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Rapid Communication

First record of the web spinner *Haploembia solieri* (Rambur, 1842) (Embioptera: Oligotomidae) in Japan

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Abstract

The impact of biological invasions is unpredictable, and hence it is important to provide information at the earliest stage of invasion. This is the first report of the web spinner *Haploembia solieri* (Rambur, 1842) (Insecta: Embioptera) in Japan. We found this species in the Port of Kobe, on an artificial island in Hyogo Prefecture. The locality is clearly distant from its known distribution; *H. solieri* is native in the Mediterranean region and introduced into the United States. In our surveys, 90 individuals were collected, but no males. This is also the first report of *H. solieri* in East Asia. Because we observed the *H. solieri* population in the fall of 2016 and early summer of 2017, this species may have been able to overwinter in Japan.

Key words: biological invasion, Embioptera, *Haploembia*, Japan, asexual population

Introduction

The accidental spread of species across their natural dispersal barriers is often promoted by human activities, such as agriculture, aquaculture, and transportation (Walther et al. 2009; Hulme 2009). Anthropogenic transport allows the establishment of populations in regions distant from the original habitat of species with poor mobility. Such introduced species sometimes have serious economic and ecological impacts (Walther et al. 2009; Hulme 2009). However, predicting invasiveness is difficult (Kolar and Lodge 2001), and it is important to accumulate case reports.

Embiopterans (web spinners) are tropical insects that use silk to build shelter nests of interconnected tunnels called galleries and feed on bark and fallen leaves (Ross 1970; Miller et al. 2012). The females are wingless, while males are often winged and have low migration ability (Ross 1940). Embiopterans have been introduced into non-native regions (Ross 2000; Lee et al. 2002; Hodson et al. 2014; Murányi and Kovács 2014). For example, Saunders' embiid [*Oligotoma saundersii* (Westwood, 1837)], a cosmopolitan species, was found in a greenhouse in Seoul, Korea (Lee et al. 2002), while *Aposthonia ceylonica* (Enderlein, 1912), which is distributed to India, Laos, Madagascar, Malaya, Mauritius, Sri Lanka and Thailand, was observed in a greenhouse in Hyogo, Japan (Ichikawa 2016). In these cases, the movement of shipping containers and plant pots may facilitate the expansion of their distributions.

The genus *Haploembia* Verhoeff, 1904 is native to the Mediterranean, and both females and males show high degrees of neoteny (Ross 1966), which means that they lack typical identification traits. Nevertheless, we can easily distinguish *Haploembia* from related genera by the possession of two basitarsal papillae on their hind legs, regardless of the developmental stage (Ross 1940). To date, the genus *Haploembia* consists of ten species, while Ross (1999)

