Hindawi Publishing Corporation
Psyche
Volume 2012, Article ID 261071, 7 pages
doi:10.1155/2012/261071

Research Article

Life Histories of Two Endangered Sea Skaters *Halobates matsumurai* Esaki and *Asclepios shiranui* (Esaki) (Hemiptera: Gerridae: Halobatinae)

Terumi Ikawa,[1] Yuichi Nozoe,[2] Natsuko Yamashita,[1] Namiko Nishimura,[2] Satoshi Ohnoki,[1] Kyoko Yusa,[2] Sugihiko Hoshizaki,[3] Masayuki Komaba,[2] and Akihiro Kawakubo[2]

[1] *Faculty of Humanities, The University of Morioka, 808 Sunagome, Takizawa, Iwate 020-0183, Japan*
[2] *Kujukushima Research Group, Saikai Pearl Sea Resort, 1008 Kashimae, Sasebo, Nagasaki 858-0922, Japan*
[3] *Graduate School of Agricultural and Life Sciences, The University of Tokyo, 1-1-1 Yayoi, Bunkyo, Tokyo 113-8657, Japan*

Correspondence should be addressed to Terumi Ikawa, trmi@pop02.odn.ne.jp

Received 13 March 2012; Accepted 9 May 2012

Academic Editor: Ai-Ping Liang

Sea skaters *Halobates matsumurai* Esaki and *Asclepios shiranui* (Esaki) are among the few marine insects found in Japan. For the past several decades, they have become rare in most localities and have now been designated as endangered by the government. In order to understand their adaptive strategies to the marine environment and to develop conservation measures, it is essential to know their life histories. We studied their lifecycles in Kujukushima Bay off the north coast of Kyushu (Japan) where they co-occurred in small coves along the jagged coast. They appeared to have more than one generation a year and to overwinter in the egg stage. Eggs of *H. matsumurai* were laid on natural sandstones and man-made sandstone walls along the shore, mostly above the average sea level. The eggs had very hard shells, presumably adaptive to protect them from desiccation, solar radiation, and wave action, especially during the overwintering period.

1. Introduction

Although insects are predominant on earth over other living organisms both in species numbers and in habitat diversity, they are largely unsuccessful in conquering marine environment [1–3]. *Halobates* is the only insect genus that includes species living in the open ocean [4–7]. Among 46 known species, 5 are pelagic, 39 are found in coastal areas, and 2 occur in freshwater rivers [7]. Three species of the genus *Asclepios*, a close relative of *Halobates*, are also found in coastal waters. Most coastal *Halobates* and *Asclepios* live in tropical and subtropical mangrove habitats, many of which are now lost to development or exposed to pollution. Three coastal sea skaters, *H. matsumurai* (Figure 1(a)), *H. japonicus* Esaki, and *A. shiranui* are known in Japan. They were all described by Esaki in 1924 and found in western or southwestern coasts of Japan [8–10]. During the years of postwar rapid economic growth and industrialization in Japan (~1952–1972), many habitats suitable for coastal sea skaters were destroyed, resulting in drastic decreases in number of populations and distribution ranges [11–13]. *H. matsumurai* and *A. shiranui* were rarely seen until they were rediscovered in the 1990s [11, 14, 15]. Under these circumstances, they were both designated as threatened II (VU) and threatened I (CR + EN), respectively, by the Japanese Ministry of the Environment [16].

Little is known about the lifecycles of coastal sea skaters. Previous studies were mostly based on short-term observations in the field or in the laboratory [6, 17–21]. However, in order to understand their adaptive strategies to marine environments and to develop conservation measures, it is essential to know their life histories. Our study on *Halobates matsumurai* and *Asclepios shiranui* in their natural habitat is the first carried out over an extended period. We studied their life cycles in Kujukushima Bay (Figure 1(c), Figure 2), off the north coast of Kyushu, Japan, where they often co-occur in small coves. One of the most intriguing aspects with Japanese sea skaters is that they live in the temperate climate zone,

FIGURE 1: (a) Mating pair of *H. matsumurai* (Photo by K. Yusa). (b) Egg of *H. matsumurai* laid on sandstone. Scale = 1 mm. (Photo by T. Ikawa). (c) Deep inner bay of Kujukushima area (Photo by T. Ikawa). (d) Sandstones along the shore at low tide showing exposed oviposition area for *H. matsumurai* (Photo by K. Yusa).

