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P2-14 ENVIRONMENTAL ELEMENTS FOR RECOVERY AND CONSERVATION OF RIVERINE NATURE

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1. INTRODUCTION

Most Japanese streams have been altered into artificial channels for developing water resources and for preventing disasters. However, the recent social trends calling for 'amenity' and 'nature conservation' of riverfront areas have awoken the importance of 'biotic habitats'. And a good number of constructions aiming at 'a stream abounding with nature' have been tried in Japan. But most of the results seem to be insufficient for both recovery and conservation of biotic communities in streams. The recent trials to recover nature in streams have following problems: 1) the topography of channels is designed irrespective with geomorphology of original streams, 2) the target species for conservation are limited, 3) most of artificial habitats are insufficient for organisms to complete their life cycles, *e.g.*, fishways and shelters alone are not enough for the life cycles of fishes, and 4) the scenery of constructs using artificial matter such as concrete are far from the natural landscape. In order to solve these problems, environmental elements required for holding biotic communities have to be clarified by means of studies on the micro-geomorphology of natural streams and on the habitat use by riverine organisms.

2. METHODS

We conducted a series of field works at Takami Stream, a tributary of Yoshino River in Nara Prefecture, in March 1991 and April 1992. The study site abounded with the nature of Japanese middle streams. The microhabitat use of stream animals were investigated by "a mapping method" as follows. An observation area was established, in which a set of riffle and pool was included within 40 m in length. The stream geomorphology, vegetation, and environmental factors such as water depth, current velocity, and substratum types were measured at each grid of 1 x 1 m lattice sections in the observation area. Sampling sites and microhabitat use of stream animals were recorded on the detailed map of the area. Benthic animals were sampled quantitatively using a surver net with a 25 x 25 cm quadrat at 79 and 68 sites in March and April 1992, respectively. Mating and oviposition sites of mayflies, feeding and sheltering sites of fishes, and sheltering sites of singing-frogs were recorded. The microhabitats of benthic animals described in the present paper were based only on analyses of the quantitative samples of 41 sites in March 1991, since the other data had been under examination.

3. RESULTS AND DISCUSSION

Stream habitats have been considered in relation to the riffle-pool concept in Japan (1-4). Through our investigation, however, several types of microhabitats were detected even within a riffle or a pool, which corresponded to the micro-geomorphology of stream features. In this paper, we present some examples of microhabitats essential to stream animals and consider how we can recover and conserve such microhabitats in Japanese streams.

Figure 1 shows the micro-geomorphology of the observation area. There was a rapid at the middle stream and a pool situated downstream. Since the stream flow turned to the right in the area, the left shore line was faced to the highest current and the rock surface exposed all over the shore. On the other hand, the right shore was composed of accumulated sand and gravel which formed a bar at the middle area. The distribution of water depth was also asymmetrical. The maximum depth was recorded along the left shore line and the depth decreased gradually to the right shore.

