kawamurai*, *L. kitaokai*, *L. kuroshio* and *Miyatrombicula kochiensis* obtained from *T. osimensis* and *Rattus norvegicus* reported by Kaneko (1967).

The author conducted collections of tromciculid mites during period of 1971 to 1975 (partial additions in 1978 and 1979) by performing 89 times of soil collection from nest−tunnels of the host animals and examining 14 species of 7 orders of host animals (Table 6). As a result, 40 species of 17 genera were collected as shown in Table 3. From a view point of species' component, the collection showed the fauna of oriental region. Namely, the collection included 3 genera of *Cordiseta*, *Schoengastia*, *Walchiella* and a subgenus of *Siseca* which were unrecorded in Japan main−land, and 5 species of genus *Ascoschoengastia* and 4 species of genus *Doloisia* which were commonly found in south east Asia. Naturally, the species' component was much different from that of Japan main−land.

The most dominant species of the collection was *L. kawamurai* which were widely distributed in entire Amamioshima Island and collected throughout a year (Table 5). Host animals for *L. kawamurai* were also quite various, i. e., wild rodents of *R. norvegicus*, *R. rattus*, *T. osimensis* and *D. legata*; *C. orii* of Insectivora; *Garrulus lidthi* of wild birds (Table 6). *L. kawamurai* is a species known to be distributed extremely peculiar, namely distributed originally in Miyakejima Island and then widely distributed in Hokkaido, Akita, Nagano, Fukui, Nagasaki and Kagoshima Prefecture. From results of this survey, another new suggestion may be given to the distribution of *L. kawamurai* because it was found from wide range of hosts, even from wild birds. Asanuma *et al.* reported (1976) that the infection rate of *L. kawamurai* with scrub−typhus rickettsia in Hokkaido was found to be nearly equivalent to that of *L. akamushi*, a vector mite of classical type scrub−typhus in Honshu. Though there were no cases reporting this species sticking to humans hitherto, the possibility to be a vector of the infection is still undeniable because of the wide range of host animals collected in this survey and also because of the fact the species is most dominant in this island.

L. deliense collected initially by Kano *et al.* (1961) at this island is known to be a main vector of scrub−typhus in south−east Asia. In this survey the author collected mites which could be called "approximate species to *L. akamushi*". It was found that the species was morphologically an intermediate type between *L. deliense* and *L. akamushi*. Definite identification of the species was not determined but further studies should carried out for this question in near future.

L. scutellare is a vector of Izu−seven−island type scrub−typhus and is scatteredly distributed in wide areas from Yamagata to Kagoshima Prefectures. In Amamioshima Island, the species were collected from November to April of the year in good many numbers (Tables 3 and 5).

L. pallidum is the most noticeable species recently because it has been confirmed

Table 3. Summariezd list of larval trombiculid mites collected on Amami-Gunto

Trombiculid mites \ Localities	Yoronto	Okinoerabujima	Tokunoshima	Amamioshima
Leptotrombidium [*L.*] *akamushi* group	0	0	0	1
L. [*L.*] *deliense*	0	0	0	?
L. [*L.*] *kawamurai*	0	0	365	9872
L. [*L.*] *kitaokai*	0	0	0	?
L. [*L.*] *kuroshio*	0	0	9	563
L. [*L.*] *miyajimai*	0	0	0	65
L. [*L.*] *pallidum burnsi*	0	0	0	3057
L. [*L.*] *scutellare*	0	0	0	1876
Eutrombicula [*S.*] *haematocheiri*	0	0	0	164
E. [*S.*] sp.	0	0	0	4
Miyatrombicula [*M.*] *kochiensis*	0	0	0	?
M. [*M.*] *okadai*	0	0	0	218
Eltonella [*E.*] *ichikawai*	0	0	0	20
Toritrombicula [*T.*] *gygis*	0	0	0	4
T. [*T.*] *hasegawai*	0	0	0	3
Ascoschoengastia [*A.*] *ctenacarus*	0	0	0	556
A. [*A.*] *indica*	0	0	0	?
A. [*A.*] *noborui*	0	0	14	295
A. [*A.*] sp.	0	0	0	2
A. [*P.*] *monticola*	0	0	0	6
Walchiella [*W.*] *amamiensis*	0	0	0	64
W. [*W.*] *oudemansi*	0	0	0	?
Schoengastia [*S.*] *hanmyaensis*	0	0	0	68
Doloisia [*D.*] *minamii*	0	0	0	280
D. [*D.*] *okabei*	1	0	0	0
D. [*D.*] *satoiana*	0	1	1	227
D. [*D.*] *synoti*	0	0	0	?
D. [*D.*] *zentokii*	0	0	0	14
Helenicula [*H.*] sp.	0	0	0	3
Mackiena [*M.*] *todai*	0	0	0	2
Cordiseta [*K.*] *nakayamai*	0	0	0	808
Neoschoengastia [*M.*] *carveri*	0	0	0	7
N. [*N.*] *americana solomonis*	0	0	0	1
N. [*N.*] *posekanyi*	0	1	1	1
N. [*N.*] *shiraii*	0	0	2	755
Babiangia [*V.*] *ipoides*	0	0	0	?
Acomatacarus [*O.*] *yosanoi*	0	0	1	53
Gahrliepia [*G.*] *saduski*	0	0	2273	1377
Walchia [*W.*] *pentalagi*	0	0	167	10232
W. [*R.*] *sawaii*	0	0	4	97

