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Auticles

Effects of catastrophic floods on daytime interstitial habitat of bagrid catfish *Pseudobagrus ichikawai*

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Abstract

We examined the daytime habitat used by highly endangered bagrid catfish *Pseudobagrus ichikawai* before and after rare catastrophic floods for the unaltered reach in a tributary flowing into the Miya River of Mie Prefecture, Japan. Although the magnitude of the floods were large (>15-fold increase in water level), the floods had no effect on the population level of the catfish at both reach and channel-unit scales. The bagrid catfish were consistently more abundant in the pool and sheltered interstitial spaces formed by cobble and boulder substrates. Although the floods did not have recognizable effects on the overall catfish population at the reach or channel-unit scales, the catfish's spatial use at a microhabitat scale changed over the floods. Only 20% of the patches where fish were observed before the floods contained individuals after the events. There was an uncommonly deep (>5m) and large-volume pool in this small stream where individuals of various sizes occupied spaces beneath single boulder and the number of individuals there increased by more than 3-fold over the events. These results suggest that this unique microhabitat functioned as a critically important hydraulic refuge for the bagrid catfish to minimize the effects of the catastrophic flooding event.

Key words: Bagridae, boulder, microhabitat, nocturnal, refugia

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Introduction

High flow events play important roles in the organization of lotic fauna (e.g. Resh et al. 1988). For fish communities, floods may increase the abundance and species richness by temporarily connecting isolated pools and creating potential movement opportunities previously impeded by barriers (Taylor, 1997; Taylor and Warren, 2001; Franssen et al. 2006). Conversely, floods could negatively affect individuals by altering channel morphology, leading to death or displacement of individuals downstream (Harrell, 1978; Matthews, 1986; Fritz et al., 2002; Tew et al. 2002). Because severe floods may limit animal population levels (Grossman et al., 1982), understanding the effects of catastrophic events with low recurrence intervals provides crucial management implications for lotic organisms. Effects of floods have been relatively well studied for both water-column fish (e.g., salmonids) and demersal fish (e.g., cottids and gobiids) in terms of the effects on populations that often require interstitial spaces between and underneath cobble-boulder substrates, particularly for concealment (salmonids: Hartman, 1963; Meyer and Gregory, 2000, cottids: Davey et al., 2005, cobitids: Bohlen, 2000, 2003). However, the actual habitat use of such space by demersal fish such as catfish has not been rigorously studied by comparing before and after the high flow events in a relatively unaltered stream environment.

The bagrid catfish *Pseudobagrus ichikawai* is an endemic, nationally endangered demersal freshwater fish, distributed in rivers flowing into the Ise and Mikawa bays in Japan (Nakamura, 1963; Tokuhara and Hara, 2002; Miyamoto et al., 2004). The species has been designated as a "natural monument" in Japan since 1977 and also listed in a threatened category under the IUCN Red List

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of Threatened Species (International Union for Conservation of Nature and Natural Resources, 2007). Mie Prefecture is one of the species' primary distribution areas where their populations have been historically recorded in eight watersheds. However, by now, their distribution range is limited to only four watersheds (Mizuno et al., 2007). For example, in a tributary of the Inabe River in the northern part of the prefecture, a catfish population decreased from several hundred to only a few individuals after a severe flood in September, 1990, but the catfish population has not fully recovered from the damage caused by the flood (Board of Education of Mie Prefecture and Tokai Research Association of Freshwater Ecology, 1993; Board of Education of Mie Prefecture and Mie Prefectural Science and Technology Promotion Center, 2003; Board of Education of Mie Prefecture 2006). As of today, most catfish populations remaining in the prefecture are found in the Miya River watershed, and therefore it is crucially important to preserve their populations there and also to study them in relation to severe flood events.