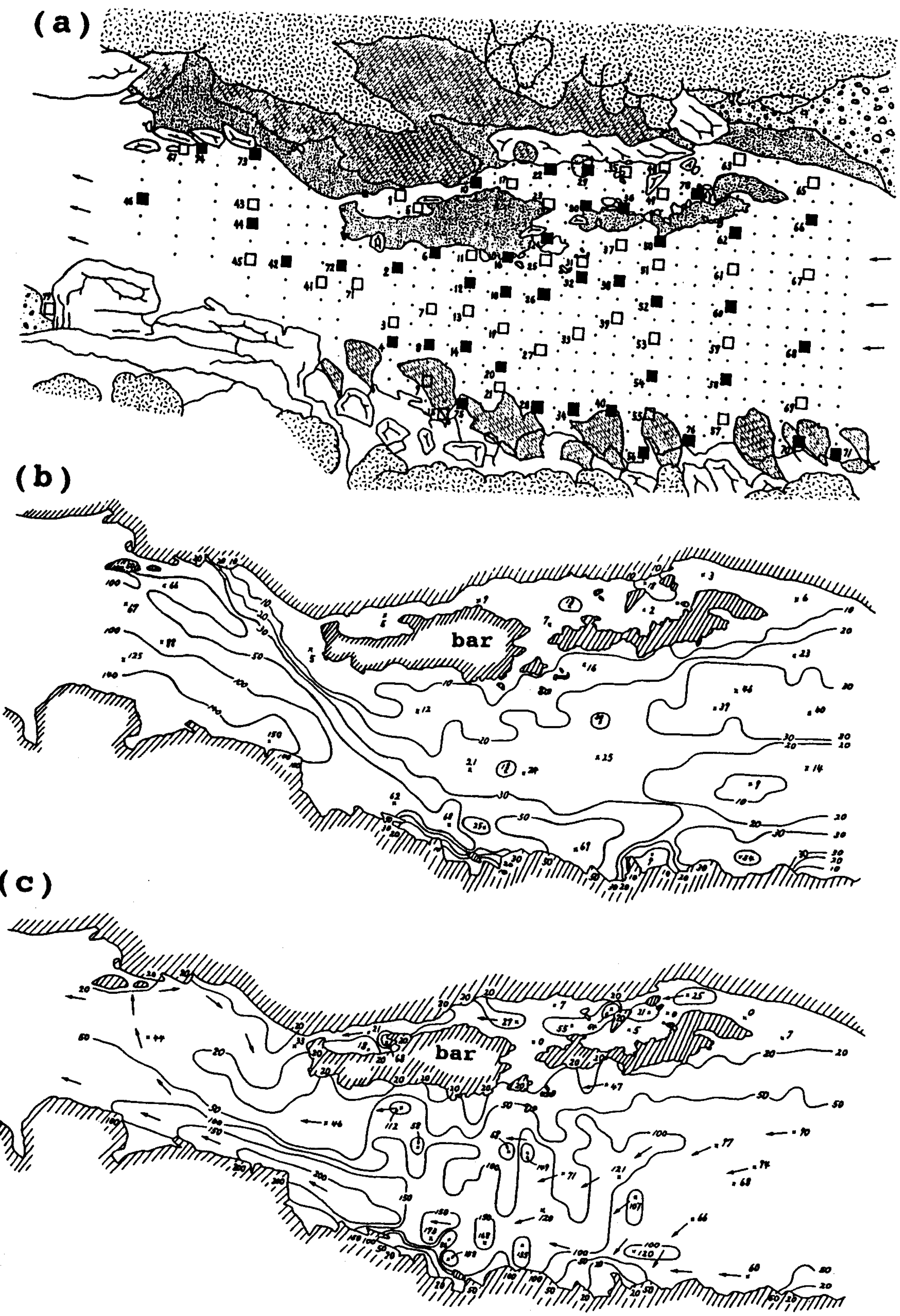
(a)
(b)
bar
(c)
bar

Figure 1. Maps of the observation area in Takami Stream in Yshino River measured on 12 March, 1991. (a) A map of the shore area and bankside vegetation. The dot, closed square, and open square in the open water represents the measuring site of environmental factors, sampling site of benthic animals not yet analysed, and that already analysed, respectively. The numerals beside the square show the sample numbers. The shaded areas with dots, with solid and broken lines, with broken lines, and the other open areas represent the sand and gravel ground, the bush of willow trees, tree canopies, and rocks, respectively. Arrows show the flow directions. (b) The distributional pattern of water depth (cm) in the observation area. The shaded area shows the shore land and the submerged stones. (c) The distributional pattern of current velocity (cm/sec) in the observation area. Arrows show the flow directions.