as a vector of new type scrub−typhus which incedence are oftenly reported from various localities in Japan. Jackson *et al.* reported a successful isolation of the rickettsia from this species in Korea (1957). *L. pallidum burnsi*, describing as a subspecies of *L. pallidum* in this report, were first collected from a wild bird of *Turdus celaenops* in Hachijo Island of Tokyo. In Amamioshima Island, the species were collected from Amami−Rabbits and wild rodents, and collections of 2,381 individuals were obtained from male Amami−Rabbits in April 1979. It indicated that the spring time was a growthpeak of larval mites of the species. The mites had same arrangements of dorsal setae as that of *L. p. burnsi* but also had close size of the scutum to that of *L. pallidum*. For the present, the mites are describing as *L. p. burusi* in the report, but further studies may be necessary for reexamining a question of species−subspecies and comparing the epidemiological defference between the two.

Tamiya *et al.* examined wild rodents of 12 *R. norvegicus*, 45 *R. rattus* and 2 *Suncus murinus* collected in Amamioshima Island for isolating the rickettsia, but the result was negative (1962). All those rodents they examined, however, were the ones finding near houses and they did not examine any of *T. osimensis*, the most dominant rodent at fields in Amamioshima Island (Suzuki, 1979). For confirming existence of scrub−typhus in this island, the all species of rodents including *D. legata* living at fields of the island should be examined for isolating the rickettsia, in future.

There are two cases when ones get sticks by trombiculid mites; one getting infection of scrub-typhus and another getting just itchy eruptions. For the latter, *Eutrom-*

Table 4. Summarized list of larval trombiculid mites collected on Ryukyu Islands

Locarities / Trmiobculid mites	Iriomotejima	Ishigakijima	Okinawa
Leptotrombidium [*L.*] *kawamurai*	0	0	688
Microtrombicula [*M.*] sp.	0	0	1
Eutrombicula [*E.*] *ablephara*	0	43	0
E. [*E.*] *wichmanni*	26	?	0
Toritrombicula [*T.*] *anus*	13	0	0
Ascoschoengastia [*A.*] *noborui*	0	0	2
A. [*P.*] *monticoa*	0	0	44
Walchiella [*W.*] *amamiensis*	0	0	1
Neoschoengastia [*M.*] *carveri*	0	0	14
N. [*M.*] *namurui*	0	0	1
N. [*N.*] *americana solomonis*	0	0	34
N. [*N.*] *atollensis*	0	0	1
N. [*N.*] *egretta*	0	0	3
N. [*N.*] *posekanyi*	0	0	17
Babiangia [*V.*] *ipoies*	0	?	0
Whartonia [*A.*] *iwasakii*	5	0	0
Gahrliepia [*G.*] *saduski*	0	0	21

bicula wichmanni is known as a mite in Japan. Furthermore, *Schoengastia hanmyaensis* was found sticking on the author's arms at a time of the collection in Amamioshima Island. *S. schuffneri* and *S. vandersundei*, relative speceies to *S. hanmyansis*, are well known as mites for the eruptive infection in south Asia. Therefore, *S. hanmyaensis* collected in this island may also be the one of those itch-mites.

Of 37 species of 17 genera collected in Amamioshima Island, the author is reporting here 29 species of 15 genera as newly recorded species and 11 species of 7 genera as new species (1975, 1976a and 1976b).

