The Rhizome-Boring Shipworm *Zachsia zenkewitschi* (Bivalvia: Teredinidae) in Drifted Eelgrass

Takuma Haga

Department of Biological Sciences, Graduate School of Science, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-0033, Japan

The shipworm *Zachsia zenkewitschi* Bulatoff & Rjabtschikoff, 1933 lives inside the rhizomes of the eelgrasses *Phyllospadix* and *Zostera* (Helobiales; Zosteraceae) and has sporadic distribution records from Primorskii Krai (=Primoriye Region) to Siberia in the Russian Far East and in Japanese waters (Higo *et al*., 1999). Its detailed distribution and habitats have been surveyed in detail only locally along the coast of Vladivostok in Primoriye (Turner *et al*., 1983; Fig. 1F). In Japanese waters, this species has been recorded in only three catalogues of local molluscan faunas (Fig. 1; Inaba, 1982; Kano, 1981; Kuroda & Habe, 1981). These catalogues, however, did not provide information on detailed collecting sites and habitats. This rare species was recently rediscovered along the coast of Miyagi Prefecture, northeast Japan (Sasaki *et al*., 2006; Fig. 1C).

Z. zenkewitschi has dwarf males and exhibits remarkable sexual dimorphism. Bulatoff & Rjabtschikoff (1933) noted the presence of 'larvae' within the female body with a long tail-like appendage and an internal shell. Turner & Yakovlev (1983) confirmed that the 'larvae' are dwarf males, a rare example of sexual dimorphism in bivalves.

Subsequent authors studied the biology of *Z. zenkewitschi* in detail and determined that: 1) spawning occurs 2–5 times in summer; 2) fertilization then takes place in the suprabranchial cavity of the female using sperm received from the dwarf males; 3) after fertilization, the larvae are brooded until they grow to the straight-hinge stage; 4) the released larvae settle on the rhizomes of the eelgrass after a short planktonic stage; and 5) the larvae either crawl into the lateral pouches of a female within the rhizome and grow into dwarf males or develop into females in cases where the rhizomes are free from any adult female (Drozdov *et al*., 1999; Turner *et al*., 1983; Yakovlev *et al*., 1998).

However, it is still not yet known how this species dispersed so widely despite its short-term, free-swimming larval stage. Turner & Yakovlev (1983) observed that the larvae swam mostly near the bottom of a culture dish in their laboratory. They hypothesized that in natural environments the larvae can swim only for short distances within the eelgrass beds and that wide dispersal might have been achieved through long-distance transportation of the host eelgrass by accidental drifting. However, this hypothesis has not been verified to date.

This report is the first documentation of *Z. zenkewitschi* in drifted rhizomes of eelgrass, and describes the soft animal morphology of this species.

Zachsia zenkewitschi in drift eelgrass

Out of ten batches of *Zostera marina* eelgrass collected floating in seawater at an embankment in Ishinomaki fishing port, Miyagi Prefecture, northeast Honshu, 38°24′34″N, 141°19′53″E, on October 27, 2005 (Fig. 1D), three individuals of *Z. zenkewitschi* were discovered from three rhizomes. Other specimens of *Z. zenkewitschi* obtained from rhizomes of *Zostera caulescens* collected at 3–5 m depths in Shizugawa Bay, 38°38′40″N, 141°28′47″E, were also examined. The animals can only be found by carefully breaking open the rhizomes to expose the calcareous tubes (Fig. 3; t). When taken out of the tube, the live soft parts are translucent grayish in color, and the internal organs, such as gills (g), heart (h), caecum (c) and ovary, are visible through the mantle (Fig. 4). Tiny granules of unknown function were also found spread over the surface of the mantle, and the minute, *Teredo*-like valves (s) and discoid foot (f) are located at the anterior part of the body. The largely extended cephalic hood covers the valves almost entirely, leaving only the margin of the anterior slope exposed. Unlike other teredinids studied by Röder (1977), this species does not execute antero-posterior boring move-