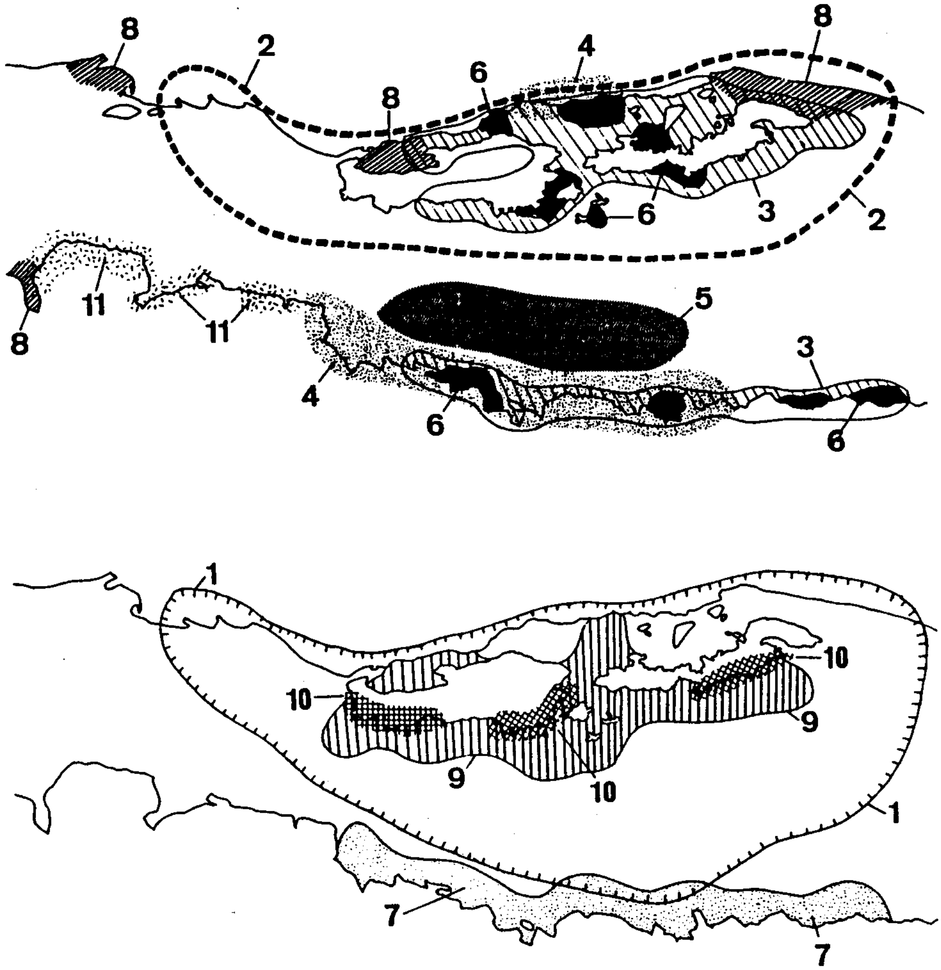

Figure 2. Micro-habitat distribution of stream animals detected by the quantitative sampling surveys and field observations in the study area in Takami Stream. The numerical order of each micro-habitat corresponds to that in the text for its explanation. The boundary of each micro-habitat was drawn by enclosing sites where each set of animals was collected or a particular behaviour was observed.

According to the asymmetrical features of the stream, the habitat distribution of benthic animals tended to be restricted to one side of the stream or a particular area within a riffle or a pool. Although the numerical data were unable to present here, the quantitative sampling of benthic animals and behavioural observation on mayflies, fishes, and singing-frogs revealed the following micro-habitats being distinctive in species composition of inhabitants and in their particular habitat use (Fig. 2).

1) **Hyporheic zone in accumulated debris:** The young mayfly nymphs of *Paraleptophlebia chocorata* Imanishi and *Drunella yoshinoensis* (Gose), were collected widely from the sites of accumulated debris. The hyporheic zone, the micro-habitat of interstitial water in debris, seems to be important for the habitats of aquatic insects in younger stages.

2) **Bar at the inner side of stream corner:** The larvae of a species of Elmidae, *Eriocera* sp., *Gibosia* sp., and Naididae spp. were collected only from the right side of the stream. Their density was particularly high along the bar near the right shore. The larvae of these species were also inhabitants of the hyporheic zone. Although the reason of their restricted distribution was unknown, the bar at the inner side of stream corner may have some advantages to their life.

3) **Shore areas of accumulated debris:** The mature nymphs of mayflies, *Ameletus* spp. and *Paraleptophlebia spinosa* Ueno were found to live just along the shore of accumulated debris. Since the nymphs of all these species emerge after crawling up to the shore (5-6), they might have moved to the shore area before emergence. This habitat was known also for holding the young nymphs of the same species after hatching out of eggs (7).

4) **Shore areas of rocky substrata:** The nymphs of stonefly, *Cryptoperla japonica* (Okamoto) were restricted to the shore areas of rocky substrata. Their density was higher along the left shore line than the right one. The nymphs were

found frequently on the wet surface of rocky debris just above the water surface.