Unlike blood sucking type Acarina as ticks which suck blood throughout period from larva to adult, trombiculid mites engorge to mammal hosts only at larval period

Table 5. Seasonal appearence of trombiculid mites in Sonthern Amamioshima (1971—1975)

Trombiculid mites \ Month	Jan.	Feb.	Mar.	Apr.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Leptotrombidium [*L.*] *kawamurai*	○	○	○	○	○	○	○	○	○	○	○
L. [*L.*] *kuroshio*	○	○	○	○	○	○					○
L. [*L.*] *miyajimai*	○	○	○								○
L. [*L.*] *pallidum burnsi*	○	○	○	○						○	○
L. [*L.*] *scutellare*	○	○	○	○						○	○
M. [*M.*] *okadai*	○	○	○	○							○
Eltonella [*E.*] *ichikawai*										○	○
Eutrombicula [*S.*] *haematocheiri*							○	○	○	○	
Toritrombicula [*T.*] *gygis*							○				
T. [*T.*] *hasegawai*							○				
Ascoschoengastia [*A.*] *ctenacarus*											○
A. [*A.*] *noborui*	○	○	○	○							○
A. [*P.*] *monticola*							○				
Schengastia [*S.*] *hanmyaensis*		○	○	○	○	○	○	○			
Walchiella [*W.*] *amamiensis*	○	○	○	○							○
Doloisia [*D.*] *minamii*	○	○	○	○						○	○
D. [*D.*] *satoiana*	○	○	○	○						○	○
D. [*D.*] *zentokii*	○										○
Mackiena [*M.*] *todai*										○	
Cordiseta [*K.*] *nakayamai*	○	○	○	○	○	○	○	○			
Neoschoengastia [*M.*] *carveri*							○				
N. [*N.*] *americana solomonis*							○				
N. [*N.*] *posekanyi*							○				
N. [*N.*] *shiraii*							○				
Acomatacarus [*O.*] *yosanoi*	○	○	○	○	○	○	○				○
Gahrliepia [*G.*] *saduski*	○	○	○	○	○	○	○	○	○	○	○
Walchia [*W.*] *pentalagi*	○	○	○	○	○	○	○	○	○	○	○
Walchia [*R.*] *sawaii*	○	○	○	○	○						
Nymphs	○	○	○	○	○	○	○	○	○	○	○
Adults	○	○	○	○	○	○	○	○	○	○	○

Table 6. Summarized list of larval trombiculid mites and

Class	Order	Suborder	Family
CRUSTACEA	DECAPODA	BRACHYURA	POTAMONIDAE
			GRAPSUS
REPTILIA	TESTUDINATA	CRYPTODIRA	TESTUDINIDAE
	SQUAMATA	LACERTILIA	AGAMIDAE
		OPHIDIA	COLUBIDAE
			ELAPIDAE
AVES	GRESSORES	ARDEAE	ARDEIDAE
	CHARADRIIFORMES	LARI	LARIDAE
	COLUMBIFORMES	COLUMBAE	COLUMBIDAE
	PASSERES	OSCINES	MUSCICAPIDAE
			CORVIDAE
MAMMALIA	INSECTIVORA	DILAMBOODONTA	SORICIDAE
			TALPIDAE
	CHIROPTERA	MICROCHROPTERA	HIPPOSIDERIDAE
			RHINOLOPHIDAE
	PRIMATES	SIMIAE	HOMINIDAE
	LAGOMORPHA		LEPORIDAE
	RODENTIA	MYOMOPPHA	MURIDAE
	CARNIVORA	FISSIPEDA	MUSTELIDAE