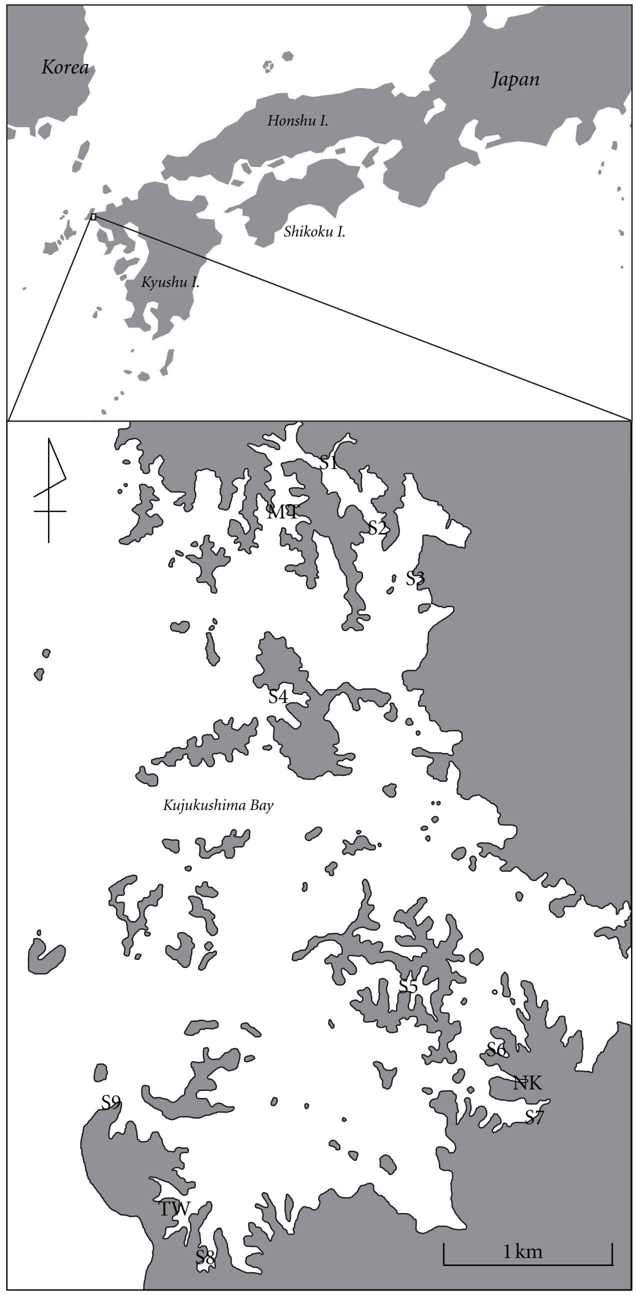

FIGURE 2: Locations of study stations MT, NK, TW and S1~S9 in Kujukushima area.

while most others are found in tropical waters. Where and in what stage they overwinter is of particular interest. Soon after this study was completed, collection of *H. matsumurai* and *A. shiranui* as well as other endangered organisms was banned. Thus, we had a unique opportunity to study their life cycles.

2. Materials and Methods

2.1. Study Site. The distribution ranges of the three Japanese sea skaters are as follows: *A. shiranui* is known in the coasts of northwestern Kyushu Is. [11]; *H. matsumurai* is found along the coasts of northwestern Kyushu Is. and western Honshu Is. [11, 22–24]; *H. japonicus* is known from the western Pacific coast of Honshu Is. to the Nansei Islands [12]. *A. shiranui* and *H. matsumurai* often co-occur in small coves or inner bays [11, 22, 24], but *H. japonicus* has never yet been found to co-occur with either *A. shiranui* or *H. matsumurai*. Only *H. matsumurai* and *A. shiranui* are known in coastal areas of Kujukushima [11, 22–24]. Kujukushima consists of more than 200 islands scattered off the northwest coast of Kyushu. The two species can be found in small coves off uninhabited jagged coastlines many of which were only

