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CONSERVATION ECOLOGY OF THE BRACKISH WATER DAMSELFLY, *MORTONAGRION HIROSEI* ASAHINA: DYNAMICS OF A NEWLY ESTABLISHED REED COMMUNITY (ZYGOPTERA: COENAGRIONIDAE)

M. MORIMOTO[1], Y. YAMAMURA[2*] and M. WATANABE[3]
[1] Graduate School of Science and Engineering, Ibaraki University, Mito, Ibaraki 310-8512, Japan
[2] College of Science, Ibaraki University, Mito, Ibaraki 310-8512, Japan; – yama@mx.ibaraki.ac.jp
[3] Institute of Biological Sciences, University of Tsukuba, Tsukuba, Ibaraki 305-8572, Japan

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The endangered *M. hirosei* perches in the understory of dense reed communities in brackish water. To aid the conservation of a population, a new reed community (2110 m^2) was established in abandoned rice paddy fields adjacent to the original, threatened community (500 m^2) by transplanting reed rhizomes in January 2003; brackish water was supplied to the new community. It was assessed whether the new community developed into a suitable habitat for *M. hirosei* by comparing it to the original community in 2005. Shoot height, density, and aboveground biomass of the reeds and relative light intensity in the community were measured periodically during the growing season. Reed height and biomass were significantly lower in the new community than in the original one. This suggests that 3 yr after transplantation the new community was still underdeveloped. However, shoot density and relative light intensity in the understory were not significantly different between the two communities. Thus, the new reed community was offered in 2005 to *M. hirosei* adults as a suitable habitat.

INTRODUCTION

The endangered *Mortonagrion hirosei* Asahina inhabits reed [*Phragmites australis* (Cav.) Trin. ex Steudel] communities in brackish water (HIROSE, 1985). This species does not perform a maiden flight (WATANABE & MIMURA, 2003), and adults remain in the understory of the reed community throughout their lives, reproducing there (HIROSE & KOSUGE, 1973; SOMEYA, 1998; FUKUI & KATO, 1999; WATANABE & MIMURA, 2004). Therefore, the loss of brack-

* **Corresponding author**

ish reed communities contributes to local extinctions of the species.

In 1998, a *M. hirosei* population was discovered in a small community (surface ca 500 m^2) on a narrow stream in the construction site of the Miyagawa Ryuuiki Sewage Plant in the city of Ise, Mie prefecture, Japan (WATANABE et al., 2002; WATANABE & MIMURA, 2003). A total of about 5,000 adults inhabited this community (WATANABE & MIMURA, 2003). Brackish water conditions in the community had been maintained by the supply of freshwater from upstream and seawater from downstream. When the sewage plant is functional, it will interfere with the supply of fresh water, resulting in the extinction of this damselfly population, due to increased salinity and/or increased sediment and litter deposition in the community. Therefore, the government of Mie prefecture decided not only to preserve the original habitat, but also to establish a new habitat to aid in the conservation of this population.

M. hirosei adults perch mainly on live and dead shoots of reeds, preferring the tips of broken stems or the dead blades of reeds 20 cm above the water surface. Further, they show little flight activity (WATANABE & MIMURA, 2004). The perch sites have a relative light intensity of about 10% and a max total shoot density (living and dead standing shoots) of 440 m^{-2} (WATANABE et al., 2002). Based on these facts, in January 2003, reed rhizomes were transplanted into abandoned rice paddy fields adjacent to the original community to create a new habitat for *M. hirosei*.

Mitigation plans have recently become more common for conserving species in developed areas. However, an analysis of 43 habitat conservation plans in the United States found that most included little information about habitat quantity and quality (HARDING et al. 2001). In this study, we investigated the growth and microenvironment of the newly established community to evaluate its development relative to the original community. This allowed us to evaluate the suitability of the new community as *M. hirosei* habitat.

STUDY SITES AND METHODS

Mortonagrion hirosei inhabits only a few isolated reed communities in Ise (WATANABE & MIMURA, 2004). The construction site of the Miyagawa Sewage Plant, located in an estuary of the Miyagawa River, was surrounded by rice paddy fields (34°31' N, 136°44' E). The original reed community was in a narrow stream at the site, where water depth was less than 5 cm and salinity averaged 10‰, with a maximum of 20‰ (WATANABE et al., 2002).