Various characteristics of bagrid catfish have been examined with regard to their spawning and growth (Watanabe, 1994a, b), morphology (Watanabe 1998a), diel activity (Watanabe, 2008), genetic structure (Maeda et al., 1994; Okazaki et al., 1999; Watanabe et al., 2001; Watanabe and Nishida, 2003), distribution areas (Okada and Kubota, 1957; Watanabe, 1998b; Watanabe and Ito, 1999; Watanabe and Uyeno, 1999; Tokuhara and Hara, 2002; Miyamoto et al. 2004), and conservation (Watanabe, 1997). Their habitat requirements have also been examined (Shimizu and Shimizu, 1982; Shimizu, 1988; Watanabe, 1994a; Tashiro et al., 2005), and the decreasing trends have been attributed primarily to degradations of interstitial habitats, which are suggested as one of the most preferred microhabitats due, for example, to the channelization work (e.g., Watanabe, 1994a). On the other hand, it is less well known how bagrid catfish respond to natural disturbances that may alter the interstitial habitats in a relatively unaltered river environment. The overall aim of the present study was to examine whether catastrophic floods with low recurrence intervals (> 50-year events) act as a major factor in limiting the population level of bagrid catfish *P. ichikawai* in the Miya River watershed. Specific objectives were: (1) to assess the effects of severe floods on abundance of bagrid catfish inhabiting interstitial space, (2) to examine habitat characteristics of bagrid catfish related to the persistence of the population over the floods, and (3) to elucidate the critical microhabitat factors for their conservation.

Materials and methods

Study design

The study reach was located in a fourth-order stream of the Miya River basin, Mie Prefecture, Japan (Fig. 1). The exact locations of the study tributary will remain undisclosed for conservation purposes. The study reach was a 200-m long alluvial channel, which consisted of two 50-m channel units (glide and pool) and

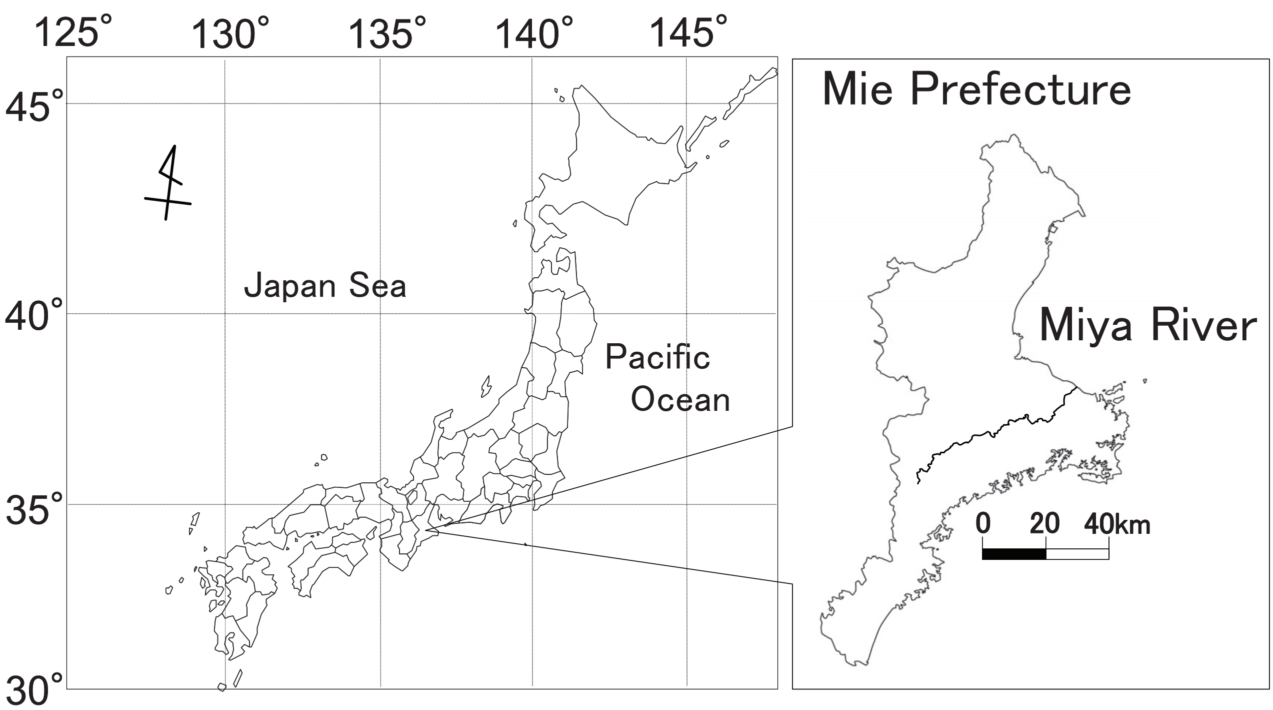

Fig. 1 Location of the Miya River in Mie Prefecture, of which one tributary was studied.

