Survey of Kuroshima and Takashima, two major islands of Kujukushima as habitats of the threatened marine insects, *Halobates matsumurai* Esaki and *Asclepios shiranui* Esaki (Hemiptara: Gerridae)

Terumi Ikawa

INTRODUCTION

The genus *Halobates* is the only insect group that includes species inhabiting the open ocean; five species are oceanic and most others live along the coasts of tropical and subtropical regions (Andersen and Cheng, 2004). Two species of *Halobates*, i.e., *H. matsumurai* and *H. japonicus*, and the related marine species *Asclepios shiranui* are known to live in Japan (Esaki, 1924). Due to the pollution and development of coastal environments, habitats suitable for coastal marine insects are being destroyed, resulting in a drastic decrease of their population. *A. shiranui* had been considered extinct in the 1960's, but more than thirty years later it was rediscovered in Hizen and Imari (Saga Prefecture), and Tsushima Island, Fukushima, Sasebo, and Kinkai (Nagasaki Prefecture), in 1996 by Hayashi and Miyamoto (1997). *H. matsumurai* had also become very rare in most localities in Japan. However, in the 1990's, it was discovered in Saga Prefecture and Nagasaki Prefecture (Miyamoto, 1996; Hayashi and Miyamoto, 1997, 2003). Under these circumstances, *H. matsumurai* and *A. shiranui* (Fig. 1) have now been designated as threatened II (VU) and threatened I (CR+EN) by the Japanese Ministry of the Environment (2007).

Furthermore, *H. matsumurai* and *A. shiranui* have been found off the coasts of the Kujukushima area in Nagasaki Prefecture by Kawachino (2001). Kujukushima consists of more than 200 islands which are scattered off the north coast of Nagasaki Prefecture (Fig. 2). The Kujukushima area is characterized by deeply indented shorelines and clean seawater. As was stated by Kawachino (2001), for conservation of these threatened marine insects, it is essential to investigate their distributions in this whole area. The southern area of Kujukushima Islands has been intensively examined by the members of Kujukushima Aquarium (Yone, 2004), however, many islands of the northern area still remain unexplored. In the present study, the author surveyed Kuroshima and Takashima, two major islands of northern Kujukushima, compared the features of their coastlines and discussed suitable habitats for the sea skaters *H. matsumurai and A. shiranui*. Kuroshima, the largest island of Kujukushima, has not yet been surveyed, while in Takashima, *H. matsumurai* has been found by Kawachino (2001).

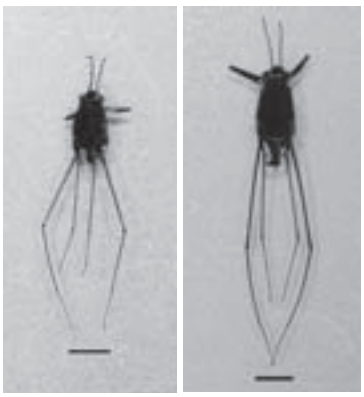

Fig. 1 Male adults of *Asclepios shiranui* (left) and *Halobates matsumurai* (right) collected from Takashima.

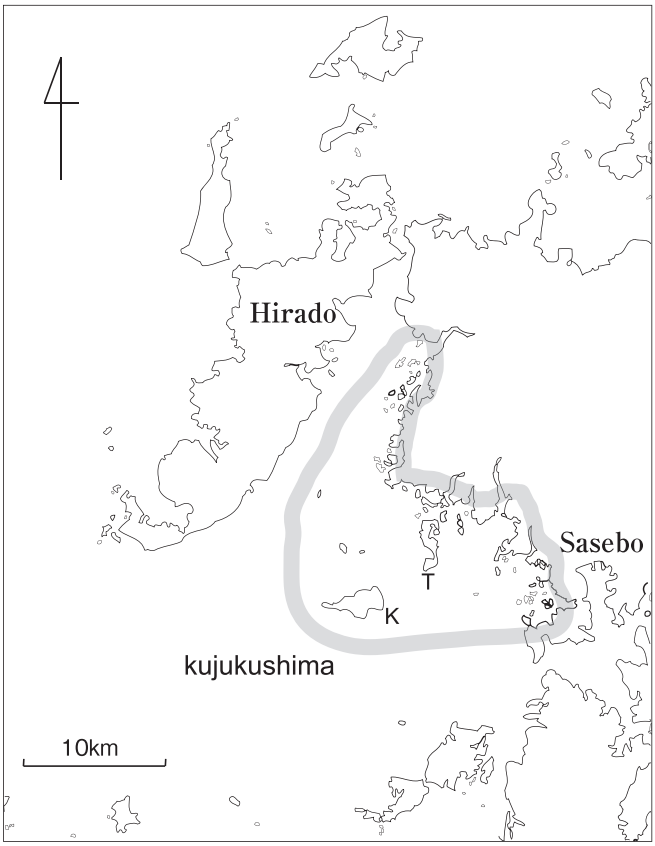

Fig. 2 Location of the Kujukushima area. K: Kuroshima, T: Takashima.