In January 2003, reed communities with shoot densities similar to the original community were identified. Soil blocks (20 cm deep, 1.6 m wide, and 0.6 m long) including reed rhizomes connected to dead shoots (cut 50 cm above the ground) were transported from these communities to an abandoned rice paddy fields (2110 m^2) adjacent to the original community (Fig. 1). The soil blocks were densely laid on the abandoned rice paddy fields. Artificial brackish water, a mixture of sea water and tap water, is supplied to the new reed community from three inflow sites on the west side (Fig. 1). The salinity of the artificial brackish water is regulated to an average of 10 ‰, not to exceed 20‰.

We established five quadrats (50 × 50 cm) both in the original community and in the new community

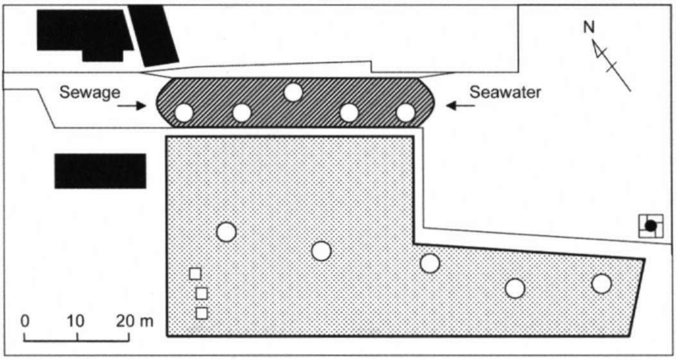

Fig. 1. The locations of the study sites. The original and established reed communities are shown by striped and doted areas, respectively. Sewage freshwater from west and seawater from east are supplied to the original community. Artificial brackish water, a mixture of seawater drawn from near the original community with tap water, is supplied to the new reed community from three inflow systems. Open circles show quadrats for investigation of reed growth process. Black areas show private houses.

(Fig. 1). In each quadrat, we marked all reed shoots and measured shoot density, height (H), and diameter at ground level (D). Aboveground biomass in each quadrat was estimated by the allometric relationship between D^2H and the dry weight of sampled shoots during the flight season of *M. hirosei* (late May to early August) in 2005. Light intensity was measured 20 cm above the water level in the community and simultaneously in a nearby open site with a digital luxmeter (IM-5, TOPCON) within 2 h of noon on cloudy days. Relative light intensity (RLI) was calculated as the ratio of light intensity in the community to light intensity in the open site. These measurements were taken at least once a month from April to October in 2003, 2004, and 2005.

RESULTS

COMMUNITY HEIGHT

In 2003, shoot growth began in early April in the original community. Reed height was 73 ± 3 (SE) cm in late April, and then increased gradually to 100 cm by mid-July (Fig. 2a). Reed height decreased in September because of shoot tip breakage. Most of the reed shoots were standing dead in October. In the new community, however, shoot growth was delayed and reed height was only 18 ± 1 cm in late April. In late May, when adult *M. hirosei* emerge, reed height was 40 cm, and then increased gradually to 60 cm by mid-September. Reed height in the new community was significantly lower than in the original community throughout the 2003 growing season ($p<0.001$, Mann-Whitney U test).

In 2005, the height of the original community in late April was 90 ± 2 cm, and then increased gradually to 160 cm by early July (Fig. 2b). The height of the new community was 88 ± 1 cm in late April, and increased to 140 cm in early July.

Reed height in the new community was significantly lower than in the original community from late May to early August 2005 ($p<0.001$, Mann-Whitney U test).

ABOVEGROUND BIOMASS

In 2005, the estimated aboveground biomass of the original community was 1067 ± 78 (SE) g m^{-2} in late May and 1285 ± 91 g m^{-2} in early August. Aboveground biomass of the new community was 744 ± 87 g m^{-2} in late May and 1321 ± 177 g m^{-2} in early August. Aboveground biomass differed significantly between the two communities in late May ($p<0.05$, Mann-Whitney U test) but not in early August ($p>0.05$, Mann-Whitney U test).

SHOOT DENSITY

In 2003, shoot density in the original community was 176 ± 40 (SE) m^{-2} in late April, and averaged 244 ± 15 m^{-2} during the *M. hirosei* flight season (Fig. 3a). Shoot density in the new community was 126 ± 26 m^{-2} in late April. The shoot density averaged 284 ± 13 m^{-2} during the flight season and increased until mid-September. Shoot density did not differ between the two communities during the growing season ($p>0.05$, Mann-Whitney U test), except in October ($p<0.05$, Mann-Whitney U test).