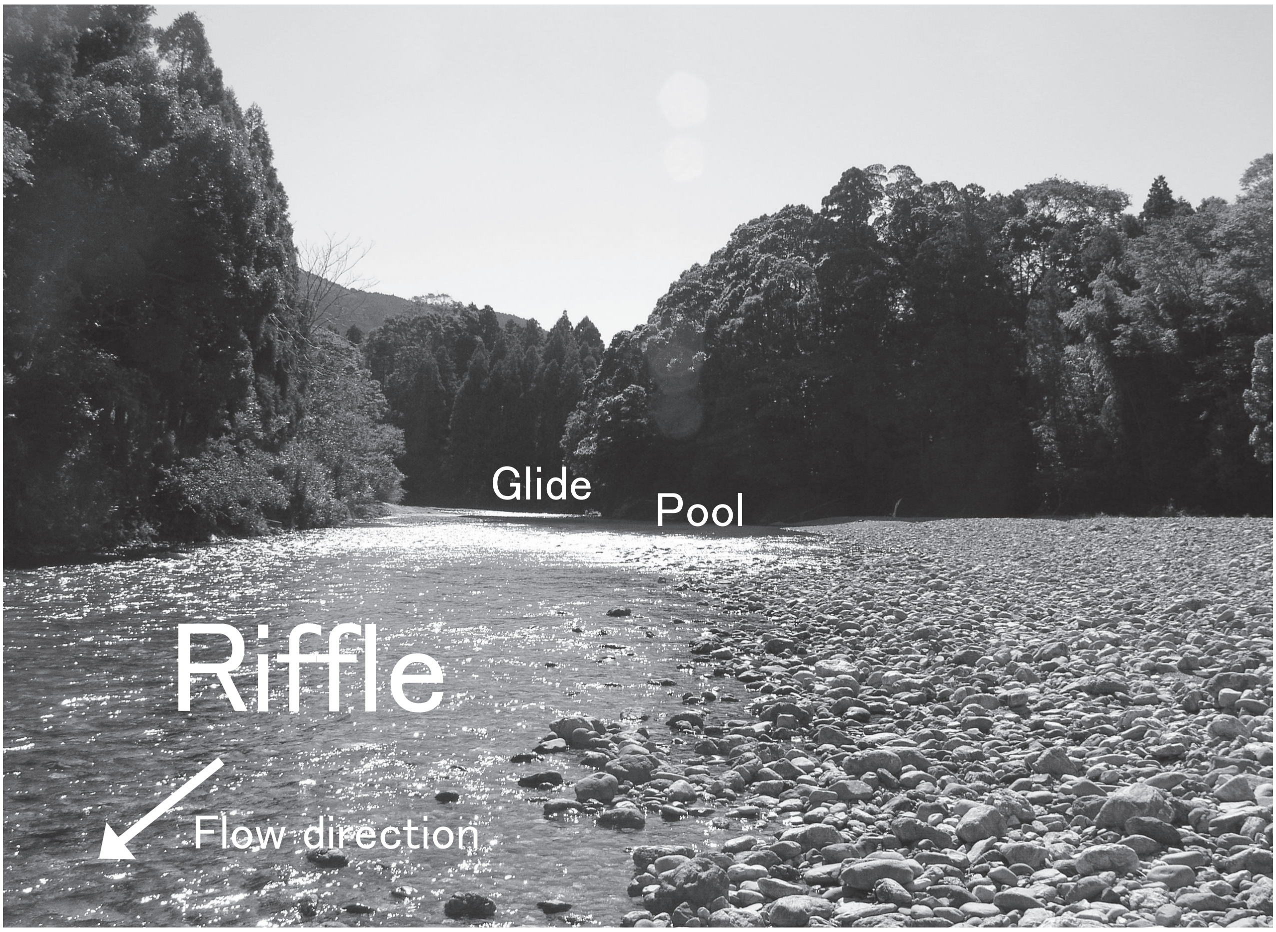

Fig. 2 View of the study reach consisting of a sequence of glide, pool, and riffle.

one 100-m channel unit (riffle), with a mean channel gradient of approximately 0.3%, and a mean wetted width of 15-30 m (Fig. 2, Table 1). The average depth of glide, pool, and riffle were approximately 60, 110, and 35 cm, respectively. For the pool, maximum depth was >5 m. Cobbles were the most abundant materials for both stream bed and riparian bank in the glide and riffle whereas boulders were the dominant bed material with bedrock forming riparian banks in the pool. The shore of the study reach was covered with sparse grass under the riparian trees.