LOCATIONS SURVEYED AND METHODS

Among Kujukushima islands, there are only four inhabited islands, i.e., Kuroshima, Takashima, and two others. Kuroshima is the largest with its area and boundary length being 5.3 km^2 and 12.5km, respectively and Takashima the second largest with an area of 2.6km^2 and a length of 21km (Fig. 2 and 3). It is hard to access the beaches of Kuroshima and Takashima, as well as most of the other islands of Kujukushima, by either sea or by land because the water is shallow with hidden reefs and there are few land routes to the shores. In this study, beaches accessible by land were surveyed. Eight locations (Figs. 3, 4A-4H) were explored on Kuroshima on July 9-10, 2009 and three locations on Takashima on July 11, 2009 (Figs. 3, 4I-4K). The sea skaters were collected by the use of an insect net with a diameter of 25cm and were stored in 99% ethanol for further examination in the laboratory. Under the microscope, the specimens were identified, and the adult females were dissected to count the eggs in the ovarioles. The tide levels of Sasebo at full tide and at low tide during the survey were as follows: July 9 - 279 cm (9:07) and 37 cm (15:35); July 10 - 278 cm (9:41) and 41cm (16:07); July 11 - 274 cm (10:17) and 50 cm (16:38).

Fig. 3. Upper: locations surveyed on Kuroshima. A, B, C, D, E, F, G, and H stand for Kushigahama, Todobira, Kuroshima Port, Nakiri, Neya, Furusato-1, Furusato-2, and Mezenohama, respectively. Lower: locations surveyed on Takashima. I, J and K stand for Magome-1, Magome-2 and Takashima Port, respectively.

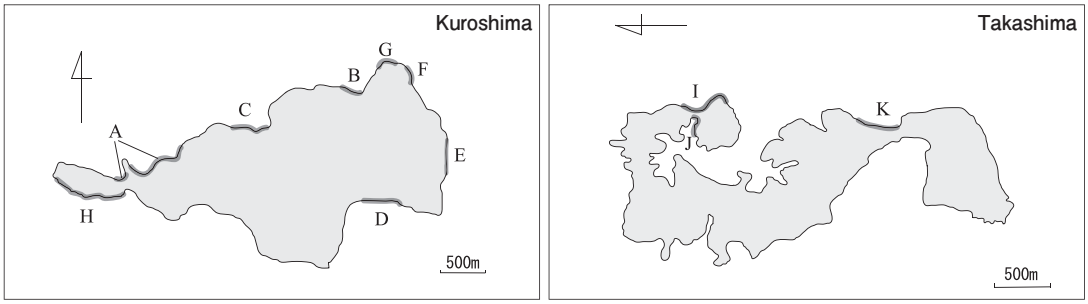

Fig. 4. Pictures of surveyed locations on Kuroshima (A-H) and on Takashima (I-K).

A (Kushigahama)

B (Todobira)

C (Kuroshima Port)

D (Nakiri)

E (Neya)

F (Furusato-1)

G (Furusato-2)

H (Mezenohama)

I (Magome-1)

J-1 (Magome-2)

J-2 (Magome-2)

K (Takashima Port)

RESULTS AND DISCUSSION

H. matsumurai and *A. shiranui* were found at Magome-2 on Takahsima (Table 1, Figs. 3, 4J-1 and 4J-2). This is the first record of *A. shiranui* on Takashima. No sea skaters were found in the other locations on Takahsima nor on Kuroshima.