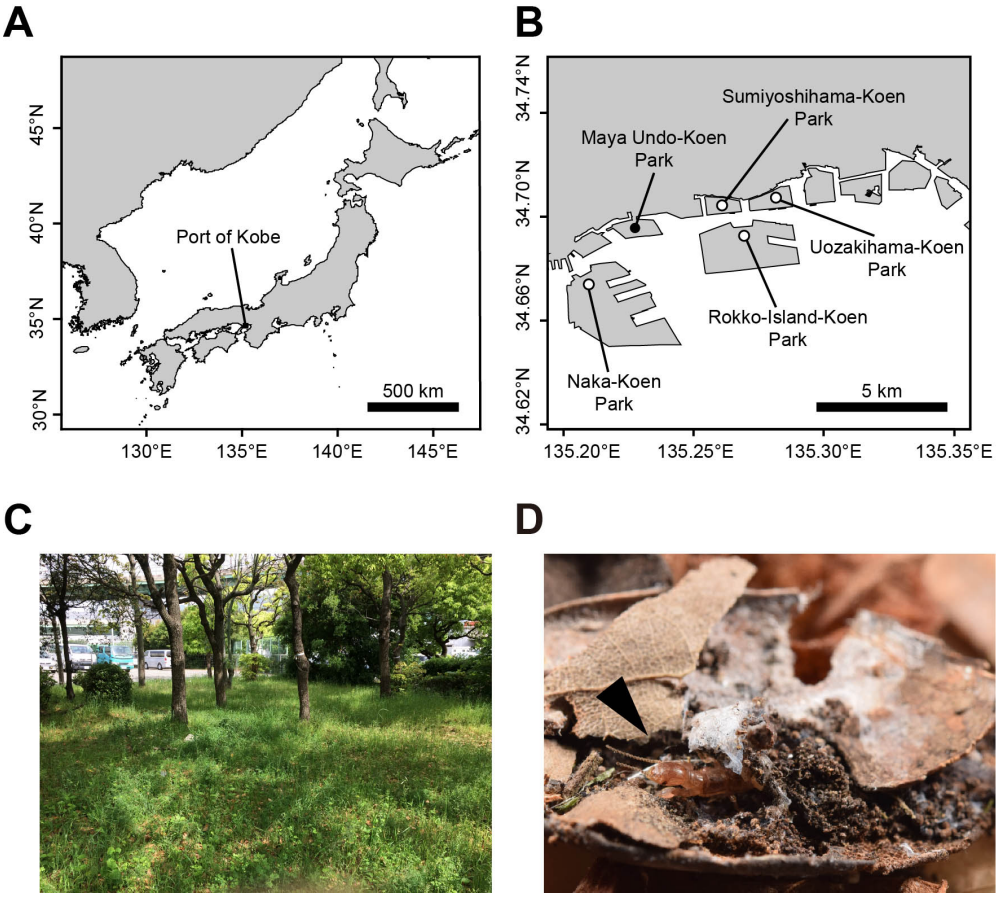

Figure 1. Collection sites and habitat of *H. solieri* in the Port of Kobe, Hyogo, Japan. **A**, **B:** A map of the collection sites. Filled and open circles indicate the presence and absence of *H. solieri*, respectively. The map was drawn using the library maptools in the software R (version 3.1.0; http://cran.r-project.org/) with the data provided by National Land Numerical Information, Ministry of Land, Infrastructure, Transport and Tourism (http://nlftp.mlit.go.jp/ksj-e/gml/datalist/KsjTmplt-C23.html), and by Natural Earth (http://www.naturalearthdata.com/). **C**, **D:** Habitat and microhabitat of *H. solieri*. Arrowhead indicates a late instar larva of *H. solieri*. Photographs by T. Nozaki (C) and W. Suehiro (D).

supported that most of them should be transferred to other genera. According to this suggestion, the genus comprises of only two species, *H. solieri* and *H. palaui*. The distribution of these two species may overlap, but it has been known that *H. palaui* can be readily separated by its larger body size and more uniformly dark coloration than *H. solieri* Ross (1966). One species, *H. solieri*, has been regarded as a widespread species in the Mediterranean region, and introduced into several states in the USA (Hodson et al. 2014). In this study, we found a population of web spinners on an artificial island in Hyogo Prefecture, Japan and identified them as the Mediterranean web spinner, *H. solieri* (Rambur, 1842), based on the morphology of their hind legs, color patterns of their body, the shape of head and their adult body size. This paper presents a new record of the Mediterranean web spinner, *H. solieri* in Japan.

Material and methods

Fifteen individuals of Embioptera were observed at Maya Undo-Koen Park (34º41′49.5″N; 135º13′42.7″E), Maya Port, Kobe, Hyogo Prefecture, Japan on October 30, 2016. Subsequently, we conducted a second survey in five public gardens in the Port of Kobe, including Maya Undo-Koen Park in Maya Port, Naka-Koen Park (34º40′24.3″N; 135º12′29.1″E) on Port Island, Rokko-Island-Koen Park (34º41′34.9″N; 135º15′59.6″E) on Rokko Island, Sumiyosihama-Koen Park (34º42′22.6″N; 135º15′41.5″E), and Uozakihama-Koen Park (34º42′23N; 135º16′54E) (Figure 1A, B) on May 7, 2017. Hyogo prefecture is in a temperate zone and our sampling sites are located in urban areas on artificial islands. When shelter tunnels (galleries) were observed on bark or fallen leaves, we carefully dissected the tunnels and collected individuals

