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Localized Distribution of an Alien Termite *Reticulitermes kanmonensis* (Isoptera: Rhinotermitidae)

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Abstract. The distributional range of *Reticulitermes kanmonensis*, a termite species so far recorded only in and around Shimonoseki, Japan, was investigated. On the Honshu side of the Kanmon Strait where Shimonoseki is located, *R. kanmonensis* has a wider distributional range than has been thought; colonies were found not only in areas along the coast, but also in inland areas including forests with natural vegetation. In Kyushu the termite was found only in and around the Kiku Peninsula. The distributional patterns of *R. kanmonensis* and related species and the historical background of the distributional area strongly suggest the artificial introduction of this species into Shimonoseki.

Key words: termite, artificial introduction, symbiotic protist.

Introduction

The subterranean termite genus *Reticulitermes*, consisting of about 125 species, is the most common termite group in palearctic and nearctic regions (Harris, 1970; Weesner, 1970). The following seven *Reticulitermes* species are known from the Japan Archipelago: *R. speratus* (Kolbe) is distributed in southern part of Hokkaido, and the remaining three major islands (Honshu, Shikoku, Kyushu) and outlying islands including Yakushima Is. and Tanegashima Is. as well as a distant oceanic island, Chichijima Is. of the Bonin Islands; *R. kanmonensis* Takematsu is restricted to the coastal areas on both of Honshu and Kyushu sides of the Kanmon Strait (Nawa, 1911, 1912a, b, 1917; Kitade & Matsumoto, 1993; Takematsu, 1999; Morimoto, 2000); in the Ryukyu Archipelago (southern islands of the Japan Archipelago), *R. miyakakei* Morimoto has been recorded from Amamioshima Is., Tokunoshima Is. and northern part of Okinawa-Honto Is.; *R. amamianus* Morimoto from Amamioshima Is., Tokunoshima Is. and Yoron Is.; *R. okinawanus* Morimoto from Okinawa-Honto Is. including its outlying small islands and Miyako Is., *R. yaeyamanus* Morimoto from Ishigaki Is., Iriomote Is., Okinawa-Honto Is. and Noho Is.; and *R. flaviceps* (Oshima) from Ishigaki Is., Iriomote Is. and Yonaguni Is. (Takematsu, 1999; Yasuda *et al.*, 2000).

The distribution pattern of termites occurring in the Japan Archipelago can be interpreted in terms of the paleogeographical barriers and the yearly minimum temperature regime (Morimoto, 1975). An exception is *Reticulitermes kanmonensis*, whose distribution pattern has often been interpreted in terms of the artificial introduction to the Kanmon area where a traditional international port, Shimonoseki lies (Kitade & Matsumoto, 1993; Takematsu, 1999; Morimoto, 2000). This species was recently described by Takematsu (1999) and Morimoto (2000) summarized the morphology, localities, ecology and research history of this species. Its occurrence in the Kanmon area, on the other hand, was firstly reported by Nawa (1911) who identified the species as *R. flaviceps* and noted that this species was ecologically distinguished from the sympatrically occurring *R. speratus* in having seasonally earlier alate emergence and nuptual flight than *R. speratus* (see Ito, 1994a, b). To date, however, details of the distributional range of *R. kanmonensis* have not been investigated, which prevents us from making further arguments on the artificial introduction assumption.

Kitade & Matsumoto (1993) investigated symbiotic protist fauna in the digestive tracts of workers from four colonies of *R. kanmonensis* and recognized a distinctly different protist fauna from that of the sympatrically occurring species, *R. speratus*.

In this study we investigated colonies of *R. kanmonensis* and *R. speratus* in western part of Yamaguchi Prefecture (Honshu) and in northern part of Fukuoka Prefecture (Kyushu) to (1) clarify the distributional

range of *R. kanmonensis*, (2) examine whether the difference in symbiont fauna between *R. kanmonensis* and *R. speratus* is consistent throughout their sympatrically occurring areas, and (3) discuss the distributional origin of *R. kanmonensis*.