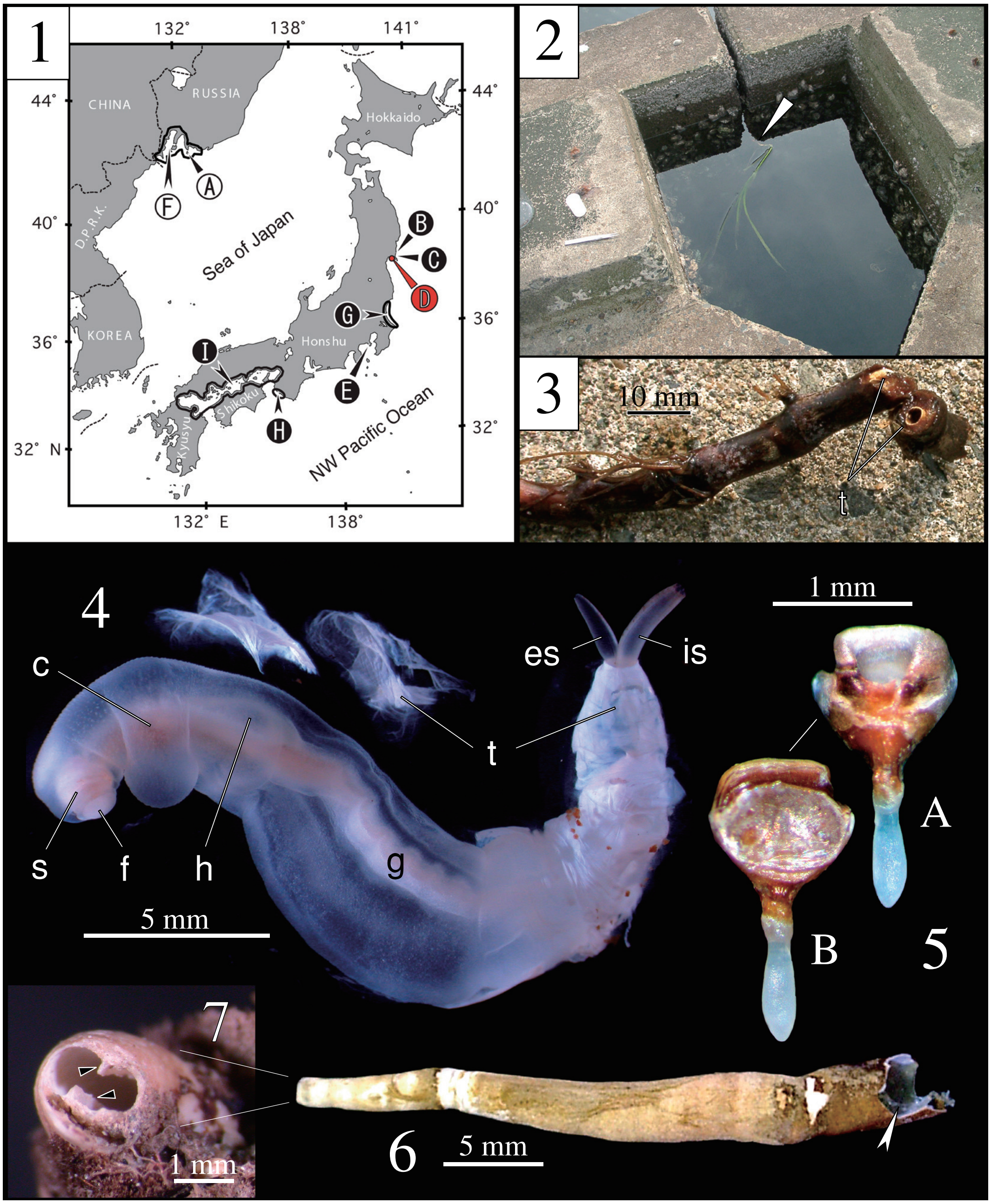

Fig. 1. Distribution of *Z. zenkewitschi*. **A.** Putyatin Island, Vladivostok, the type locality (Bulatoff & Rjabtschikoff, 1933). **B.** Shizugawa Bay, Miyagi Prefecture (this report). **C.** Same-ura Bay, Miyagi Prefecture (Sasaki *et al*., 2006). **D.** Ishinomaki, Miyagi Prefecture (this report). **E.** Aburatsubo, Kanagawa Prefecture (this report; specimen from Mr. Hayase). **F.** Peter the Great Bay (Turner *et al*., 1983). **G.** Ibaraki Prefecture (Kano, 1981). **H.** Wakayama Prefecture (Kuroda *et al*., 1981). **I.** Seto Inland Sea (Inaba, 1982). Open and closed circles indicate the occurrences with *Phyllospadix* and *Zostera* eelgrass, respectively. **Fig. 2.** Floating eelgrass *Z. marina* (arrowhead) with *Z. zenkewitschi*, Ishinomaki, Miyagi Prefecture. **Fig. 3.** Rhizome of *Z. marina in situ* with an exposed tube of *Z. zenkewitschi*. **Fig. 4.** Live animal with a regenerated tube. **Fig. 5.** Pallet: **A**, external; **B**, internal. **Fig. 6.** Calcareous tube with a cellophane-like membrane (arrowhead). **Fig. 7.** Posterior tip of a tube with a pair of internal blades (arrowheads). See text for abbreviations.