their host animals in Nansei Islands

Species	Locality	Trombiculid mite
Potamon dehaani	Amamioshima	*E. haematocheiri*
Sesaruma haematocheir	Amamioshima	*E. haematocheiri*
Cyclemys flavomarginata	Ishigakijima	*E. wichmanni*
Japalura polygonata	Ishigakijima	*E. ablephara*, *E. wichmanni*
Opheodrys semicarinatus	Amamioshima	*E.* sp.
Laticauda laticaudata	Amamioshima	*B. ipoides*
L. affinis, *L. semifasciata*	Ishigakijima	*B. ipoides*
Egretta intermedia	Okinawa	*N. egretta*
E. sacra	Iriomotejima	*T. anus*
Butorides strientalis	Okinawa	*N. americana solomonis*
Gygis alba	Okinawa	*N. carveri*, *N. namurui*
Streptopelia orientalis	Okinawa	*N. a. solomonis*, *N. posekanyi*
Monticola solitarius magnus	Amamioshima	*N. posekanyi*, *N. a. solomonis*, *N. carveri*, *A. monticola* *T. gygis*
	Okinawa	*A. monticola*
Corvus macrorhycus connectens	Amamioshima	*T. hasegawai*, *H.* sp.
Garrulus lidthi	Amamioshima	*L. kawamurai*
Crocidura dsinezumi orii	Amamioshima	*L. kawamurai*
Suncus murinus riukiuanus	Yoronjima	*D. okabei*
Mogera wogura kanai	Yakushima	*D. okabei*
Hipposideros turpis	Ishigakijima	*W. iwasakii*
Rhinolophus ferrumequinum nippon	Yakushima	*S. koomori*
Homo sapiens	Amamioshima	*S. hanmyaensis*
Pentalagus furnessi	Amamioshima	*G. saduski*, *W. pentalagi*, *L. kawamurai*, *L. kuroshio*, *L. p. burnsi*, *L. scutellare*, *M. okadai*, *E. ichikawai*, *A. ctenacarus*, *A. noborui*, *A.* sp, *C. nakayamai*, *A. yosanoi*
Apodemus speciosus dorsalis	Yakushima	*G. saduski*, *L. fuji*, *L. kuroshio*, *L. miyajimai*, *D. okabei*
	Tanegashima	*G. saduski*, *L. fuji*, *L. kuroshio*, *M. kochiensis*, *N. tamiyai*, *D. okabei*
Apodemus argenteus yakui	Yakusihma	*G. saduski*, *L. kawamurai*, *L. kuroshio*, *L. miyajimai*, *L. fuji*
A. a. tanei	Tanegashima	*G. saduski*, *L. fuji*
Mus musculus orii	Tanegashima	*L. fuji*
Tokudaia osimensis	Amamioshima	*G. saduski*, *W. sawaii*, *L. kawamurai*, *L. kuroshio*, *L. kitaokai*, *L. miyajimai*, *L. p. burnsi*, *L. scutellare*, *M. kochiensis*, *E. ichikawai*, *A. noborui*, *W. amamiensis*, *D. minamii*, *D. satoiana*, *D. synoti*, *D. zentokii*
Rattus rattus	Amamioshima	*G. saduski*, *L. kawamurai*, *L. kuroshio*, *L. miyajimai*, *L. scutellare*, *M. kochiensis*, *M. okadai*, *A. noborui*, *W. amamiensis*, *D. minamii*, *D. okabei*, *D. zentokii*
Rattus norvegicus	Amamioshima	*L. kawamurai*, *L. kitaokai*, *D. synoti*,
Diplothrix legata	Amamioshima	*L. deliense*, *L. kawamurai*, *A. indica*, *W. oudemansi*
Mustela sibirica sho	Yakushima	*L. kawamurai*

and suck only fluid of inscects or their eggs at later period of nymph and adult. In another word, only larval period is the time for them to transmit the scrub-typhus. Therefore, it is quite significant to clarify the ecology of the mite in this larval period for studies on epidemiology and preventive medicine of scrub-typhus.

Table 5 shows results of the survey on seasonal appearance of larval mites collected by the direct method at south-western region of Amamioshima Island. As seen in the result, *L. kawamurai*, *Gahrliepea saduski*, *Walchia pentalagi* appeared throughout a year; *L. kuroshio*, *Cordiseta nakayamai* and *Acomatacarus yosanoi* appeared in all periods except August to November; *L. p. burnsi*, *L. scutellare*, *Miyatrombicula okadai*, *Walchiella amamiensis*, *Ascoschoengastia noborui*, *Doloisia minamii*, *D. satoiana* and *Walchia sawaii* appeared in all seasons except the summer; 6 species of genus *Neoschoengastia* found in birds appeared only in the summer. Anyhow, it was the first study on seasonal variation of trombiculid mites by a different method other than usual host-examining method. Then, it was proved that the direct method was useful and effective for a survey of trombiculid mites.