Materials and Methods

Collection of Reticulitermes *colonies*

Reticulitermes colonies were collected in 43 and 10 sampling localities in the western Yamaguchi Prefecture and the northern part of Fukuoka Prefecture, respectively. In each sampling locality, fractions of one to five termite colonies were collected with their nest logs. Some soldiers in each colony were immediately fixed in 70% ethanol for later observation of morphology, and the remaining termite samples were kept by colony in 4.8× 6.0×2.4 cm plastic boxes until inspection of symbiotic protists. Plant species of nest logs were also recorded if they were identifiable.

Identification and morphological observation of soldiers

Termite species were identified on soldiers according to Takematsu (1999). The number of setae on the pronotal disc, one of the characters showing explicit differences between *R. speratus* and *R. kanmonensis*, was counted for one to three soldiers per colony.

Observation of symbiotic protist composition

Two workers per colony were examined within 15 days after collection to identify the types of the symbiotic protist composition by the following procedure. The hindgut of a worker was dissected out and directly placed on a glass slide, and then dissected in a drop of 0.4% NaCl. The whole contents of the hindgut including living flagellates was observed under a Nomarski differential interference microscope (Olympus BX-50 system) to examine presence/absence of the following three protist species: *Spirotrichonympha* (*Spironympha*) *porteri* (Hypermastigida) is the symbiont specific to *R. kanmonensis*; and *Pyrsonympha* (*Dinenympha*) *rugosa* and *P.* (*D.*) *parva* (Oxymonadida) are specific to *R. speratus* (Kitade & Matsumoto, 1993).