Figure 2. Morphological characteristics of the collected embiopterans. **A:** The entire body. **B:** Color pattern of the head and prothorax. **C:** There are two medial-ventral papillae on the hind basitarsi (white arrowheads). Photographs by T. Nozaki.

using fine tweezers. The individuals were kept alive in glass vials and transported to the laboratory, where they were stored at –25 °C until morphological observations were made. The sexual characters of the abdomen (highly asymmetrical male genitalia; Ross 1940; Ross 1966), basitarsal papillae of the hind legs, body color pattern, the shape of head and body length were examined using a stereomicroscope with a digital camera (Olympus SZX7 with FX380-3CCD, Olympus). The gonads were dissected in phosphate-buffered saline as needed. All specimens were stored in 99.5% ethanol and deposited in the Osaka Museum of Natural History, in Osaka, Japan.

Results and discussion

The Mediterranean web spinner, *H. solieri* was found on an artificial island, in Hyogo Prefecture, Japan. Since October 2016, we have observed *H. solieri* twice in Maya Undo-Koen Park, Maya Port, while no embiopterans were observed at the other four locations surveyed (Figure 1A, B). In Maya Undo-Koen Park, there were several Camphor trees (*Cinnamomum camphora*) as garden trees. Silk tunnels, which are the nests of embiopterans, were observed on the ground shaded by trees. The silk tunnels were built on the adaxial side of fallen leaves and not on bark (Figure 1C, D). In total, we collected 15 and 75 embiopterans in first and second survey, respectively.

All of the collected individuals were apterous. None showed male characteristics (highly asymmetrical male genitalia). Figure 2 shows a representative individual. The body length ranged from 3.86 to 11.70 mm. The five largest individuals (9.97–11.70 mm) were chosen and identified to be adult, because they had well-developed ovaries and developing oocytes (Niwa et al. 1993). These adult females had two ventral papillae on the hind basitarsus (Figure 2C), which is an autapomorphy in *Haploembia* (Ross 1966). Then, we identified the species on the basis of their color pattern (Figure 2A), the shape of head (Figure 2B), and the body size. Ross (1940, 1966) indicated that *H. solieri* had pale prothorax and legs (*H. palaui* had uniformly dark coloration) and the head of *H. solieri* was slightly longer than broad. Furthermore, the body lengths of adult *Haploembia*

species exceed 15 mm, except *H. solieri*, which has a body length less than 14 mm (Ross 1966; Hodson et al. 2014). The individuals collected in this study were shorter than 12.0 mm. Based on the combination of these observations, we concluded that the collected individuals were *H. solieri*.

Many authors have reported sexual and asexual (maleless) populations of *H. solieri* (Stefani and Contini 1961; Ross 1966; Fontana 2002). According to Stefani and Contini (1961), sexual females are shorter (10.0–12.0 mm) and have darker pigmentation than parthenogentic females, which are larger (12.2–14.0 mm) and paler than sexual females. In this study, we found only females. Therefore, the introduced population in the Port of Kobe likely reproduces parthenogenetically. Nevertheless, the size of the females (all < 12.0 mm) presumably indicates that they were all sexual biotype. Further detailed morphological and phylogenetical information is needed to conclude which biotypes were introduced in the Port of Kobe.

This is the first record of this species in East Asia or Japan. While the species is endemic to the Mediterranean region (Ross 1966), populations of *H. solieri* are also found in the southwestern United States (Ross 1940; Hodson et al. 2014), presumably introduced through historical economic activity, such as the movement of shipping containers between these two regions. These facts suggest that *H. solieri* will most probably be found in other Japanese seaports and other Asian regions. The population of *H. solieri* may have overwintered for at least 1 year because we conducted surveys in the fall of 2016 and early summer of 2017. In the second survey, small individuals (presumably first instar larvae) were also collected, suggesting successful reproduction. In our survey, embiopterans were found only in Maya Undo-Koen, implying that their distribution is limited. However, this species has spread inland in the USA (Hodson et al. 2014). Although this species has not been recognized as invasive at this time, the possibility of affecting soil animal fauna cannot be ruled out. Currently, this species has been reported only in Maya Undo-Koen, so it would be better to prevent dispersal from the artificial island.

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