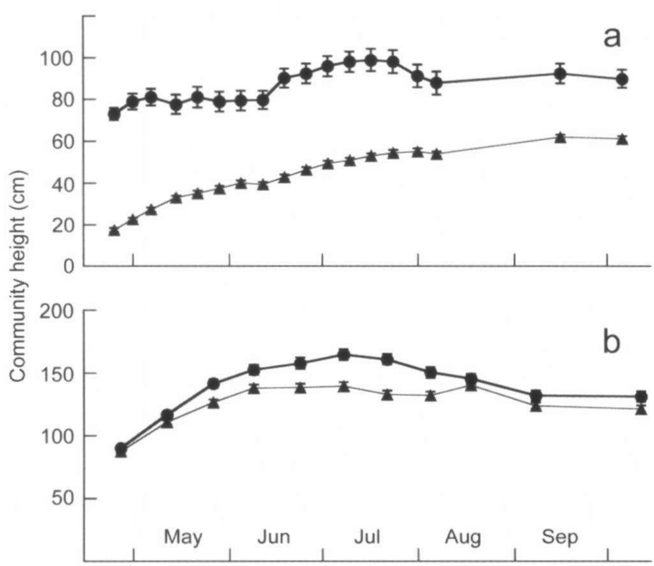

Fig. 2. Seasonal changes in community height in 2003 (a) and 2005 (b) (mean ± SE). Circles and triangles show the original and established reed community, respectively.

In 2005, shoot density in the original community was 228 ± 20 m^{-2}, with little change throughout the growing season (Fig. 3b). Shoot density in the new community was 250 ± 19 m^{-2} from late April to early August, and then decreased until the end of the growing season. Shoot density did not differ between the two communities ($p<0.05$, Mann-Whitney U test).

LIGHT CONDITIONS IN REED COMMUNITIES

The canopy of the reed communities created shade in the understory. In 2003, RLI 20 cm above the water level in the original community was about 40% in late April and decreased to 10% by late June. Mean RLI during the flight season was 20% (Fig. 4a). RLI in the new community was about 90% in late April and decreased until the end of growing season. RLI in the new community was significantly higher than in the original community from late April to late July ($p<0.05$, Mann-Whitney U test).

In 2005, RLI in the original community was about 20% in late April and about 6% after late May (Fig. 4b). RLI in the new community was about 20% in late April, decreased to 6% by late May, and increased gradually after early August. RLI in the new community was not significantly different than in the original community from late April to mid-August ($p>0.05$, Mann-Whitney U test).

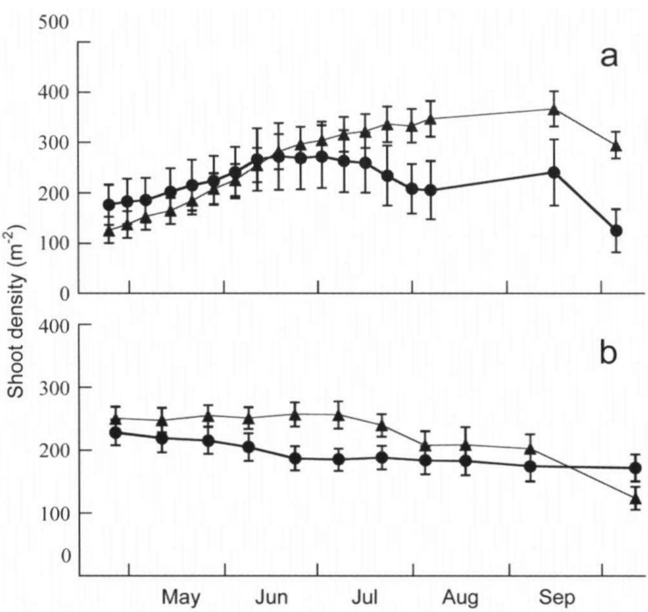

Fig. 3. Seasonal changes in shoot density of reed community in 2003 (a) and 2005 (b) (mean ± SE, n = 5). Circles and triangles show the original and established reed community, respectively.