5) Accumulated stones in a violent riffle: The stony substrata in the riffle part of higher current speed exceeding 150 cm/sec held a remarkable set of benthic animals, *Epeorus uenoi* Matsumura, 6 species of Blepharocerinae, and Diamesinae spp. Even considering the possibility of their additional distribution on the rock surface, the micro-habitat of this group of animals may be restricted mostly to the narrow area in the outer corner of the riffle.

6) Litter pack: The litter-packed habitat, a mass of leaves and twigs trapped between stones or accumulated in a still water area, was characterised by a particular species of Elmidae and high density of the mayfly nymphs of *Cincticostella nigra* (Ueno). The litter packs in the right half of the stream were found between stones, whereas those in the left side were developed in the roots of willow trees along the shore line.

7) Moss-mat on the surface of rocks: The rock surface along the left shore line was covered by the thick mat of moss, *Rhynchostegium riparioides* (Hedw.) Card., which grew not only along the water's edge but also on deeper substrata. The larvae of caddisflies, *Hydropsyche orientalis* Martynov, *Micrasema* sp.MC, and *Micrasema hanasensis* Tuda inhabited the moss-mat in high density and the nymphs of *Cincticostella nigra* were also abundant in this habitat. The moss-mat habitat was restricted to the rocky substrata washed by the flow of high current velocity.

8) Side pool: The habitat called 'side pool' is a small stagnant water situated at curved shores or behind big rocks (8). In the observation area it was found at the lower stream of the big rocks in the pool and along the right shore, where silt and detritus deposited on the sandy substrata. The inhabitants of this habitat was characterised by nymphs of the mayfly *Ephemera strigata* Eaton, the dragonflies Gomphidae spp. The fry and young fishes of *Zacco temmincki* (Temminck et

Schlegel) and *Phoxinus logowski* Dybowski f. *oxycephalus* (Sauvage & Dabry) were observed in the side pools.

9) Submerged stones in a water course: There were a lot of submerged stones around the bar in the right side of the stream. The search for frogs by turning all the stones over in this area revealed that 24 individuals of the singing-frogs, *Rhacophorus japonicus* (Hallowell), stayed under the submerged stones. Their distribution corresponded to the stony substrata in the shallow riffles where a lot of stones were submerged. This area was also used frequently for the feeding place by the wagtail, *Motacilla cinerea* Leach.

10) Border of pool and rapid: We found that the oviposition sites of the mayfly *Ephemera strigata* concentrated at the upper and lower end of the bar near the right shore of the stream. These places situated at the border of pool and rapid. This part of stream is selected for oviposition sites by a lot of species of aquatic insects and several species of fishes (8). The adaptive reason of their selection has been considered to be the merit of fresh under-ground water supplied through the debris, which is expected to raise the survival rate of offsprings during the egg stage and young instars (3,8).

11) Rock caves in a pool: There were several rock caves and shelters along the left side of the pool. One of them held more than twenty individuals of the fish *Leuciscus hakonensis* Gunther and three individuals of *Oncorhinchus masou macrostomus* Gunther. The geomorphological features suitable for the fish shelter seem to be formed by the erosion of the bank and substrata at the outer corner of the stream.

4. CONCLUSION

The micro-habitats described in this paper seem to be indispensable or important elements for conservation and recovery of riverine nature. Considering the life history of stream animals, however, these microhabitats should be arranged within an accessible distance by the animals. In this respect, the topography of the whole habitats or the design of the arrangement is also an important factor for consideration of the riverine nature.

The riffle-pool geomorphology and other stream features indispensable to stream animals are structured by the actions of erosion, transportation, and accumulation of debris (9). In other words, the habitats of stream animals are maintained by the dynamic nature of streams. For example, the hyporheic habitats in the bar structure are reincarnated by floods. If there were no flood, the hyporheic habitat would decrease in size and quality, since it would be blocked by silt and FPOM (fine particle organic matter) producing an anaerobic condition. In order to recover and conserve riverine nature, therefore, the processes of erosion, transportation, and accumulation of debris should be maintained to some extent. It means that we have to develop a river management system not by inhibiting the movement of debris at all but by controlling its amount within an suitable level.

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