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Patterns of Local Distribution and Coexistence of Two Giant Water Bugs, *Diplonychus japonicus* and *D. major* (Hemiptera, Belostomatidae) in Okayama, Western Japan

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Abstract Patterns of local distribution of *D. japonicus* and *D. major* in Okayama, Japan were investigated. The two species occurred in different habitats and seldom coexisted. The main factor causing such an exclusive distribution could be a difference in preferred water temperature between the two species. *D. japonicus* lived in warmer habitats than *D. major*. In a few sites where water temperature was intermediate between the preferred habitats of the two species, they were found co-existing.

Key words: Local distribution; giant water bug; *Diplonychus japonicus*; *D. major*; Okayama.

Introduction

Two species of giant water bugs, *Diplonychus japonicus* VUILLEFROY, 1864, and *D. major* ESAKI, 1934 (Hemiptera, Belostomatidae), are distributed in Honshu Island in Japan (HIURA, 1977). ICHIKAWA (1985) has suggested that *D. japonicus* occurs in lowland regions and *D. major* in hills or mountains. However, the habitat utilization by these species has been scarcely studied.

In this paper, we report a difference in the local distribution pattern between *D. japonicus* and *major* in Okayama, western Japan, and discuss the factors affecting their habitat preference.

Materials and Methods

To compare the distribution pattern between *D. japonicus* and *D. major*, we investigated seasonal occurrence of the two species in 7 sites in Okayama, western Japan. The habitat conditions of each census site are shown in Table 1.

Censuses were carried out in Hyakkengawa, Kachi, Kanayama, Kuko and Tsuboi in 1989 and in Nadasaki in 1990. We collected adult bugs by sweeping with a net (30 cm in diameter) 30 times and repeated this procedure 4 or 5 times a

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Table 1. Topographical characters and flora of the census sites.

	Census site		
	Hyakkengawa	Kachi	Nadasaki
Topography	A riverside temporary pool 160 m ² in surface area	A canal 5 m in width running through a pasture land and connected with a river	An abandoned paddy field in a reclaimed land, draining in summer and utilized as a upland field in autumn and winter
Altitude	0 m	0 m	0 m
Period of wetting	April–October	All the year round	June–October
Source of water	Rain fall only	Inflow from a river	Inflow from water way
Depth of water at the center of census area	30–50 cm	> 100 cm	0–40 cm
Flora	<i>Typha</i> sp. and <i>Marsilea quadrifolia</i> predominating in surrounding areas	<i>Pseudoraphis ukishiba</i> , <i>Hydrocharis morusus</i> and <i>Eichhornia crassipes</i> covering water surface	<i>Monochoria vaginalis</i> predominating during summer
Census area			
	Kanayama	Kuko	Tsuboi
Topography	Pond in a skirt of a mountain 120 m ² in surface area	Marsh in a hilly region	Abandoned paddy fields composed of 13 terraced fields in a small valley (each piece less than 50 m ²)
Altitude	310 m	150 m	180 m
Period of wetting	All the year round	All the year round	All the year round
Source of water	Inflow from springs	Inflow from springs	Inflow from springs
Depth of water at the center of census area	50–80 cm	20–30 cm	20–70 cm
Flora	<i>Trapa natans</i> covering the water surface and <i>Ameiema keisak</i> and submerged terrestrial plants covering the edge	<i>Sphagnum</i> sp. covering the edge of water and the bottom of shallow area	<i>Sasa</i> sp. covering the bank and the marginal zone, and a small patch of <i>Typha</i> spp. growing in the water

