Tetranychid Mites of Okinawa Island (Acari: Tetranychidae)

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ABSTRACT

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This study was undertaken to elucidate: 1) the spider mite fauna of Okinawa Island and the occurrence of *Tetranychus okinawanus*, a newly described species from the Ryukyu Islands, 2) whether populations of *T. kanzawai* from the Island are one of two previously described strains, the kerria strain or the kerria-avoiding strain, and 3) whether populations of *T. pueraricola* from Okinawa and Honshu are conspecific. Six species of tetranychid mites (*T. urticae* (green form), *T. okinawanus*, *T. piercei*, *T. pueraricola*, *T. kanzawai* and *Oligonychus biharensis*) were collected from 13 different plants. *T. okinawanus* was not found on agricultural crops in the present survey, but was abundant on weeds. Crossing experiments revealed that all seven populations of *T. kanzawai* collected from seven plant species were the kerria strain. There was a strong reproductive incompatibility between the Nago and Hitachi-Ohta (Ibaraki Pref.) populations of *T. pueraricola*, but the mechanism responsible for the incompatibility was unknown.

Key words: Okinawa, Tetranychidae, *Tetranychus kanzawai*, *Tetranychus urticae*, reproductive compatibility, mite fauna

INTRODUCTION

Little information has been published on the spider mites of the Ryukyu (Okinawa) Islands, except for systematic reports (Ehara, 1966, 1995). As the Islands are in the sub-tropical region, the ecological features of the mites, especially their diapause characteristics, may differ from those in temperate regions. In August 1995, we collected spider mites from various plants on Okinawa Island, the main island of the group, to study the mite fauna including *Tetranychus okinawanus* Ehara, a species newly described by Ehara (1995).

Among the tetranychid mites we collected, we paid special attention to *T. kanzawai* Kishida, because a recent study (Gomi and Gotoh, 1996) revealed that it includes two different strains. One is a kerria strain that develops on the kerria plant, *Kerria japonica* (L.), and consists of populations that occur on tea, pear and hydrangea. The other is a

kerria-avoiding strain that does not mature on kerria, consisting of populations that occur on kudzu vine, *Pueraria lobata* (Willd.). Unidirectional reproductive incompatibility has been observed between these two strains (Gomi and Gotoh, 1996): a cross between females of the kerria strain and males of the kerria-avoiding strain gives a normal female-biased sex ratio, whereas the reciprocal cross produces no females, probably due to the failure in unidirectional fertilization. Crossing experiments, therefore, were conducted to clarify whether the populations collected from the Island are the kerria strain or the kerria-avoiding strain.

We also paid special attention to *Tetranychus pueraricola* Ehara et Gotoh, which was collected from kudzu vine in Honshu Japan, and which was described as a new species by Ehara and Gotoh (1996). This species closely resembles *T. urticae* Koch, and differs only in the size of the aedeagal knob. The width of the terminal knob is $2.1\mu\text{m}$ for *T. pueraricola* and $2.5\text{--}2.6\mu\text{m}$ for *T. urticae* (Ehara and Gotoh, 1996). As the morphological difference between the two species is thus extremely small, crossing experiments between the Honshu and the Okinawa populations were conducted to confirm species identification based on this single morphological character.

MATERIALS AND METHODS

Collection. Mites were sampled from 13 species of plants at 16 sites on Okinawa Island (Table 1), and they were put into vinyl bags and kept in an ice-cooled cooler.

Identification. From each mite sample, 50 to 200 adult females were chosen and individually transferred onto a leaf disc (ca. 4cm^2) of the kidney bean (*Phaseolus vulgaris* L.) placed on a water-saturated polyurethane mat in a petri dish (9 cm diam) at $25\pm 1^\circ\text{C}$: 16 L–8 D. If mites failed to lay eggs, they were preserved in 70% ethanol and later mounted in Hoyer's medium. If the females successfully oviposited, they were individually allowed to lay eggs for 5 days, and then mounted in Hoyer's medium. Males obtained were also mounted in Hoyer's medium. Identification was made under a phase-contrast microscope, only if both sexes were obtained as adults.

Discrimination of *T. kanzawai* strains. To elucidate whether the populations of *T. kanzawai* collected belong to the kerria strain or the kerria-avoiding strain, females and males from the seven populations collected were respectively crossed with males of the kerria strain collected from tea in Kanaya, Shizuoka, and females of the kerria-avoiding strain collected from kudzu vine in Ami, Ibaraki. Females in the teleiochrysalis stage were picked from each stock culture and individually transferred onto a leaf disc (ca. 4cm^2), together with a male adult chosen from each of the other populations. The male was removed 2 days after the females matured. Each female was then allowed to lay eggs for 5 days and then removed. The offspring were checked daily until adulthood to score egg hatchability, survival of the immature stages, and sex ratio. If female progeny were obtained from the cross between females of the tested population and males of the kerria strain, but not from the cross between females of the kerria-avoiding strain and males of the tested population, then the tested population was judged to belong to the kerria strain (Gomi and Gotoh, 1996).