A field survey was conducted from 27 September to 15 October, 2004 (Fig. 3). The timing of the survey was adjusted by checking the typhoon track map on the weather chart. A pre-flood survey was conducted on 27 September a few hours before the onset of floods caused by the typhoon Meari, and a post-flood survey was conducted on 15 October after the water level and turbidity completely subsided to the level similar to the pre-flood condition. The typhoon Meari was severe causing a catastrophic flood with an exceedingly low recurrence interval; it was the most severe typhoon to hit Mie Prefecture in 2004 and resulted in by far the largest flood since recording began in 1957 (Suwa et al., 2005).

Table 1. General characteristics of the study reach with three channel units in the tributary of the Miya River.

Variables	Glide	Pool	Riffle
Channel length (m)	50	50	100
Wetted width (m)	30	15	15
Dominant substrate	Cobble	Boulder	Cobble
Dominant bank material	Cobble	Rock	Cobble
Bank vegetation	Sparse grass under the riparian cover		

Maximum 1-h and 24-h rainfall intensity from 28 to 29 September 2004 in the upstream mountain area of the drainage reached 119 mm (> 100-year event) and 732 mm (> 50-year event), respectively. The daily mean and instantaneous peak water levels reached 4.69 and 9.44 m, respectively, in our study tributary where water levels at pre- and post-flood survey occasions were 0.62 and 0.66 m, respectively. The swollen downstream caused inundation and damage to houses. In spite of the catastrophic magnitude of these floods, the longitudinal channel morphology (glide, pool, and riffle structures) remained similar over the floods.

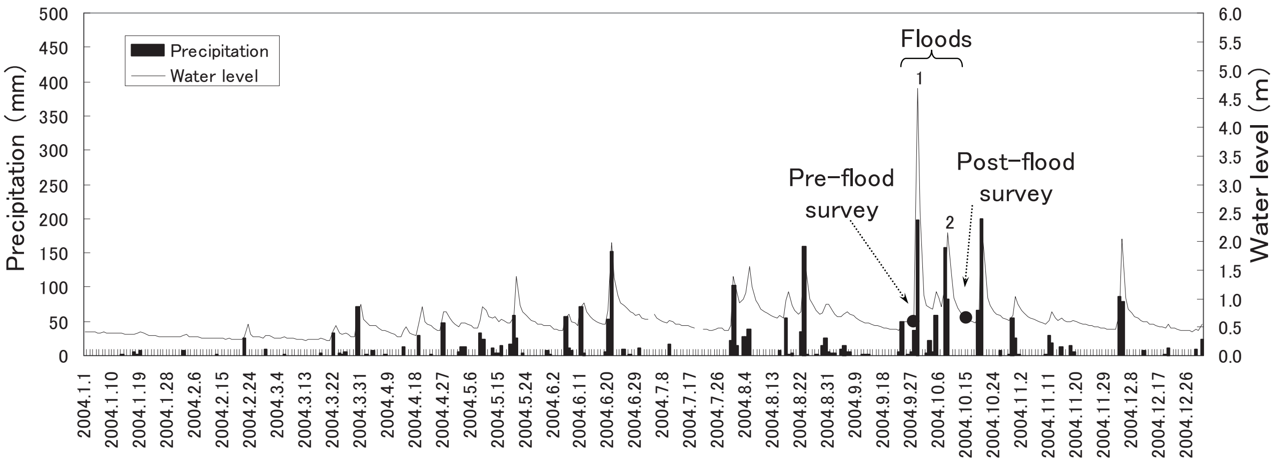

Fig. 3 Fluctuations of the precipitation and water level for the study tributary of the Miya River, which were measured at a gauging station approximately 850m downstream of the study reach (Mie Preferctural Government).