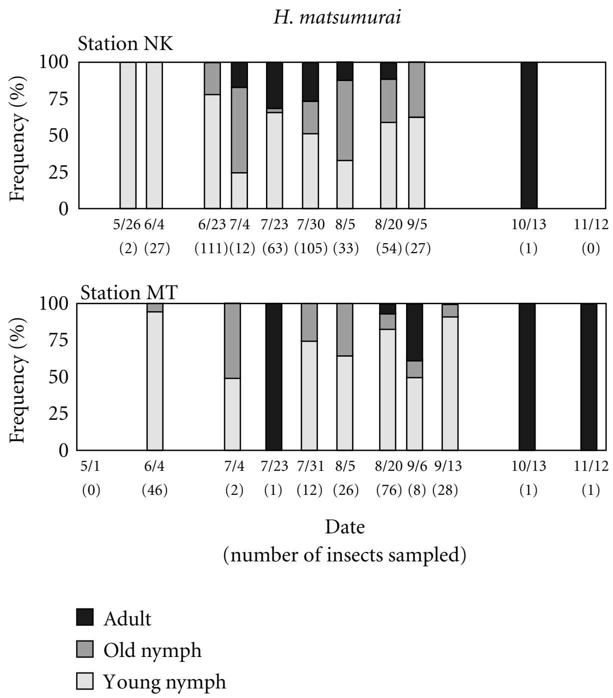

Figure 3: Seasonal changes in the composition of developmental stages of *H. matsumurai* at Station NK (top) and MT (bottom).

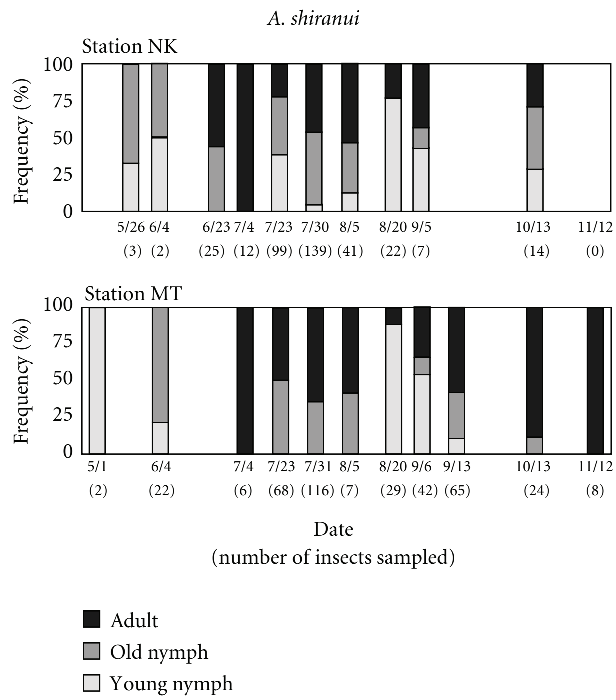

Figure 4: Seasonal changes in the composition of developmental stages of *A. shiranui* at Station NK (top) and MT (bottom).

accessible by boat [11, 23]. We conducted field surveys at stations MT, NK, TW, and S1~S9 in Kujukushima Bay (ca. 33°8′N 129°40′E) (Figure 2). Each station was visited by vessels owned by Kujukushima Aquarium. The studies were carried out between March 2008 and February 2009.

2.2. Oviposition Sites and Appearance of Nymphs and Adults. *H. matsumurai* females were known to lay eggs on the rocks on the shore [11, 23] but oviposition sites of *A. shiranui* were unknown. In the laboratory, females of *A. shiranui* oviposited on sandstones [Nozoe, unpublished observation]. Eggs of *A. shiranui* could be distinguished by size much smaller than those of *H. matsumurai.* Throughout our study period, we examined the presence of *H. matsumurai* eggs and also searched for *A. shiranui* eggs.

On March 4–6, 2008, we intensively searched nine sites (S1, S2, S3, S5, S6, S8, S9, TW, and NK in Figure 2) for eggs, nymphs, and adults. For eggs, we mainly searched sandstones and man-made stonewalls along the shore and some seaweeds nearby. For adults and nymphs, we looked on the sea surface and the shore. Similar surveys were carried out in late March and April at five stations: NK (March 22), S3 (March 31), S2 (April 11), S4 (April 15), and S8 (April 20).