Table 6 shows results of trombiculid mites collected from various animal hosts in entire Nansei Islands. Of them, those from Amamioshima Island were 37 species of 15 genera obtained from hosts of 14 species of 7 orders. Those from which many number of parasites detected were *T. osimensis* (17 species of 8 genera), *P. furnessi* (13 species of 7 genera) and *R. rattus* (12 species of 6 genera). The result indecated that wild rodents and Amami-Rabbits were main hosts for trombiculid mites in the island. All of the mites of genus *Neoschoengastia* and genus *Toritrombicula* were found in birds, and *Babiagia ipoides* was discovered in lungs of sea snake. Among the all hosts examined, the most peculiar one was fresh water crabs, *Potamon dehaani* (Fig. 3-D) and *Sesaruma haematocheir*, in which *Eutrombicula haematocheiri* were found parasitized. The mites were discovered at a part of leg-joints of the crabs and also found in abdominal joints of only female crabs. The crabs were distributing at southern and south-western region of the island. Hitherto, there is no other report in the world about trombiculid mite parasitizing in crabs. Among trombiculid mites collected by the direct method at this island, the author had noticed that two species of *W. pentalagi* and *C. nakayamai* were collected only from soils of nest-tunnels of Amami-Rabbit (Suzuki, 1973, 1975 and 1976 b). Then, comparative studies were undertaken for the mites found on *P. furnessi*, *T. osimensis* and *R. rattus* living in Amamioshima Island (Suzuki, 1977). In the study, 10,902 individuals of trombiculid mites, 18 species of 9 genera, were obtained from 6 *P. furnessi*, 183 *T. osimensis* and 84 *R. rattus*. A 91% of the mites found from Amami-Rabbit was *W. pentalagi* and 81% of those found from wild rodents was *L. kawamurai*. Moreover, all *W. pentalagi* and *C. nakayamai* were collected only from Amami-Rabbit not any other hosts. Considering these results together with results of the direct method described previously, it seemed that the two species of *W. pentaagil* and *C. nakayamai* were trombiculid mites specificly parasitized in Amami-Rabbits.

b) Tokunoshima Island.

The mammal fauna of this island resembles to that of Amamioshima Island; such as *P. furnessi*, *T. osimensis*, *D. legata* and *C. orii*. Only record as to trombiculid mites in this island was the one surveyed by the auther in 1973. In the survey, 9 species of 7 genera were collected by the direct method (Table 3). With an exception of *D. okabei*, eight of nine species corresponded to the mites found in Amamioshima Island. The species' component of the collection also corresponded to that of Amamioshima Island, namely, *L. kawamurai* and *G. saduski* were found to be dominant.

In Tokunoshima Island, *W. pentalagi* were collected also only from soils of nest-tunnels of Amami-Rabbit. This indicated *W. pentalagi* was geographically specific to two islands of Amamioshima and Tokunoshima.

c) Okinoerabu and Yoron Islands.

These two islands are hilly coral islands where plants are simple and only a few animals are living at. Consequently, trombiculid mites reported hitherto from these islands were also a few. The author collected *Neoschoengastia pesekanyi* and *D. satoiana* in Okinoerabu Island by the direct collecting method (1972). For Yoron Island, Yaita reported only one species of *D. okabei* in 1959.

3. Ryukyu Islands (Okinawa, Ishigaki and Iriomote Islands).

Many animals living in Ryukyu Islands are quite unique and are much different from animals found in Amami Islands.

The most famous animal in this area is Iriomote wild-cat. It is said that the wild-cat, *Mayailurus iriomotensis*, is a close relative to Chile wild-cat, *Oncifelis geoffroyi*, distributing in Chile and the most premitive wild-cat in the world.

a) Okinawa Island.

Wharton and Hardcastle reported (1946) that they collected 7 species of 2 genera of trombiculid mites from 6 species of wild birds in Okinawa Island. The author had collections of 5 species of 5 genera by the direct method at northern part of the island in 1973 and 1976 (Table 4). Of the collections, *L. kawamurai* was the most dominant species. It meant the species, *L. kawamurai*, was the most dominant trombiculid mite both in Amami Islands and Okinawa Island.

b) Ishigaki and Iriomote Islands.

In Ishigaki and Iriomote Islands, Kano *et al.* reported collections of *E. wichmanni* obtained from *Japarula polygonata* (lizard) and *Cyclemys flavomarginata* (turtle), *E. ablephara* obtained from *J. polygonata* and *Toritrombicula anus* obtained from *Egretta sacra* (heron). They also examined 50 wild rodents captured at the two islands but trombiculid mites were not collected at all. The author conducted a survey by the direct method at Iriomote Island in winter of 1974, but no trombiculid mites were collected. Kano *et al.* assumed in their report that the reason of their negative results was because of the rodents were captured near houses. However, it seems that trombiculid mites found in mammals in the two islands are exceedingly few from the first, taking com-

Table 7 Geographical distribution of trombiculid mites in Nansei Islands and Main land of Japan