Field survey

The daytime interstitial habitat use of bagrid catfish was surveyed by four people making snorkeling observations over a period of four hours (one hour each for the 50-m glide and pool, and two hours for the 100-m riffle). Observations were made in the upstream direction, carefully examining shore vegetation, beneath substrate materials (cobble, boulder), and crevices on rock (hereafter referred to as "shelter type"), all of which have been described as preferred habitats for bagrid catfish (Shimizu and Shimizu, 1982; Shimizu, 1988; Watanabe, 1994a; Watanabe, 2008). Whenever necessary and possible, we checked concealed interstitial habitats by carefully moving substrate materials to avoid disturbing the fish, and all the substrate materials were placed back immediately after each observation. Even when substrate materials were moved, none of the fish reacted by swimming away, and thus our observation was considered to cause negligible impact on their micro-distributions during the study period. When finding the catfish, we set up a 2 m × 2 m quadrate with the fish-locating point as the center (hereafter referred to as "observed site"), and a recorded shelter type within the quadrate on a map. Furthermore, we thoroughly searched for any other catfish in the whole area of the observed sites, and if spotted, we visually estimated the body sizes (total length) and classified into three different classes: Class I = < 50 mm; Class II = 60-110 mm; and Class III = > 120 mm. The size classes were defined according to the frequency-histogram based on 83 individuals of bagrid catfish recorded from primarily the Miya and Inabe rivers from late August to late September in 2001-2002 (Fig. 4, Board of Education of Mie Prefecture and Mie Prefectural Science and Technology Promotion Center, 2003).

Our intention was to measure physical environments for each observed site at both pre- and post-flood survey occasions. At the pre-flood occasion, however, water level started rising just when physical measurements were being taken forcing the termination of measurements. Thus, we only quantified physical environments for the post-flood occasion following snorkeling observations. The quadrate set up for each observed site was divided into 16 subgrids (0.5 m × 0.5 m). At every corner of the subgrids (a total of 25), current velocity (cm s-1), water depth (cm), substrate coarseness, and embeddedness were measured. Current velocity was measured with an electromagnetic current meter (model VP-201, Kenek Co., Ltd., Tokyo, Japan) at 60% of the total water depth. Dominant substrate size was recorded through visual examinations using 5 size codes: 1) sand (< 2mm), 2) gravel (2–16mm), 3) pebble (16–64mm), 4) cobble (64–256 mm), and 5) boulder (> 256mm). The longest diameter and the corresponding

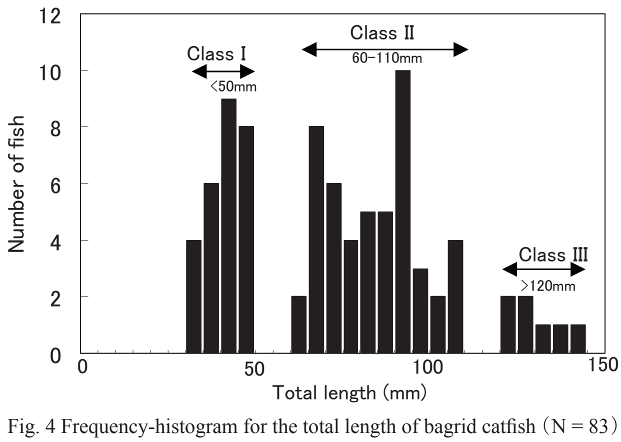

Fig. 4 Frequency-histogram for the total length of bagrid catfish (N = 83) caught in the rivers of Mie Prefecture from late August to late September in 2001-2002 (Board of Education of Mie Prefecture, Mie Prefectural Science and Technology Promotion Center 2003). Fish were categorized into one of three size classes: Class I (below 50mm TL), Class II (60-110 mm TL), and Class III (above 120 mm TL).

Table 2. Fifteen environmental variables used for PCA and their calculation methods.

	Variables	Calculation methods
1.	Mean water depth	The mean of values from 25 measurement points in the quadrate
2.	Mean current velocity	
3.	Mean substrate size	The average value of two diameters (the longest diameter and the shorter one perpendicular to the longest one) of the substrates larger than the size of pebble.
4.	Water depth complexity	The coefficient of variance (CV, the standard deviation divided by the mean) for 25 measurements in the quadrate
5.	Current velocity complexity	
6.	Substrate size complexity	
7.	Percentage of substrate area (>pebble)	The percentage covered by materials larger than respective substrate sizes among 25 measurement points in the quadrate
8.	Percentage of substrate area (>cobble)	
9.	Percentage of substrate area (>boulder)	
10.	Percentage of over-lying substrate area (>pebble)	The percentage covered by over-lying materials larger than respective substrate sizes among 25 measurement points in the quadrate
11.	Percentage of over-lying substrate area (>cobble)	
12.	Percentage of over-lying substrate area (>boulder)	
13.	Number of substrates (>pebble)	The number of materials larger than respective substrate sizes within each quadrate.
14.	Number of substrates (>cobble)	
15.	Number of substrates (>boulder)	

perpendicular shorter diameter were measured for the substrates larger than the size of a pebble, and the substrate embeddedness were classified as "over-lying" or "embedded" according to the presence or absence of interstitial spaces underneath substrate materials, respectively. The total water depth at the points with over-lying substrate was corrected by adding median diameter (the average of two diameters) to the depth measured from the water surface.