From May to November 2008, we sampled nymphs and adults for a total of 11 times at stations NK and MT on the following dates: station NK, May 26, June 4, 23, July 4, 23, 30, Aug. 5, 20, Sept. 5, Oct. 13, Nov. 12; station MT, May 1, June 4, July 4, 23, 31, Aug. 5, 20, Sept. 6, 13, Oct. 13, Nov. 12. We collected sea skaters using insect nets with an opening of 25 cm in diameter either from a boat or from shore.

In late November, we repeated our intensive searches for eggs, nymphs, and adults at S8 and S9 (Nov. 26), and at MT, S5, and TW (Nov. 27), as we did in March and April. During the cold season (December 2008 to February 2009), in addition to stations NK and MT we searched three more sites (S4, TW, S8) in Kujukushima Bay to confirm whether nymphs or adults were present. Surveys were made once a month, that is, Dec. 13, 2008, Jan. 9, and Feb. 10, 2009.

Specimens collected were preserved in 99% ethanol for further studies in the laboratory. They were identified to species under a stereomicroscope. Adults and 5th instar nymphs were sexed, and nymphs were sorted to each of five developmental stages. The species and the developmental stages were separated based on the color pattern of dorsal side, the length of midleg femur, and the presence of genitalic organ (Ikawa et al., in preparation). Some of the adult females were dissected to count eggs in ovarioles and to measure the length and width of mature eggs.

2.3. Vertical Distributions of H. matsumurai Eggs and Duration of Submergence Underwater. The location of *H. matsumurai* eggs in relation to the sea level was studied at station TW on November 28, 2008. The eggs were laid on a man-made 1240 cm wide sandstone wall along the shore. The lower edge of the stonewall was 119 cm above the sea level and upper edge was 281 cm high. The mean sea level at Kujukushima Bay area including station TW is 164 cm [25]. Since the eggs were found on the same stonewall in March 2009, they would have remained there throughout the winter until they hatched in May or later [Ikawa et al., unpublished observation]. To estimate how long the eggs

Table 1: Average numbers of mature and submature eggs per female and length and width of mature eggs of *H. matsumurai*.

Date of sampling (2008)	N*	No. (average ± S.D.) of eggs/female		Length and width (average ± S.D.) of mature egg	
		Mature eggs	Submature eggs	Length (mm)	Width (mm)
June 23, 30; July 4	6 (1)	4.3 ± 4.84	1.8 ± 2.48	1.59 ± 0.01	0.53 ± 0.04
Aug. 1, 20	10 (0)	7.7 ± 3.16	4.1 ± 2.02	1.61 ± 0.09	0.52 ± 0.04
Sept. 17; Oct. 14	10 (1)	5.3 ± 2.63	3.0 ± 2.49	1.73 ± 0.10	0.59 ± 0.04

* Number of females dissected. Values in parenthesis are the number of females with neither mature nor sub-mature eggs.

Table 2: Average numbers of mature and submature eggs per female and length and width of mature eggs of *A. shiranui*.

Date of sampling (2008)	N*	No. (average ± S.D.) of eggs/female		Length and width (average ± S.D.) of mature egg	
		Mature eggs	Submature eggs	Length (mm)	Width (mm)
June 6, 23	10 (1)	1.0 ± 2.83	5.5 ± 3.66	1.16 ± 0.08	0.37 ± 0.07
July 30, 31; Aug. 1	20 (0)	7.1 ± 3.55	6.2 ± 2.43	1.20 ± 0.04	0.39 ± 0.02
Oct. 14; Nov. 20	10 (0)	5.2 ± 1.87	3.7 ± 2.06	1.33 ± 0.05	0.39 ± 0.02

* Number of females dissected. Values in parenthesis are the number of females with neither mature nor sub-mature eggs.

had been submerged underwater during the overwintering period, percentage duration of submergence of each egg from November to April was calculated using the tidal data provided by Sasebo Coast Guard Office to Kujukushima Aquarium.

3. Results

3.1. Oviposition Sites and Appearance of Nymphs and Adults. On March 4~6, 2008, we found no eggs of *A. shiranui,* while the eggs of *H. matsumurai* were found in all nine sites. *H. matsumurai* eggs were laid mainly on natural sandstones (Figure 1(b), and 1(d)) or man-made sandstone walls, and occasionally on concrete seawalls along the shore. Neither nymphs nor adults of either species were observed during these dates or in late March or April.