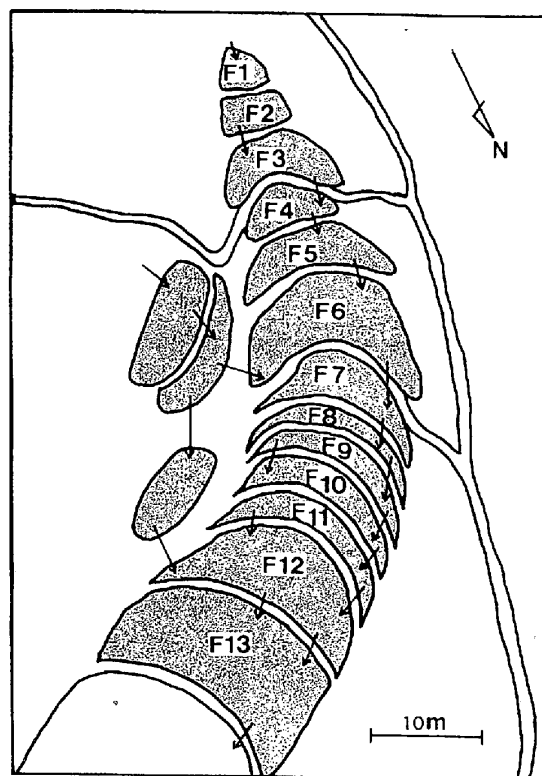


Fig. 1. Map of the paddy fields in Yuge. Arrows show inflows of water.

month in the former 4 sites and 10 times a month in Tsuboi from April to September. In Nadasaki, we collected bugs once or twice a month from July to September.

Yuge, one of our study sites, was composed of 13 shallow paddy fields as shown in Fig. 1. We collected adult bugs by searching with our eyes for 30 minutes census twice a month in each paddy field from June to September in 1988. The collected bugs were identified and released immediately.

Water temperatures were measured each time when census was carried out in all sites except Nadasaki. In Yuge, temperatures were measured in 4 paddy fields, F2, F6, F11 and F13 in 1989.

Results

The total number of collected bugs and the relative abundance of each species in each site are shown in Table 2. Although more than 30 bugs were collected in each site, there was no site where the two species lived together except for Yuge. *D. japonicus* lived in low lands of Hyakkengawa, Kachi and Nadasaki, while *D. major* occurred in hills or mountainous regions such as Kanayama, Kuko, Yuge and Tsuboi. The relative abundance of each species in Yuge was shown in Table 3. Though both species were found together in lower paddy fields, the proportion

Table 2. Relative abundance of *D. japonicus* and *D. major* in each census site.

Census site (Year)	Number of collected bugs	Percentage		Mean water temp. (C°) ¹⁾
		<i>D. japonicus</i>	<i>D. major</i>	
Hyakkengawa (1989)	94	100	0	22.2
Kachi (1989)	95	100	0	22.3
Nadasaki (1990)	31	100	0	—
Kanayama (1989)	46	0	100	19.6
Kuko (1989)	76	0	100	18.6
Yuge (1988)	807 ²⁾	0.7	99.3	19.1
Tsuboi (1989)	991	0	100	17.8

1) Average from March through September. Temperature in Yuge is the mean among F2, 6, 11 and 13.

2) Total number of bugs collected in 13 paddy fields.

Table 3. Relative abundance of *D. japonicus* and *D. major* in each paddy field in Yuge, 1988.

Paddy field ¹⁾	Number of collected bugs	Percentage		Mean water ²⁾ temp. (C°)
		<i>D. japonicus</i>	<i>D. major</i>	
F 1	10	0	100	—
F 2	11	0	100	18.4
F 3	27	0	100	—
F 4	41	0	100	—
F 5	82	0	100	—
F 6	74	0	100	18.7
F 7	90	0	100	—
F 8	43	0	100	—
F 9	49	0	100	—
F10	103	0	100	—
F11	52	3.8	96.2	19.7
F12	148	2.7	97.3	—
F13	77	0	100	21.0

1) Location of each paddy field was shown in Fig. 1.

2) Average from March through September, 1989.

of *D. japonicus* was much smaller than that of *D. major*.

Figure 2 shows seasonal fluctuations in water temperature in each census site. In April through July, water temperature in low land regions of Hyakkengawa and Kachi was about 3°C higher than that in hills or mountainous regions of Kanayama, Kuko and Tsuboi (Fig. 2 A). In Yuge, water temperature considerably differed among the individual paddy fields (Fig. 2 B) and it was higher in lower paddy fields.