ments, but instead, bores by retraction of the foot and twisting of the anterior part of the body. The tips of the inhalant (is) and exhalant (es) siphons are pigmented with bright red spots. The inhalant siphon extends about 1.5–2 times longer than the exhalant siphon, and has a serrated tip. The pallets are minute and consist of a stalk and a cuneiform blade that is covered with brownish periostracum (Fig. 5). The calcareous tube is grayish and thick (Fig. 6), and bears a pair of lateral "blades" positioned at the posterior end of the interior surface (Fig. 7; arrowheads). The blades are rather obscure in young individuals.

Implications for long-distance dispersal

Z. zenkewitschi is recorded as living mostly inside full grown, thick rhizomes of *Phillospadix iwatensis* in Primoriye (Turner *et al*., 1983), whereas in Japanese waters it is found in the rhizomes of *Zostera marina* (Inaba, 1982; Kano, 1981; Kuroda & Habe, 1981; Sasaki *et al*., 2006). Turner *et al*. (1983) observed that some animals inhabited rhizomes exposed above the substrate in Primoriye. Likewise *Z. zenkewitschi* was present in exposed rhizomes of *Zostera caulescens* in Shizugawa Bay. Animals living in such an environment are usually prone to drift over long distances when the host rhizomes break off or are uprooted from the natural bed by strong waves or other agents.

Kiyashko (1986) reported that *Z. zenkewitschi* fed mainly on organic matter originating from the host rhizome. Turner *et al*. (1983) observed that it can also resist starvation for three months and can tolerate temperature changes from −1.5 C° to 28 C°. Rafting by drifted algal fronds and seagrass is a well-known agent for long-distance transportation of marine benthic organisms that develop directly or have short-lived planktonic larvae (e.g. Johannesson, 1988). A good example is the cosmopolitan breeding brittle star *Amphiphilis squamata*, whose dispersal occurs through passive transport by drifting fronds of macroalgae (Sponer & Roy, 2002). It is therefore highly probable that rhizomes of eelgrass also can drift over long distances and can transport live *Z. zenkewitschi* far from their original habitats.

The reproductive method of *Z. zenkewitschi* may also have an advantage in establishing new populations in stranded areas even if drifting rarely occurs, because the female always harbors many dwarf males necessary for reproduction. Bulatoff & Rjabtschikoff (1933) and Turner *et al*. (1983) observed that a transparent cellophane-like membrane covers the animal almost entirely except for the foot and siphons, and weakly adheres to the interior surface of the tube (Fig. 6, arrowhead). This structure is absent in all other teredinids (unpublished observation). In the laboratory, a living animal was removed from the rhizome to observe the regeneration of the calcareous tube. The animal quickly produced a membrane around the body, and almost simultaneously deposited calcareous material on the surface of that membrane (Fig. 4, t). This membrane, therefore, appears to play a role in protecting the animal's body when it is accidentally exposed.

In conclusion, the observation reported herein presents direct evidence supporting Turner & Yakovlev's (1983) hypothesis that *Z. zenkewitschi* can be dispersed widely by drifting of the host eelgrass.

Acknowledgements: I thank Mr. A. Dazai, Drs. K. Tanaka and Y. Yokohama (Shizugawa Nature Center) who provided the material from Shizugawa Bay; Mr. Y. Hayase (Tokai Aquanauts Ltd.) for the donation of his specimen; Drs. M. Aoki, N. Kumagai and Mr. A. Ito (Shimoda Marine Research Center, University of Tsukuba), Dr. S. Nishihama (Seikai National Fisheries Research Institute), Dr. T. Kase (National Science Museum) and Dr. T. Sasaki (The University Museum, The University of Tokyo) for helpful discussions.

References

Bulatoff, G. A. & Rjabtschikoff, P. I. 1933. Eine neue Gattung aus der Familie der Teredinidae aus dem Japanischen Meer. *Zoologischer Anzeiger* 104: 165–176.

Drozdov, A. L., Ferraguti, M. & Yakovlev, Y. M. 1999. The fine structure of spermatozoa of the bivalve *Zachsia zenkewitschi*. *Russian Journal of Marine Biology* (*Biologiya Morya*) 25: 65–67.