From May to November 2008, nymphs and adults of both species were collected at stations NK and MT. Young nymphs (1st~3rd instar nymphs) of *H. matsumurai* first appeared in May at NK and in early June at MT (Figure 3). Older nymphs (4th~5th instar nymphs) appeared in June, and adults were found from July onwards. Nymphs and adults co-occurred from July to August at NK and from late August to September at MT. In the autumn, only a small number of adults were found at both stations.

As shown in Figure 4, young nymphs of *A. shiranui* first appeared in May, and older nymphs appeared from May at NK and from June at MT. Adults were found from June at NK and from July at MT. At NK, nymphs and adults co-occurred from June to October, and no individuals were found in November. At MT, nymphs and adults co-occurred from July to October and only adults were found in November.

In late November, we found eggs of *H. matsumurai* on the sandstones and stonewalls in all five sites surveyed (S5, S8, S9, MT, TW in Figure 2). Neither nymphs nor adults of either species were observed.

From December 2008 to February 2009, we found no nymphs nor adults of either species at stations NK and MT or the other three sites (TW, S4, S8). Eggs of *H. matsumurai* were seen on the sandstones and stonewalls. Throughout the study period, we found no eggs of *A. shiranui* in the field.

3.2. Egg Load of Adult Females. Most females of *H. matsumurai* and *A. shiranui* carried mature and/or submature eggs from early summer to autumn (Tables 1 and 2). The average numbers of mature or submature eggs/female of both species were at most 7 or 8. The eggs of *H. matsumurai* were much larger than those of *A. shiranui*. Submature eggs of both species were semitransparent and soft, but mature eggs near the oviducts had hard shells.

3.3. Vertical Distributions of H. matsumurai Eggs and Duration of Submergence Underwater. Figure 5 shows the vertical distribution of the eggs of *H. matsumurai* laid and the percentage duration of submergence under seawater. The positional height of the eggs ranged from 161 cm to 273 cm with an average of 213 cm. Thus, most eggs were laid above the average sea level (164 cm) at station TW. They were submerged under water at most twice a day. The total duration of submergence from November 2008 to April 2009 ranged from 3.8% to 51.5%.

4. Discussion

4.1. Life Cycles of H. matsumurai and A. shiranui. Our observations in the field indicated that (1) neither nymphs nor adults of *H. matsumurai* or *A. shiranui* were found during winter or early spring; (2) the eggs of *H. matsumurai* were seen throughout the year; (3) young nymphs of both species were first observed in May or June. Older nymphs and adults appeared later (Figures 3 and 4); (4) both species probably overwinter in the egg stage with 1st instar nymphs of the overwintering generation hatching out in May or June.

We estimate that for *H. matsumurai*, nymphal development time from overwintering eggs lasted approximately 40~50 days with the adults appearing in July (Figure 3). After July, composition of developmental stages was rather obscure. There were considerable variations in timing of

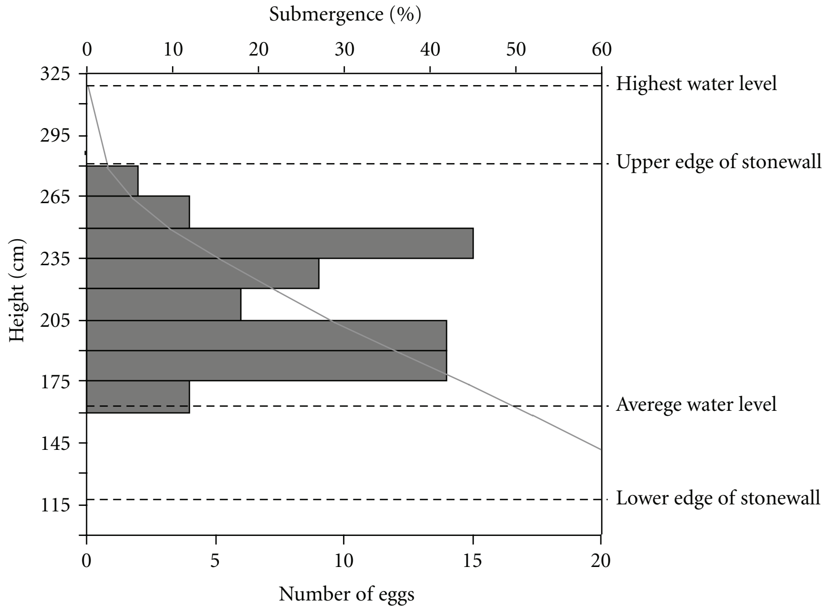

FIGURE 5: Frequency distribution of height of *H. matsumurai* eggs laid on a sandstone wall in relation to tidal level. The solid line is percent of duration of submergence under water of the period from November 2008 to April 2009.