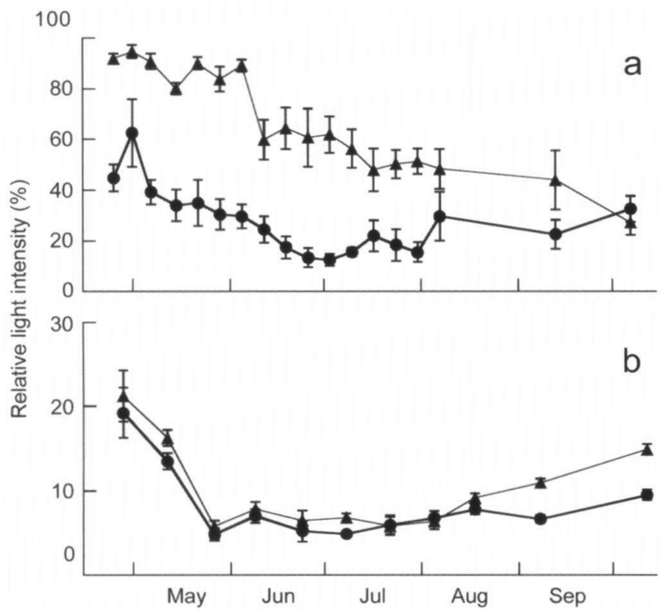

Fig. 4. Seasonal changes in relative light intensity 20 cm above the water level in 2003 (a) and 2005 (b) (mean ± SE, n = 5). Circles and triangles show the original and established reed community, respectively.

DISCUSSION

M. hirosei adults perch in the understory of dense reed communities where RLI is about 10% (WATANABE et al., 2002). In such dense communities, odonate species with low flight activity, such as *M. hirosei*, are able to move among perches (WATANABE & MIMURA, 2004), whereas species with higher flight activity, such as the predatory *Ischnura senegalensis* (Rambur), are not be able to move freely (NISYU, 1997). Therefore, suitable communities for adult *M. hirosei* should have high shoot density and a shaded understory. We found that newly created communities may not initially be suitable habitat for *M. hirosei*, but become more suitable as the communities develop.

In the first growing season after transplantation (2003), the new community had a higher number of shorter shoots than the original community. This growth pattern is thought to be a response to stress that occurs when reeds are damaged (CLEVERING, 1999; ARMSTRONG et al., 1996a, 1996b), suggesting that the transplantation process damaged the reed growth. This underdeveloped reed community resulted in higher light intensity in the understory during the flight season of *M. hirosei*. MATSU'URA & WATANABE (2004) found that *Anax parthenope julius* Brauer, *Orthetrum albistylum speciosum* (Uhler), and *Sympetrum* spp. oviposited in a newly created community. Many adult *I. senegalensis*, *I. asiatica* Brauer, and *Mortonagrion selenion* (Ris) were observed in the community during the first year of our study. Consequently, the new community seemed to be an unsuitable habitat for adult *M. hirosei* during the first year because it provided other odonate species with the open space they need for flight. For *M. hirosei*, it is necessary to maintain a higher shoot density without mowing dead standing shoots (MATSU'URA & WATANABE, 2004).

In the third year after transplantation (2005), the reeds in the new community were still shorter than those in the original community during the flight season of *M. hirosei*, although the new community was taller than it was in 2003. In the new community, low RLI in the understory (less than 10%) was maintained during the flight season of *M. hirosei*, as was a high shoot density. Consequently, the new community was a more suitable habitat for adult *M. hirosei* in 2005 than it was in 2003. The growth rate of spring shoots in the new community may be lower than that in the original community because the total aboveground biomass of the new community was lower than that of the original community in late May. Spring shoots grow using materials stored in the rhizome (GRANÉLI et al., 1992). If stored materials were used to recover from damage suffered during transplantation, they may have been less available for spring shoot growth in the new community. Newly formed rhizomes grow by the second year after transplantation and store materials for spring shoot growth after the third year (YUTANI & ASAEDA, 2002; ASAEDA et al., 2006). Thus, rhizomes formed after transplantation will act as storage organs after 2005, suggesting that the new community will develop further in the coming years. We expect that the new community will become an even more suitable habitat for *M. hirosei* after 2006.

YAMANE and colleagues (2004) transplanted reed rhizomes to conserve a *M. hirosei* population in a wetland along the Tone river in eastern Japan. There, the height of the new community was similar to that of the original one during the first year after transplantation, and adult *M. hirosei* were observed in the new community. However, 5 years later, no *M. hirosei* were observed in the community. Therefore, continuous monitoring of the reed community and the *M. hirosei* population are necessary in our new community. This study suggests that quantitative monitoring of the environmental conditions within a newly created habitat is necessary for the successful conservation of endangered species.