Trombicolulid mites \ Locality	Ryukyu Islands	Amami Gunto	Yakushima and Tanegashima	Main land of Japan
1. *Acomatacarus (O.) yosanoi*		×××××××		×××××××
2. *Whartonia (A.) iwasakii*	×××××××			
3. *Gahrliepia (G.) saduski*	×××××××	×××××××	×××××××	×××××××
4. *Walchia (W.) ogatai*			×××××××	×××××××
5. *W. (W.) pentalagi*		×××××××		
6. *W. (R.) sawaii*		×××××××		
7. *Eutrombicula (E.) ablephara*	×××××××			
8. *E. (E.) wichmanni*	×××××××			×××××××
9. *E. (S.) haematocheiri*		×××××××		
10. *E. (S.)* sp.		×××××××		
11. *Babiangia (V.) ipoides*	×××××××	×××××××		
12. *Leptotrombidium (L.) akamushi* group		×××××××		
13. *L. (L.) deliense*		×××××××		
14. *L. (L.) fuji*			×××××××	×××××××
15. *L. (L.) kawamurai*	×××××××	×××××××	×××××××	×××××××
16. *L. (L.) kitaokai*		×××××××	×××××××	×××××××
17. *L. (L.) kuroshio*		×××××××	×××××××	×××××××
18. *L. (L.) miyajimai*		×××××××	×××××××	×××××××
19. *L. (L.) pallidum burnsi*		×××××××		×××××××
20. *L. (L.) pallidum pallidum*			×××××××	×××××××
21. *L. (L.) scutellare*		×××××××		×××××××
22. *L. (T.) kansai*			×××××××	×××××××
23. *Microtrombicula (M.)* sp.	×××××××			
24. *Miyatrombicula (M.) kochiensis*		×××××××	×××××××	×××××××
25. *M. (M.) okadai*		×××××××		
26. *Neotrombicula (N.) tamiyai*			×××××××	×××××××
27. *N. (N.) mitamurai*			×××××××	×××××××
28. *Eltonella (E.) ichikawai*		×××××××		×××××××
29. *Toritrombicula (T.) anus*	×××××××			×××××××
30. *T. (T.) gygis*		×××××××	×××××××	
31. *T. (T.) hasegawai*		×××××××		×××××××
32. *Sasatrombicula (Sasatrombicula) koomori*			×××××××	×××××××
33. *Ascoschoengastia (A.) ctenacarus*		×××××××		
34. *A. (A.) indica*		×××××××		
35. *A. (A.) noborui*	×××××××	×××××××		
36. *A. (P.) monticola*	×××××××	×××××××		
37. *A. (A.)* sp.		×××××××		
38. *Schoengastia (S.) hanmyaensis*		×××××××		
39. *Walchiella (W.) amamiensis*	×××××××	×××××××		
40. *W. (W.) oudemansi*		×××××××		
41. *Doloisia (D.) minamii*		×××××××		
42. *D. (D.) satoiana*		×××××××	×××××××	
43. *D. (D.) okabei*		×××××××	×××××××	×××××××
44. *D. (D.) synoti*		×××××××		
45. *D. (D.) zentokii*		×××××××		
46. *Helenicula (H.)* sp.		×××××××		
47. *Mackiena (M.) todai*		×××××××		×××××××
48. *Cordiseta (K.) nakayamai*		×××××××		
49. *Neoschoengastia (M.) carveri*	×××××××	×××××××		×××××××
50. *N. (M.) namurui*	×××××××			
51. *N. (N.) americana solomonis*	×××××××	×××××××		×××××××
52. *N. (N.) atollensis*	×××××××			
53. *N. (N.) egretta*	×××××××			
54. *N. (N.) posekanyi*	×××××××	×××××××		×××××××
55. *N. (N.) shiraii*		×××××××		×××××××

bined results of two surveys of theirs and the author's into consideration. As the reason for that, the author believes that sufficient number of wild rodents, main host of the mites, are not living in mountains of the two islands. Besides the above two surveys, Miyazaki *et al.* collected *Whartonia iwasakii* obtained from *Hipposideros turpis* (1959), and Toshioka *et al.* collected *Babiangia ipoides* obtained from lungs three species of sea snakes (*Laticauda laticaudata*, *L. affinis*, *L. semifasciata*). Those mites were then unrecorded in Japan.

There have been no reports of scrub typhus surveyed in Ryukyu Islands hitherto except a report by Kano *et al.* on cases of eruptions by mite-bite found among children of Ishigaki Island.