eclosion of eggs, which ranged from early May to late June [Ikawa et al., unpublished observation]. These variations might have led to the concurrent appearance of different stages in later generations. Copulating adults and newly laid eggs were both found in July. Hence, young nymphs found in late July and early August were presumed to belong to the subsequent generation. We found two peaks of young nymphs (in late July–early August and in late August–September), which we assume to belong to two different generations. However, some of the young nymphs that appeared in September would probably die before reaching the adult stage. In October and November, only small numbers of adults were found. Throughout the year, whenever adults were present, most females were found to have mature and/or submature eggs in their ovarioles (Table 1), suggesting that females may lay eggs from July until late autumn. Thus, *H. matsumurai* probably overwinters in the egg stage, the overwintering generation ecloses in May or June, and there may be two or three generations a year.

The life cycle of *A. shiranui* is similar to that of *H. matsumurai* (Figure 4, Table 2). The eggs of *A. shiranui* have not yet been found in the field. However, temporal changes in the appearance of nymphs and adults suggest that it repeats two or three generations a year and overwinters in the egg stage. *A. shiranui* probably also lays eggs on sandstones on the shore since adult females kept in a tank in the laboratory laid eggs around the waterline on the sandstones provided [Nozoe, unpublished observation]. The oviposition site of *A. shiranui* could be very different from that of *H. matsumurai*.

Not much is known previously about the lifecycles of coastal *Halobates* and *Asclepios*. Because the sea-surface temperature at Kujukushima falls below 15°C during the winter, the winter diapause would be a requisite for the sea skaters. Our study suggests that *H. matsumurai* and also probably *A. shiranui* overwinter in the egg stage at Kujukushima. On the other hand, temperate gerrids overwinter most often as adults [26, 27]. Egg diapause in Gerridae is known only for *Metrobates hesperius* [28] and *Metrocoris histro* [29] and was postulated for a few genera [27]. *Metrocoris* as well as *Halobates* and *Asclepios* belongs to the subfamily Halobatinae.

4.2. Egg Load of Adult Females. Average numbers of mature or submature eggs per female of *H. matsumurai and A. shiranu*i were at most 7 or 8 (Tables 1 and 2). These values are similar to those of *H. japonicus*, the other coastal species of *Halobates* found in Japan [20, 21]. The size of *H. matsumurai* egg was slightly larger than that of *H. japonicus* (ca. 1.5 mm long and 0.4 mm wide) [20, 21] and much larger than that of *A. shiranui* (Tables 1 and 2). The egg size of *Halobates* spp. ranges 0.8–1.3 mm long and about 0.5 mm wide [7]. Thus, *H. matsumurai* and *H. japonicus* have relatively larger eggs in the genus *Halobates*. Adults of the two species are morphologically similar [8]. However, the mature eggs in the oviduct of *H. japonicus* are semitransparent and soft without hard eggshell [Ikawa, unpublished observation], while those of *H. matsumurai* and *A. shiranui* have the hard eggshell (the present study). No sea skaters are known to have such hard eggshells as *H. matsumurai* and *A. shiranui.*

4.3. Vertical Distributions of H. matsumurai Eggs. The eggs of *H. matsumurai* were laid on natural sandstones and sandstone walls along the shore, mostly above average water level, and were submerged less than 50% of the time during the egg stage. *H. fijiensis*, the only other coastal *Halobates* for which oviposition site in the field is known, laid its eggs mainly on the leaves of the turtle grass *Syringodium* *isoetifolium* or on the fronds of the green algae, *Halimeda* sp. [19]. Both plants are sublittoral and remain submerged underwater most of the time. Oviposition behavior of *H. fijiensis* was observed only during days of extreme low spring tide when these plants were exposed to the air. Foster and Treherne [19] concluded that eggs laid at the extreme low spring level would be protected from overheating and desiccation, and perhaps also from the wave action. They might also be protected from parasitoids. In fact, percentage parasitism of eggs of pond skaters was found to decrease with increasing depth under submersion of eggs (e.g., [30]).