REFFERENCES

ARMSTRONG, J., W. ARMSTRONG, I. B. ARMSTRONG & G. R. PITTAWAY, 1996a. Senescene and phytotoxin, insect, fungal, fungal and mechanical damage: factors reducing convective gas-flows in Phragmites australis. *Aquat. Bot.* 54: 211-226.

ARMSTRONG, J., W. ARMSTRONG & W. H. VAN DER PUTTEN, 1996b. Phragmites die-back: bud and root death, blockages within the aeration and vascular systems and the possible role of phytotoxins. *New Phytol.* 133: 399-414.

ASAEDA, T., J. MANATUNGE., J. ROBERTS & D. N. HAI, 2006. Seasonal dynamics of resource translocation between the aboveground organs and age-specific rhizome segments of Phragmites australis. *Environ. exp. Bot.* 57: 9-18.

CLEVERING, O. A., 1999. The effects of litter on growth and plasticity of Phragmites australis clones originating from infertile, fertile or eutrophicated habitats. *Aquat. Bot.* 64: 35-50.

FUKUI, J. & T. KATO, 1999. Life history of Mortonagrion hirosei in the estuary of Toda river. *Suruga-no-Kontyu* (185): 5170-5178. – [Jap.]

GRANÉLI, W., S. E. B. WEISNER & M. D. SYSTMA, 1992. Rhizome dynamics and resource storage in Phragmites australis. *Wetlands Ecol. Mngmt* 1: 239-247.

HARDING, E. K., E. E. CRONE, B. D. ELDERD, J. M. HOEKSTRA, A. J. MCKERROW, J. D. PERRINE, J. REGETZ, L. J. RISSLER, A. G. STANLEY, E. L. WALTERS & NCEAS HABITAT CONSERVATION PLAN WORKING GROUP, 2001. The scientific foundations of habitat conservation plans: a quantitative assessment. *Conserv. Biol.* 15: 488-500.

HIROSE, M. 1985. The present state of Mortonagrion hirosei, a new species of dragonfly first discovered in 1971. *Collecting Breed.* 47: 390-391. – [Jap.]

HIROSE, M. & T. KOSUGE, 1973. Life history of Mortonagrion hirosei in Hinuma pond, Ibaraki Prefecture. *Nature & Insects* 8(4): 2-6. – [Jap.]

MATSU'URA, S. & M. WATANABE, 2004. Dynamics of reed community artificially established for conservation of the endangered damselfly Mortonagrion hirosei and odonate larvae inhabiting the community. *Jap. J. Conserv. Ecol.* 9: 165-172

NISHU, S., 1997. Life history and habitat of Mortonagrion hirosei. *Midori-no-Tokuhon* 43: 811-816. – [Jap.]

SOMEYA, T., 1998. The present state of the damselfly, Mortonagrion hirosei. *Nature & Insects* 33(10): 4-8. – [Jap.]

WATANABE, M. & Y. MIMURA, 2003. Population dynamics of Mortonagrion hirosei (Odonata: Coenagrionidae). *Int. J. Odonatol.* 6: 65-78.

WATANABE, M. & Y. MIMURA, 2004. Diurnal changes in perching sites and low mobility of adult Mortonagrion hirosei Asahina inhabiting understory of dense reed community (Zygoptera: Coenagrionidae). *Odonatologica* 33: 303-313.

WATANABE, M., Y. MIMURA & T. HIGASHI, 2002. Ecological studies on habitat establishment for threatened brackish water damselfly, Mortonagrion hirosei: microclimate of the habitat. *Annu. Rep. interdiscipl. Res. Inst. environ. SCI.* 21: 47-58. – [Jap., with Engl. s.]

YAMANE, S., S. KOJIMA & S. SATO, 2004. Preparation of a substitute habitat for the damselfly Mortonagrion hirosei (Odonata: Coenagrionidae) at the construction site of Tone-Kamome Bridge over the Tone river. *Bull. Ibaraki nat. Mus.* 7: 45-61.

YUTANI, K. & T. ASAEDA, 2002. Effects of rhizome age of Phragmites australis on the characteristics of rhizome resource storage. *J. Jap Soc. Water Environ.* 25: 685-688.