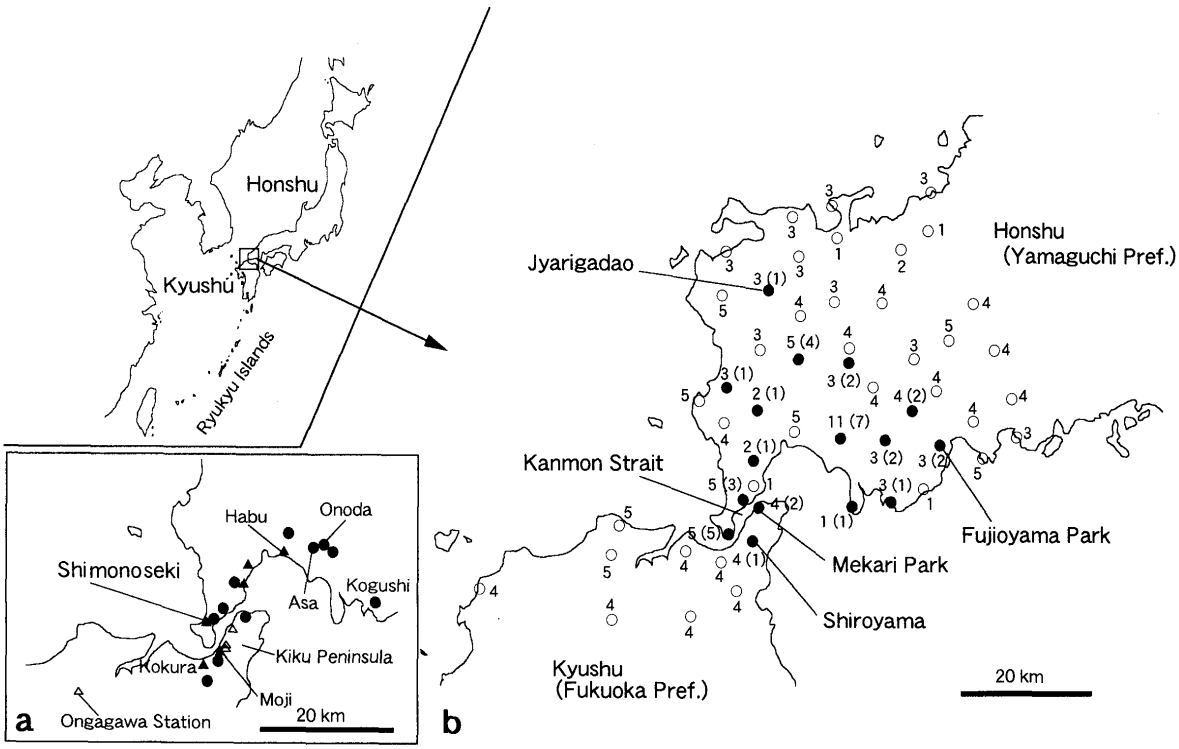

Fig. 1. Maps showing occurrences of *Reticulitermes* termites. a. Previously recorded localities of *R. kanmonensis*. Solid circles: localities reported by Kitade & Matsumoto (1993), Takematsu (1999, personal communication) and Morimoto, (2000); solid triangles: localities of "*Reticulitermes* with early emerging alates" (=*R. kanmonensis*) confirmed by Nawa (1911, 1912a); open triangles: localities where early emergence of alates was reported without direct observation (Nawa, 1912a, b). b. Sampling localities of *Reticulitermes* colonies in this study. Solid circles and open circles indicate the sampling localities where *R. kanmonensis* colonies were or were not collected, respectively. The number of *Reticulitermes* colonies collected in each sampling locality is shown, together with that of *R. kanmonensis* colonies in parentheses.

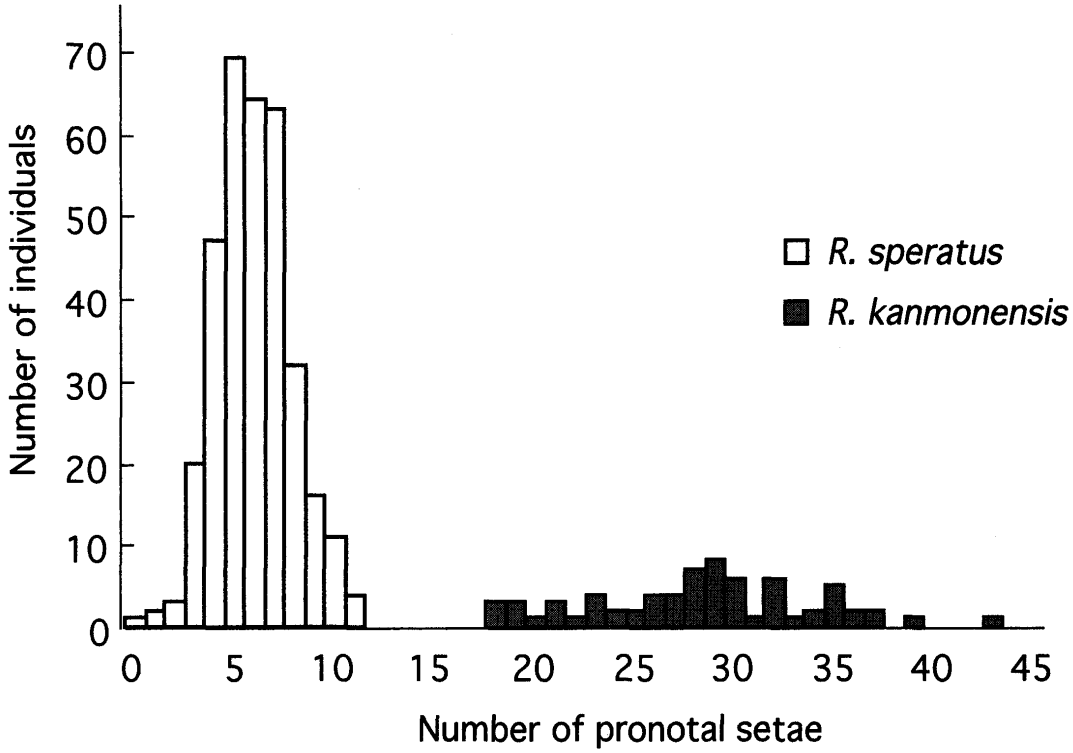

Fig. 2. Number of pronotal setae in *R. speratus* and *R. kanmonensis* soldiers.