It must be more adaptive for *H. matsumurai* to lay eggs above the average water level than at low water level as *H. fijiensis* does. A possible selective force for *H. matsumurai* to oviposit above the average water level in Kujukushima could be paucity of suitable oviposition sites at low water level. The area around low water mark in Kujukushima is mostly sandy, with neither mangrove roots nor abundant sublittoral plants. In addition, most grass plants along the shore die during the winter. Sandstones on the shore might be the only stable substrate for oviposition. However, the eggs laid on sandstones are exposed to solar radiation, wind, and storms, and also to predation. *H. matsumurai* might have developed the hard eggshell as a protection against such harsh physical conditions, especially during the long overwintering period.

Acknowledgments

The authors thank the members of Kujukushima Aquarium and T. Matsuo for assistance of field survey. They are indebted to A. Chiba, M. Iwabe, and R. Takeya for their help with various laboratory work especially identification of sea skaters and to Sasebo Coast Guard Office for offering the tidal data. Special thanks go to L. Cheng, H. Okabe, Y. Suzuki, and S. Unher for helpful discussions and/or critical reading of the paper. This study was partly supported by the Academic Grant of Morioka University for the year of 2008.

References

[1] L. Cheng, "Insects in marine environments," in *Marine Insects*, L. Cheng, Ed., pp. 1–4, North-Holland, Amsterdam, The Netherland, 1976.

[2] L. Cheng and J. H. Frank, "Marine insects and their reproduction," *Oceanography and Marine Biology: An Annual Review*, vol. 31, pp. 479–506, 1993.

[3] L. Cheng, "Marine insects," in *Encyclopedia of Insects*, V. H. Resh and R. T. Cardé, Eds., pp. 600–604, Academic Press, San Diego, Calif, USA, 2nd edition, 2009.

[4] J. L. Herring, "The genus *Halobates* (Hemiptera: Gerridae)," *Pacific Insects*, vol. 3, no. 2-3, pp. 223–305, 1961.

[5] N. M. Andersen and J. T. Polhemus, "Water-striders (Hemiptera: Gerridae, Veliidae, etc.)," in *Marine Insects*, L. Cheng, Ed., pp. 187–224, North-Holland, Amsterdam, The Netherlands, 1976.

[6] L. Cheng, "Biology of *Halobates* (Heteroptera: Gerridae)," *Annual Review of Entomology*, vol. 30, pp. 111–135, 1985.

[7] N. M. Andersen and L. Cheng, "The marine insect *Halobates* (Heteroptera: Gerridae): biology, adaptations, distribution, and phylogeny," *Oceanography and Marine Biology*, vol. 42, pp. 119–179, 2004.

[8] T. Esaki, "On the genus *Halobates* from Japanese and Formosan coasts (Hemiptera: Gerridae)," *Psyche*, vol. 31, no. 2, pp. 112–118, 1924.

[9] T. Esaki, T. Ishii, T. Kawamura et al., Eds., *Iconographia Insectorum Japonicorum*, Hokuryukan, Tokyo, Japan, 2nd edition, 1950, (japanese).

[10] S. Miyamoto, *Gerridae*, Series 1, Part 3 of of Insecta Japonica, Hokuryukan Publishing, Tokyo, Japan, 1961, (japanese).

[11] M. Hayashi and S. Miyamoto, "Distribution and habitat of *Asclepios shiranui*, with distributional notes on some other coastal marine skaters (Heteroptera: Gerridae and Veliidae) in northern Kyushu, Japan," *Rostria*, vol. 51, pp. 1–20, 2003 (Japanese).

[12] M. Hayashi and S. Miyamoto, "Hemiptera," in *Aquatic Insects of Japan: Manual with Keys and Illustrations*, T. Kawai and K. Tanida, Eds., pp. 291–378, Tokai University Press, Kanagawa, Japan, 2005, (japanese).

[13] Association of Wildlife Research and EnVision Conservation Office, *Search System of Japanese Red Data*, 2007, http://www.jpnrdb.com/index.html, (japanese).

[14] S. Miyamoto and M. Hayashi, "Discovery of *Halobates matsumurai* (Heteroptera, Gerridae) from Tsushima Is., Kyushu," *Japanese Journal of Entomology*, vol. 64, no. 1, p. 110, 1996.