Table 7 shows comparison of geographical distribution of trombiculid mites in Nansei Islands and main land of Japan. As seen in the table, 19 species of 11 genera among 48 species of 20 genera collected in south of Amamioshima Island (belongs to the oriental region) were found to be common to the mites finding in main land of Japan. Of them, mites parasitizing in birds should be out of discussion about the geographical distribution, because they distribute so wide along with migration of birds. Furthermore *E. wichmanni* and *L. p. burnsi* may also be omitted from the common species because they are found only at Izu-Seven-Islands in main land of Japan. As a result, only 10 species of 6 genera are remained common between main land of Japan and south of Amamioshima Island.

As it was mentioned previously, trombiculid fauna in Yaku and Tanegashima Islands almost corresponded to that of the main land. Therefore, it was found that trombiculid fauna in Nansei Islands were greatly varied by "Watase Line", a biological distribution boundary, linning between Yaku Island and Amamioshima Island.

Table 8 Summarized list of larval trombiculid mites collected on Nansei Islands

1. *Acomatacarus* (*Orochlorus*) *yosanoi* (Fukuzumi and Obata, 1953)
2. *Whartonia* (*Asolentria*) *iwasakii* (Miyazaki, Kamo and Kawashima, 1959)
3. *Gahrliepia* (*Gateria*) *saduski* (Womersley, 1952)
4. *Walchia* (*Walchia*) *ogatai* (Sasa and Teramura, 1952)
5. *Walchia* (*Walchia*) *pentalagi* Suzuki, 1975
6. *Walchia* (*Ripiaspichia*) *sawaii* Suzuki, 1975
7. *Eutrombicula* (*Eutrombicula*) *ablephara* (Womersley, 1952)
8. *E.* (*E.*) *wichmanni* (Oudemans, 1905)
9. *E.* (*Siseca*) *haematocheiri* Suzuki, 1976
10. *E.* (*S.*) sp.
11. *Babiangia* (*Vatacarus*) *ipoides* (Southcott, 1957)
12. *Leptotrombidium* (*Leptorombidium*) *akamushi* group
13. *L.* (*L.*) *deliense* (Walch, 1923)
14. *L.* (*L.*) *fuji* (Kuwata, Berge and Philip, 1950)

15. *L.* (*L.*) *kawamurai* (Fukizumi and Obata, 1953)
16. *L.* (*L.*) *kitaokai* (Asanuma, Suzuki and Fujikura, 1959)
17. *L.* (*L.*) *kuroshio* (Sasa and Kawashima, 1951)
18. *L.* (*L.*) *miyajimai* (Fukuzumi and Obata, 1951)
19. *L.* (*L.*) *pallidum burnsi* (Sasa, Teramura and Kano, 1950)
20. *L.* (*L.*) *pallidum pallidum* (Nagayo, Mitamura and Tamiya, 1919)
21. *L.* (*L.*) *scutellare* (Nagayo, Miyagawa, Mitamura, Tamiya and Tenjin, 1921)
22. *L.* (*Trombiculindus*) *kansai* (Jameson and Sasa, 1953)
23. *Microtrombicula* (*Microtrombicula*) sp.
24. *Miyatrombicula* (*Miyatrombicula*) *kochiensis* (Sasa, Kawashima and Egashira, 1952)
25. *M.* (*M.*) *okadai* Suzuki, 1976
26. *Neotrombicula* (*Neotrombicula*) *tamiyai* (Philip and Fuller, 1950)
27. *N.* (*N.*) *mitamurai* (Sasa, Hayshi, Kumada and Teramura, 1950)
28. *Eltonella* (*Eltonella*) *ichikawai* (Sasa, 1952)
29. *Toritrombicula* (*Toritrombicula*) *anus* (Wharton,1945)
30. *T.* (*T.*) *gygis* (Bernnan and Amerson. 1971)
31. *T.* (*T.*) *hasegawai* (Sasa, Hayashi and Kawashima, 1953)
32. *Sasatrombicula* (*Sasatrombicula*) *koomori* (Sasa and Jameson, 1954)
33. *Ascoschoengastia* (*Ascoschoengastia*) *ctenacarus* (Domrow, 1962)
34. *A.* (*A.*) *indica* (Hirst, 1915)
35. *A.* (*A.*) *noborui* Suzuki, 1976
36. *A.* (*A.*) sp.
37. *A.* (*Paraschoengastia*) *monticola* (Wharton and Hardcastle, 1946)
38. *Schoengastia* (*Schoengastia*) *hanmyaensis* Suzuki, 1976
39. *Walchiella* (*Walchiella*) *amamiensis* Suzuki, 1976
40. *W.* (*W.*) *oudemansi* (Walch, 1922)
41. *Doloisia* (*Doloisia*) *minamii* Suzuki, 1976
42. *D.* (*D.*) *okabei* (Sasa, Hayashi, Mitsutomi and Egashira, 1952)
43. *D.* (*D.*) *satoiana* Suzuki, 1976
44. *D.* (*D.*) *synoti* (Oudemans, 1910)
45. *D.* (*D.*) *zentokii* Suzuki, 1976
46. *Helenicula* (*Helenicula*) sp.
47. *Mackiena* (*Mackiena*) *todai* (Kamo, 1953)
48. *Cordiseta* (*Kayella*) *nakayamai* Suzuki, 1976
49. *Neoschoengastia* (*Megaschoengaslia*) *carveri* (Wharton and Hardcastle, 1946)
50. *N. M*(.) *namurui* (Wharton and Hardcastle, 1946)
51. *N.* (*Neoschoengastia*) *americana solomonis* (Wharton and Hardcastle, 1946)
52. *N.* (*N.*) *atollensis* (Wharton and Hardcastle, 1946)
53. *N.* (*N.*) *egretta* (Wharton and Hardcastle, 1946)
54. *N.* (*N.*) *posekanyi* (Whartonand Hardcastle, 1946)
55. *N.* (*N.*) *shiraii* (Sasa and Sato, 1953)