Results

Distribution of the two species

We collected a total of 145 *Reticulitermes* colonies from 43 sampling localities in western part of Yamaguchi Prefecture and 42 colonies from 10 localities in northern part of Fukuoka Prefecture (Fig. 1). About 58 % of the total colonies were obtained from rotten logs of pine trees (*Pinus densiflora* and *P. thunbergii*), which are the most dominant trees in the study areas. Of the 187 *Reticulitermes* colonies collected, 36 belonged to *R. kanmonensis*. From 16 sampling sites where *R. kanmonensis* colonies were collected, both *R. kanmonensis* and *R. speratus* colonies (25 in total) were collected at 14 sites: at the remaining two sites only *R. kanmonensis* colonies were found. New localities of *R. kanmonensis* recognized in this study are: Yamaguchi City (Fujioyama; Sayama); Ube City (Tokiwa Park; Mt. Shimofuridake; Fujigochi); Onoda City (Mt. Ryuoh-Zan); Mine City (Nakamura, Omine); Otsu District (Jyarigadao, Yuya); Toyoura District (Era, Toyoura; Shichimi, Kikugawa; Ichinose, Toyota); Shimonoseki City (Hinoyama Park; Mukaichou, Hikoshima); Kitakyushu City (Shiroyama, Dairi, Moji).

On the Honshu side of the Kanmon Strait, *R. kanmonensis* colonies were only found in the southwestern part of Yamaguchi Prefecture, extending eastward to Fujioyama Park in Yamaguchi City, and northward up to Jyarigadao in Toyota District (Fig. 1). On the Kyushu side, three colonies of *R. kanmonensis* were located only in Kiku Peninsula (Mekari Park and Shiroyama).

Table 1. Number of termite colonies harboring each symbiont species.

Symbiotic protist species	Host termite species	
	R. speratus	*R. kanmonensis*
Pyrsonympha (Dinenympha) rugosa	157	0
P. (D.) parva	157	0
Spirotrichonympha (Spironympha) porteri	0	36

Morphology and symbiont compositions

While the numbers of the pronotal setae varied greatly within each species, ranging 0–11 in *R. speratus* and 18–43 in *R. kanmonensis*, there was a distinct gap between the two species (Fig. 2).

All workers from the 157 *R. speratus* colonies possessed both *Pyrsonympha rugosa* and *P. parva,* and none of them had *Spirotrichonympha porteri.* All workers from the 36 *R. kanmonensis* colonies had only *S. porteri* of the three symbiotic protist species examined (Table 1).

Discussion

The present study showed that *R. kanmonensis* has, on the Honshu side of the Kanmon Strait, a wider distributional range than has been recognized (Fig. 1); that is, colonies were found not only in coastal areas, but also inland, including forests with natural vegetation. In Kyushu, on the other hand, *R. kanmonensis* colonies have been found only in and around the Kiku Peninsula (also Morimoto, 2000; Takematsu, personal communication), although Nawa (1912a) reported, without direct observation, early alate emergence in Ongagawa Station (Fig. 1).

Three mutually exclusive hypotheses could explain such a localized distribution of *R. kanmonensis*. The first is the sympatric or parapatric speciation. However, the clear difference in symbiotic protist faunae between *R. kanmonensis* and *R. speratus* contradicts this hypothesis, as the symbiotic protist faunae in termites generally reflect the relationships among host termite species (Kirby, 1937; Honigberg, 1970). Kitade & Matsumoto (1993) showed that the symbiont composition of *R. kanmonensis* was more similar to those of *Reticulitermes* species in the Ryukyu Islands rather than that of *R. speratus*.

The second possibility is the invasion of *R. kanmonensis* from the Korean Peninsula through a landbridge that had connected the Korean Peninsula and the Japan Archipelago until ca.150,000 years ago (Oshima, 1990). This, however, is also very unlikely; since no *R. kanmonensis* colony was found in northern coastal areas of either Kyushu or Yamaguchi Prefecture, nearest areas to the Korean Peninsula, and since this species has not been reported from the Korean Peninsula.

The last and the most probable explanation is an artificial introduction of *R. kanmonensis* into this area. The distributional area of *R. kanmonensis* includes Shimonoseki, which was the base of international trading between Japan and China during the period from 15th century to early 18th century (History of Shimonoseki City Editorial Committee, 1973; Yamaguchi Prefecture, 1991), with products forwarded from southern China, Taiwan and South-East Asia as major imports (Ren, 1988). In addition to the historical background of this area, the fact that mitochondrial gene (COII) sequence data of *R. kanmonensis* (Kitade, unpublished) shows high similarity with those of *Reticulitermes* species in Hong Kong and Guangzhou (southern China) strongly suggest that *R. kanmonensis* was artificially introduced from southern China a few hundreds years ago. An intensive survey on *Reticulitermes* fauna in southern China could shed light on the origin of *R. kanmonensis* in Japan.

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