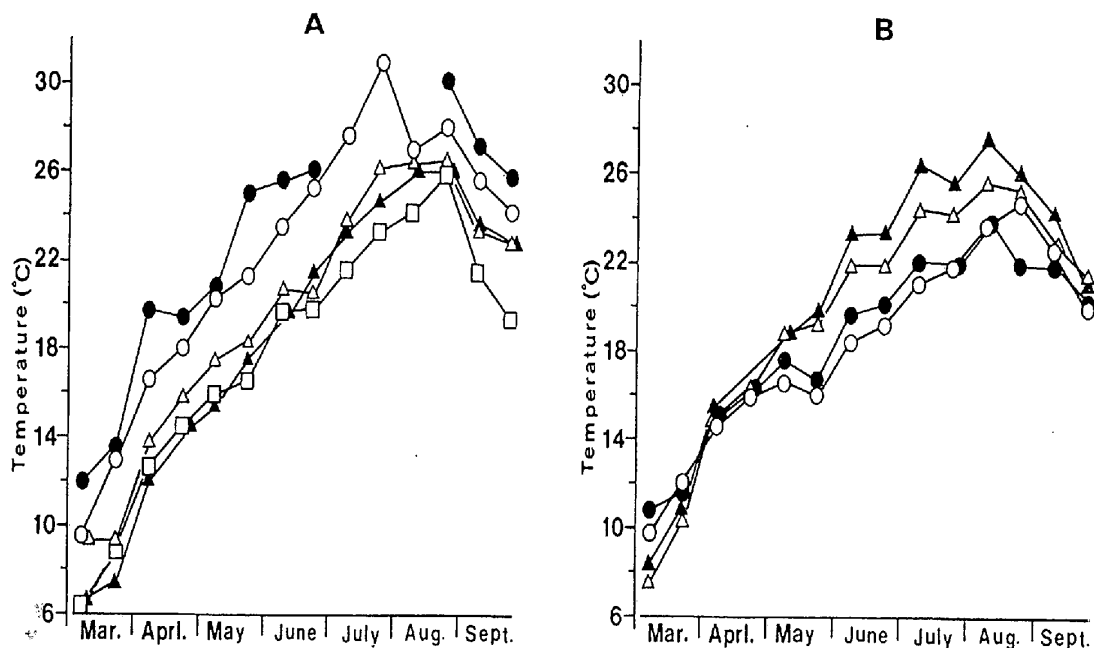


Fig. 2. Seasonal fluctuations in water temperature at census sites. A: temperatures in Hyakkengawa, Kachi, Kanayama, Kuko and Tsuboi (○, Hyakkengawa; ●, Kachi; △, Kanayama; ▲, Kuko; □, Tsuboi). The temperature in Kachi was not measured by accidents in July and early August. B: temperatures in the paddy fields in Yuge (○, F2; ●, F6; △, F11; ▲, F13).

Discussion

The present study compared the pattern of local distribution in *D. japonicus* and *D. major* in Okayama, Japan. *D. japonicus* predominated in low lands and *D. major* in hills or mountainous regions. Occurrence of *D. japonicus* and *D. major* in the same habitat has rarely been reported and the exclusive distribution seems to be common for these species. However, the present study indicates that they can coexist in certain habitats.

Water temperature is an important factor affecting development and reproduction in aquatic insects. In our study sites, the temperature is higher in low lands than in hills or mountainous regions (Fig. 2 A). Therefore, it is possible that the difference in patterns of distribution between *D. japonicus* and *D. major* is related to a difference in preference for water temperature between the two species. *D. major* might prefer relatively cool water and *D. japonicus* warm water. This hypothesis may also explain the difference in the pattern of geographic distribution between the two species; *D. major* occurs in northern parts of Japan, while *D. japonicus* is distributed mainly in southern parts of Japan (HIURA, 1977).

The two species were found together at F11 and F12 in Yuge where water temperature is intermediate between the levels in the habitats dominated by respective

species (Fig. 2 A and B). However, *D. japonicus* was much less abundant in those plots than expected from its preference for water temperature. It is likely that other factors such as interspecific competition and food availability may affect the relative abundance of the two species there, and this will be discussed elsewhere (OKADA, FUJISAKI & NAKASUJI, in press).

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