The direct method employed in the surveys reporting here was a quite effectable collecting method that could apply for surveys of a short period or for difficult cases of capturing animal hosts. By employing this direct method, unengorged larval trombiculid mites of 32 species of 16 genera were collected in entire Nansei Islands; namely, 11 species of 6 genera at Yaku and Tanegashima Islands, 24 species of 15 genera at Amami Islands and 5 species of 5 genera at Ryukyu Islands.

In islands south of Amamioshima Island, wild rodents, main hosts for trombiculid mites, were found to be much fewer both in numbers and species variation comparing with those found in main land of Japan. In addition, it is difficult to capture particular wild rodents such as *D. legata* living on top of trees in Islands of Amamioshima, Tokunoshima and Okinawa. In case of Amami−Rabbit, designated as a special natural monument, it is more difficult even to obtain a permission of the capture. In such a difficult case, the direct method was proved as a simple and effective method of collecting trombiculid mited just by collecting soil samples at entrance of nest tunnel of the host.

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南西諸島の恙虫相とその特徴

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南西諸島（種子島，屋久島，奄美大島，徳之島，与論島，沖縄，石垣島，西表島）の恙虫相を調査し，その特徴について検討した．特に恙虫病の vector となり得る恙虫種の存在と，採集方法として，各種の動物の巣坑道から土壌を採取し，Tullgren 装置で未吸着幼虫を直接採集する“直接採集法”による調査を行った．得られた結果と過去の報告を加えると南西諸島で記録された恙虫は，21属55種であった（Table 8）．この内，日本未記録属2種，新種11種，新記録種6種，南西諸島での新記録種は35種で，これまで未知の部分が多かった南西諸島の恙虫の様相が，本調査により可成り明確なものになった．旧北区の南端に位置する種子島，屋久島の恙虫は，*Doloisia satoiana* を除くすべてが九州本土産に一致するが，東洋区の北端，奄美大島産では7種が一致する他は，共通種が見出されない．また，奄美大島以南で採集された恙虫48種のうち日本本土産との共通種は10種だけであった．この事実は，トカラ海峡に引かれた生物分布境界線ワタセ線が他の動・植物に見られるように，恙虫相にも認められると考えられた．恙虫病の vector として既に我が国で確認されている恙虫のうち，南西諸島では，種子島の *Leptotrombidium pallidum pallidum* 奄美大島の *L. deliense*, *L. scutellare* の3種が確認された．更に vector の可能性が考えられる種として，屋久島，奄美大島，徳之島，沖縄本島の *L. kawamurai* 奄美大島の *L. akamushi* 近似種，*L. p. burnsi* の存在が分った．今回の調査に用いた直接採集法で32種の恙虫が採集され本法が従来行なわれている宿主採集法を充分補足出来るものと考えられた．宿主採集法によりアマミノクロウサギには *Walchia pentalagi*, *Cordiseta nakayamai*, 淡水産のカニに *Eutrombicula haematocheiri* の宿主特異寄生恙虫が寄生していることが分った．

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