Crosses between the two local populations of T. pueraricola. In order to study reproductive compatibility between the Okinawa and the Honshu populations of *T. pueraricola*, crosses between the Nago and the Hitachi-Ohta (Ibaraki) populations were carried out, as described above, to elucidate whether female offspring were produced.

RESULTS AND DISCUSSION

Six species were identified from the present study (Table 1), viz., *T. urticae* (green form), *T. okinawanus*, *T. piercei* McGregor, *T. pueraricola*, *T. kanzawai* and *Oligonychus biharensis* (Hirst). In addition, mites of the genus *Oligonychus* were collected from *Prunus campanulata* Maxim., *Erythrina lysistema* Hutchinson and *Pueraria montana* (Lour.), but we failed to identify them due to an insufficient number of specimens. Of six species, *T. pueraricola* was newly identified (Ehara and Gotoh, 1996). The green form of *T. urticae* was found only in greenhouses, but it occurred at high densities.

Tetranychus okinawanus did not seem to be as widely distributed on agricultural crops (Table 1). This was probably because the mites are highly susceptible to

Table 1. Mite species collected from various plants in Okinawa in 1995

Locality	Plant	Mite species	Date
Nakijin-A	Watermelon (greenhouse)	<i>Tetranychus urticae</i> (green form)	2 Aug.
Nakijin-B	Watermelon (greenhouse)	<i>T. urticae</i> (green form)	2 Aug.
Nakijin-C	Papaya	<i>T. kanzawai</i> (kerria strain) ¹	2 Aug.
Nakijin-D	<i>Boehmeria nivea</i> f. <i>viridula</i>	<i>T. kanzawai</i> (kerria strain)	2 Aug.
	<i>Dracaena fragrans</i>	<i>T. kanzawai</i> (kerria strain)	
Nakijin-E	<i>Erythrina lysistema</i>	<i>Oligonychus</i> sp.	2 Aug.
Nago-A	<i>Bidens pilosa</i> var. <i>minor</i>	<i>Tetranychus okinawanus</i>	2 Aug.
	<i>Sonchus</i> sp.	<i>T. okinawanus</i>	
	<i>Pueraria montana</i>	<i>T. okinawanus</i>	
Nago-B	<i>P. montana</i>	<i>Tetranychus piercei</i>	2 Aug.
		<i>Tetranychus pueraricola</i>	
		<i>Oligonychus biharensis</i>	
Nago-C	<i>Prunus campanulata</i>	<i>Oligonychus</i> sp.	2 Aug.
	<i>Prunus persica</i>	<i>Tetranychus kanzawai</i> (kerria strain)	
Naha	<i>P. montana</i>	<i>T. piercei</i>	2 Aug.
Kochinda	Cucumber (greenhouse)	<i>T. urticae</i> (green form)	3 Aug.
Itoman	Cucumber (greenhouse)	<i>T. urticae</i> (green form)	3 Aug.
Haebaru-A	Cucumber (greenhouse)	<i>T. urticae</i> (green form)	3 Aug.
Haebaru-B	<i>Vigna catieng</i> var. <i>sinensis</i>	<i>T. kanzawai</i> (kerria strain)	3 Aug.
Chinen	<i>Diplocyclos palmatus</i>	<i>T. kanzawai</i> (kerria strain)	3 Aug.
Itoman	<i>P. montana</i>	<i>T. okinawanus</i>	3 Aug.
		<i>Oligonychus</i> sp.	
		<i>T. kanzawai</i> (kerria strain)	
Tamagusuku	<i>P. montana</i>	<i>T. piercei</i>	3 Aug.

¹ This population is compatible with the tea population (kerria strain) collected from Kanaya, Shizuoka, but shows a unidirectional incompatibility when crossed with the kudzu population (kerria-avoiding strain) from Ami, Ibaraki (see Table 2).

acaricides (Goka, unpublished). This species was known to occur on *P. montana*, *Solanum nigrum* L., *P. vulgaris* and sweet potato (Ehara, 1995). Two new host plants (white spanish needle, *Bidens pilosa* var. *minor* (Bl.) and wild poppy, *Sonchus* sp.) were found in this study. Mites were abundant on both plants.

The Kanzawa spider mite, *T. kanzawai*, was common over the Island, and observed on 7 out of the 13 plant species we examined (Table 1). All seven of the populations

Table 2. Crosses between seven mite populations collected from various plants in Okinawa Island and males of the tea population (kerria strain) in Kanaya, Shizuoka or females of the kudzu population (kerria-avoiding strain) in Ami, Ibaraki, of *T. kanzawai*