In Magome-2, many individuals striding on the sea surface were observed, most of them were out of the reach of the insect net from the shore. Only individuals skating very close to the shore were sampled, i.e., as is shown in Table 2, 9 individuals of *H. matsumurai* (3 adult females, 3 adult males, 2 second instar larvae and 1 first instar larva) and 29 individuals of *A. shiranui* (11 adult females, 17 adult males and 1 first instar larva). *Halovelia septentrionalis* Esaki, which frequently

Table 1. Date, time, surveyed location, and number of *H. matsumurai* and *A. shiranui* collected

Date	Time	Location		*H. matsumurai*	*A. shiranui*
July 9, 2009	13:45	Kuroshima	Kushigahama	0	0
	15:10		Todobira	0	0
	16:30		Kuroshima Port	0	0
July 10, 2009	8:52		Nakiri	0	0
	9:17		Neya	0	0
	9:47		Furusato - 1	0	0
	10:30		Furusato - 2	0	0
	13:35		Mezenohama	0	0
	14:30		Kushigahama	0	0
July 11, 2009	8:00	Takashima	Magome-1	0	0
	9:15		Magome-2	10	29
	11:00		Takashima Port	0	0

Table 2. Number and composition of *H. matsumurai* and *A. shiranui* caught at Magome-1, Takashima

Species	I	II	III	IV	V	AM	AF
H. matsumurai	1	2	0	0	0	3	3
A. shinarui	1	0	0	0	0	17	11

I, II, III, IV, V, AM and AF stand for 1st, 2nd, 3rd, 4th and 5th instar larvae, and adult males and adult females, respectively.

Table 3. Average number and range of mature eggs and sub-mature eggs in adult females of H. *matsumurai* and *A. shinarui*

Species	No. females dissected	Average number of mature eggs per female (range)	Average number of sub-mature eggs per female (range)
H. matsumurai	3	10.0 (9-11)	3.3 (3-4)
A. shinarui	11	6.3 (5-13)	2.8 (1-5)

occurs with *H. matsumurai* and *A. shiranui* (Hayashi and Miyamoto, 2003), was not collected. All adult females of *H. matsumurai* and *A. shiranui* had mature and sub-matured eggs which would eventually be laid and would produce the next generation (Table 3). Many young instar larvae were observed skating on the water. Since there would not be many possibilities that fragile young nymphs could successfully immigrate from other islands, this suggested that they had emerged from the eggs laid on Magome-2 or adjacent shores. Both species probably repeat generations there.

In the Kujukushima area, the sea skaters appear to be most abundant in early summer (Ikawa et al., unpublished data). However, neither *H. matsumurai* nor *A. shiranui* was found on Kuroshima in spite of intensive exploration of almost all the shores accessible by land. The coast of Kuroshima may not be suitable for the survival of these species. Kuroshima is different from other islands of Kujukushima in that its shoreline is rather flat and there are no narrow coves (Fig. 3, Fig.4A-4H).

The beaches are rocky and are directly exposed to wind and waves from the sea. During the low tide, no large tidal sand flats were observed, which are typical to the coasts of many Kujukushima islands. Overhanging vegetation was very limited on the shoreline of Kuroshima. In this study it was observed in a very small scale in Furusato-1 (Fig. 4F). Sea skaters may occasionally drift to Kuroshima, being washed away from other islands by waves or currents. However, the environmental conditions along the coast of Kuroshima would be too rough for them to survive and to repeat generations.

On the other hand, the shoreline of Takashima is deeply indented (Fig. 3). Magome-2 was along the shoreline of a narrow cove fringed with thick overhanging vegetation (Figs. 3, 4J-1 and 4J-2). The sea skaters were found skating on the quiet sea surface within or near the shadow of this overhanging vegetation. The other two locations where no sea skaters were found, Magome-1 (Figs. 3, 4I) and Takashima Port (Figs. 3, 4H), directly faced the open sea and had no overhanging vegetation.

The seawater of the Kujukushima area is unpolluted, suitable for oyster and pearl farming. However, the good water quality is not a sufficient requirement as a suitable habitat for the sea skaters. The common environmental features observed in Magome-2 and other locations of Kujukushima area where *H. matsumurai* and *A. shiranui* live (Yone et al., 2004; Ikawa et al., unpublished data), is firstly, the quiet coastal water protected by narrow coves from exposure to wind and waves from the open sea. Different from oceanic species which are adapted to live in constant turbulence (Ikawa et al. 1998), the protection from turbulence provided by topographical features seems to be essential for these species. Secondly, the existence of abundant overhanging vegetation also serves as a suitable environmental factor for the survival of sea skaters, providing them with insects falling onto the sea surface as food (Andersen and Cheng, 2004) and also providing them with shade during the summer season (Hayashi and Miyamoto 2003,; Yone et al., 2004).

Shorelines with unpolluted seawater and narrow coves fringed with abundant vegetation are still preserved in the Kujukushima area, providing habitats for these endangered sea skaters. Thus, development and industrialization along the coasts should be planned, taking into consideration the conservation of these marine insects.

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