[15] M. Hayashi and S. Miyamoto, "Rediscovery of *Asclepios shiranui* (Heteroptera, Gerridae) from northern Kyushu, Japan," *Japanese Journal of Entomology*, vol. 65, no. 2, pp. 438–439, 1997.

[16] The Japanese Ministry of the Environment, "Red list of Threatened Insects of Japan," 2007, http://www.env.go.jp/press/press.php?serial=8648, (japanese).

[17] M. C. Birch, L. Cheng, and J. E. Treherne, "Distribution and environmental synchronization of the marine insect, *Halobates robustus*, in the Galapagos islands," *Proceedings of the Royal Society of London, Series B*, vol. 206, no. 1162, pp. 33–52, 1979.

[18] W. A. Foster and J. E. Treherne, "Feeding, predation and aggregation behaviour in a marine insect, *Halobates robustus* Barber (Hemiptera: Gerridae), in the Galapagos Islands," *Proceedings of the Royal Society of London, Series B*, vol. 209, no. 1177, pp. 539–553, 1980.

[19] W. A. Foster and J. E. Treherne, "The ecology and behaviour of a marine insect, *Halobates fijiensis* (Hemiptera: Gerridae)," *Zoological Journal of the Linnean Society*, vol. 86, no. 4, pp. 391–412, 1986.

[20] T. Ikawa, K. Susa, and M. Watanabe, "Preliminary study of aggregations and reproductive organs of the sea skater *Halobates japonicus* Esaki (Hemiptera: Gerridae)," *Journal of Morioka University*, vol. 23, pp. 103–108, 2006 (Japanese).

[21] T. Ikawa, M. Watanabe, M. Aoki, and H. Okabe, "Consecutive daily sampling of aggregations of the sea skater *Halobates japonicus* Esaki (Hemiptera: Gerridae)," *Journal of Morioka University*, vol. 25, pp. 31–37, 2008 (Japanese).

[22] Y. Kawachino, "New localities of *Asclepios shiranui* and *Halobates matsumurai* in Nagasaki Prefecture," *Transactions of the Nagasaki Biological Society*, no. 53, p. 26, 2001 (Japanese).

[23] F. Yone, T. Matsuo, A. Kawakubo, F. Saijo, and Y. Mori, "Distribution of coastal sea skaters in southern Kujukusima," *Transactions of the Nagasaki Biological Society*, vol. 57, pp. 1–9, 2004 (Japanese).

[24] T. Ikawa, "Survey of Kuroshima and Takashima, two major islands of Kujukushima as habitats of the threatened marine

insects, *Halobates matsumurai* Esaki and *Asclepios shiranui* Esaki (Hemiptera: Gerridae)," *Journal of Morioka University*, vol. 27, pp. 27–33, 2010.

[25] SASEBO Coast Guard Office, 2008, http://www.kaiho.mlit.go.jp/07kanku/sasebo/kisyou/tyouseki/hosei.html, (japanese).

[26] N. M. Andersen, *The Semiaquatic Bugs (Hemiptera, Gerromorpha). Phylogeny, Adaptations, Biogeography, and Classification*, vol. 3 of *Entomonograph*, Scandinavian Science Press, Klampenborg, Denmark, 1982.

[27] J. R. Spence and N. M. Andersen, "Biology of water striders: interactions between systematics and ecology," *Annual Review of Entomology*, vol. 39, pp. 101–128, 1994.

[28] S. Taylor, "Concurrent phenologies of three semiaquatic bugs (Heteroptera: Gerridae, Veliidae) on a small river in central Illinois, USA," *Psyche*, vol. 2009, Article ID 562471, 5 pages, 2009.

[29] Y. Ban, S. Shigeaki, and M. Ishikawa, "Life history of the water strider *Metrocoris histrio* B. White (Hemiptera: Gerridae) in Aichi Prefecture, Japan," *Verhandlungen Internationale Vereinigung für Theoretische und Angewandte Limnologie*, vol. 23, pp. 2145–2151, 1988.

[30] H. Amano, K. Hayashi, and E. Kasuya, "Avoidance of egg parasitism through submerged oviposition by tandem pairs in the water strider, *Aquarius paludum insularis* (Heteroptera: Gerridae)," *Ecological Entomology*, vol. 33, no. 4, pp. 560–563, 2008.