Cross			N	No. of eggs/ female ¹	Hatchability (%) ¹	Survival rate (%) in immatures ¹	Sex ratio (%) (F/(F+M)) ¹
F	×	M					
Papaya		Tea	15	43.4±2.41	95.3±0.93	96.1±0.69	54.6±3.15
Kudzu		Papaya	15	39.0±2.99	96.9±0.61	97.8±0.55	0
Bn ²		Tea	15	26.2±2.26	81.3±2.93	97.3±0.92	76.8±1.45
Kudzu		Bn	17	25.2±1.31	97.3±0.70	98.2±0.65	0
Df ²		Tea	18	33.1±1.78	78.4±1.98	97.2±1.04	79.9±2.16
Kudzu		Df	18	39.4±1.77	98.0±0.42	98.8±0.37	0
Pp ²		Tea	18	27.1±0.80	74.1±2.56	99.5±0.32	64.6±1.49
Kudzu		Pp	14	29.5±1.29	98.0±0.82	99.0±0.40	0
Vc ²		Tea	14	25.7±1.05	73.8±2.57	99.4±0.41	73.9±1.63
Kudzu		Vc	16	31.1±1.46	95.9±0.94	96.8±0.72	0
Dp ²		Tea	17	22.8±1.67	80.7±3.43	98.1±0.92	62.5±2.82
Kudzu		Dp	18	25.7±1.08	95.6±0.51	98.1±0.73	0
Pm ²		Tea	17	46.0±2.14	81.2±2.36	98.7±0.47	76.3±1.61
Kudzu		Pm	17	36.5±1.41	97.2±0.62	97.8±0.58	0

¹ Mean±S. E.

² Bn: *Boehmeria nivea*; Df: *Dracaena fragrans*; Pp: *Prunus persica*; Vc: *Vigna catiang*; Dp: *Diplocyclos palmatus*; Pm: *Pueraria montana*.

Table 3. Crosses between *T. pueraricola* populations from Nago, Okinawa, and Hitachi-Ohta (Ohta), Ibaraki

Cross			N	No. of eggs/ female ¹	Hatchability (%) ¹	Survival rate (%) in immatures ¹	Sex ratio (%) (F/(F+M)) ¹
F	×	M					
Ohta		Ohta ²	19	37.5±1.25 ^b	98.0±0.44 ^a	97.5±0.54 ^a	75.6±0.68 ^{bc}
Nago		Nago	45	45.8±1.20 ^a	98.1±0.34 ^a	97.5±0.44 ^a	86.9±0.54 ^{ab}
Ohta		Nago	25	49.6±1.84 ^a	86.2±3.58 ^b	95.4±0.99 ^{ab}	71.9±2.28 ^c
Nago		Ohta	27	47.2±1.85 ^a	51.6±4.29 ^c	92.2±1.55 ^{ab}	69.6±3.53 ^c
(O×N)		Ohta	16	43.1±2.84 ^{ab}	58.6±6.34 ^c	85.7±2.36 ^{bc}	93.6±1.44 ^a
(O×N)		Nago	15	43.1±1.73 ^{ab}	5.1±0.70 ^d	73.9±8.86 ^c	53.9±10.16 ^c
(N×O)		Ohta	12	0.8±0.46 ^c	0		
(N×O)		Nago	15	0			

¹ Mean±S. E. in a column followed by different letters are significantly different ($p<0.05$; Tukey-HSD test). Arcsin-transformed values are used for analyzing the percentages of hatchability, survival rate and sex ratio.

² Data of this cross is from Gotoh and Tokioka (1996).

collected were compatible with males of the kerria strain, but were incompatible with females of the kerria-avoiding strain (Table 2). This result revealed that all the populations are of the kerria strain.

Table 3 shows the results of crosses between the Nago and the Ohta populations of *T. pueraricola*. In each intrapopulation cross, egg hatchability was higher than 98.0%, and the proportion of females was higher than 75.6%. The survival rates throughout the juvenile stages were high in both intracrosses.

Reciprocal crosses between the Ohta and the Nago population resulted in a significant decrease in hatchability (Table 3). Drastic reductions in both hatchability and sex ratio were observed if F1 females from the cross between Ohta females and Nago males were backcrossed to Nago males. Almost no eggs were produced if F1 females from the reciprocal cross were backcrossed to males of either of their parents.

The results of the above experiments indicate that there is a strong reproductive incompatibility between the Ohta and Nago populations. The mechanism responsible for the incompatibility is unknown, and we need future study for confirming whether they are conspecific.

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摘 要

沖縄本島で採集したハダニ類 後藤哲雄（茨城大）・高藤晃雄（京都大）・五味 康（茨城大）

沖縄県のハダニ相に関する知見は乏しい。筆者らは、ナンゴクハダニが琉球列島から新種記載された機会に、この種を含むハダニ類の分布調査を1995年8月に沖縄本島で行った。13種の植物から6種のハダニを採集した。すなわち、ナミハダニ（黄緑型）、ナンゴクハダニ、ミヤラハダニ、ナミハダニモドキ、カンザワハダニ、そしてシュレイハダニである。このうち、ナミハダニはビニール温室のみから、ナンゴクハダニは自然生態系の植物のみから採集された。一方向不和合性の知られているカンザワハダニは7個体群を得たが、いずれも本州のチャ個体群の雄と和合し、クズ個体群の雌と和合しないヤマブキ (kerria) 系統であった。本研究ではさらに、ナミハダニモドキが沖縄にも分布するが、本州の個体群との間には著しい生殖不和合性のあることを明らかにした。本研究は、沖縄のダニ相を検討する端緒になると期待される。

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