Higo, S., Callomon, P. & Goto, Y. 1999. *Catalogue and Bibliography of the Marine Shell-bearing Mollusca of Japan*. 749 pp., 5 maps. Elle Scientific Publications, Osaka, Japan.

Inaba, A. 1982. *Molluscan fauna of the Seto Inland Sea, Japan*. 181 pp., 4 pls. Hiroshima Shell Club, Hiroshima, Japan. (in Japanese)

Johannesson, K. 1988. The paradox of Rockall: why is a brooding gastropod (*Littorina saxatilis*) more widespread than one having a planktonic larval dispersal stage (*L. littorea*)? *Marine Biology* 99: 507–513.

Kano, K. 1981. Shell-bearing Molluscan Fauna in Ibaraki Prefecture. *In*: Biology Division of Highschool Education Society of Ibaraki Prefecture (eds.), *Ibaraki-no-Seibutsu. No. 2*, pp. 296-309. Ibaraki, Japan. (in Japanese)

Kiyashko, S. I. 1986. The diet of *Zachsia zenkewitschi* (Bivalvia: Teredinidae), investigated by the ^{13}C:^{12}C method. *Asian Marine Biology* 3: 139–143.

Kuroda, T. & Habe, T. 1981. A catalogue of molluscs of Wakayama Prefecture, the Province of Kii. I. Bivalvia, Scaphopoda and Cephalopoda. *Seto Marine Biological Laboratory*, *Special Publication Series* 7(1): 1–301.

Röder, H. 1977. Zur Beziehung zwischen Konstruktion und Substrat bei mechanisch bohrenden Bohrmuscheln (Pholadidae, Teredinidae). *Senckenbergiana Maritima* 9: 105–213.

Sasaki, T., Nishi, E., Muraoka, D. & Tamaki, H. 2006. Occurrence of the rare boring bivalve *Zachsia zenkewitschi* (Bivalvia: Teredinidae) from Oshika, Miyagi Prefecture, Japan. *Chiribotan* 36: 136–139. (in Japanese)

Sponer, R. & Roy, M. S. 2002. Phylogeographic analysis of the brooding brittle star *Amphipholis squamata* (Echinodermata) along the coast of New Zealand reveals high cryptic genetic variation and cryptic dispersal potential. *Evolution* 56: 1954–1967.

Turner, R. D. & Yakovlev, Y. M. 1983. Dwarf males in the Teredinidae (Bivalvia, Pholadacea). *Science* 219: 1077–1078.

Turner, R. D., Yakovlev, Y. M. & Karaseva, E. M. 1983. Some aspects of the life history of *Zachsia zenkewitschi* (Teredinidae, Bivalvia). *Biologiya Morya* 5: 27–34. (in Russian) [English translation in *The Soviet Journal of Marine Biology*. Plenum Publishing Corporation. 1984. 257–264.]

Yakovlev, Y. M., Drozdov, A. L. & Ferraguti, M. 1998. Peculiarities of reproduction and gamete structure of the shipworm *Zachsia zenkewitschi* (Bivalvia; Teredinidae). *Korean Journal of Malacology* 14: 1–8.

(Accepted April 24, 2006)

漂流するアマモから得られたネムグリガイ

芳賀拓真

ネムグリガイ *Zachsia zenkewitschi* Bulatoff & Rjabtschikoff, 1933 は，スガモ *Phyllospadix iwatensis* やアマモ *Zostera marina* などの海草の地下茎に穿孔するフナクイムシ科の二枚貝である。本種は極端な性的二型を示し，幼生の浮遊期間は極めて短いことが知られている。本種の広範囲な分散は，成体がホストである海草とともに漂流することに起因するという説がある。筆者は宮城県石巻漁港において，漂流しているアマモの地下茎中より本種の生体を発見し，上記の説を支持する初めての直接的な証拠を得た。本種は主に海底から露出する地下茎に生息するため，ホストである海草とともに漂流する機会が多いと思われる。また，雌が矮小雄を保育するため，1 個体の雌が漂流するだけでも，遠隔地に新たな個体群を確立させることができるだろう。本種はさらに，地下茎そのものを主な餌とし，セロファン質の膜が軟体の周囲を覆うという特徴がある。それらの特徴は，餌の欠乏や地下茎の物理的損傷など，漂流中の環境ストレスに対して有利にはたらくと考えられる。