Data analysis

The effects of floods on bagrid catfish were evaluated at three spatial scales: reach (200-m reach), channel unit (riffle, pool, and glide), and observed site (2-m quadrate area). Chi-square tests were used with a significance level of 0.05 to examine whether the effects of floods on population composition differed among three size classes at the reach scale, and to examine whether the effects of floods on habitat selection differed among three channel-unit types at the channel-unit scale. In the latter analysis, we used the observations per unit effort (OPUE) for each channel unit rather than raw values of individual counts, which was the case for the former analysis; OPUE was calculated as individual counts per 4 persons per 1 hour. Because of the small sample sizes for observed sites where individuals were persistently found over the floods, we could not apply adequate statistical tests for the data at the observed site.

Furthermore, we examined physical habitat environments of the observed sites that we arbitrarily defined as either "persistent" or "less persistent" based on how bagrid catfish responded to the floods: "persistent" sites were the sites where the bagrid catfish were found at both pre- and post-flood occasions, whereas "less persistent" sites were the sites where individuals were found at either of pre- or post-flood occasion. Principal component analysis (PCA) with 15 environmental variables (see Table 2) was used to characterize habitat environments of "persistent" sites relative to "less persistent" sites in multivariate dimensions. Environmental variables were standardized for PCA. Ward's method of cluster analysis was applied to the PCA scores for all observed sites to classify the microhabitat type.

Table 3. Observed sites and observations per unit effort (OPUE) of bagrid catfish for each size class.

Channel-unit type	Observed site No.	Pre-flood survey	Post -flood survey	Shelter type
Glide	G1		I^{1}	cobble
	G2	II^{1}		cobble
Pool	P3	I^{1}		boulder
	P4		I^{1}	boulder
	P5	I^{1}, II^{1}, III^{1}	I^{6}, II^{3}, III^{1}	boulder
	P6	I^{1}	I^{1}	boulder
	P7	I^{1}		cobble
	P8	I^{1}		cobble
	P9		I^{1}	cobble
	P10		I^{1}	boulder
	P11	II^{1}		boulder
Riffle	R12	$I^{0.5}$		cobble
	R13	$I^{0.5}$		cobble
	R14	$I^{0.5}$		cobble
	R15		$I^{0.5}$	cobble
Total		$10^{10.5}$	$7^{15.5}$	

Fish size classes (mm TL): Class I< 50mm TL, Class II= 60-110mm TL, and Class III> 120mm (Board of Education of Mie Prefecture, Mie Prefectural Science and Technology Promotion Center 2003).
The OPUE is indicated as superscripts for fish size class symbols.

Results

General patterns of observations

The bagrid catfish were found at a total of 15 observed sites (Table 3). The total value of OPUE amounts to 26.0, which translates into observations of 28 individuals; 12 and 16 individuals were observed at pre- and post-flood occasions, respectively. At both the pre- and post-flood occasions, we observed synchronous occurrence of the individuals of three size classes at P5 (Pool 5). At the channel-unit scale, the number of observed sites and OPUE were the highest in the pool compared to the riffle and glide. The shelter type used by catfish was limited to interstitial spaces underneath substrate materials such as cobbles and boulders.

Changes of the numbers of observed sites and OPUE over the floods

The reach-scale analysis showed no significant relationship between the occurrence of floods and the observed number of individuals in each size class (χ^2=0.233, P=0.890). As a result of the channel-unit-scale analyses, no significant relationship were found between the occurrence of floods and the number of observed sites or OPUE for each channel-unit (the number of observed site, χ^2=0.580, P=0.748; OPUE, χ^2=1.220, P=0.543). At the observed-site scale, five sites were newly observed to contain fish in the study reach after the floods, whereas individuals were not found at eight of the previously observed sites (80% for all 10 observed sites; Table 3). Individuals were persistently found over the flood only at two observed sites (P5 and P6). OPUE of P5 was particularly high at both pre- and post-flood occasions, also exhibiting more than a 3-fold increase over the floods.

Comparisons of the environmental characteristics between the "persistent" and "less-persistent" sites

The first two PC axes together accounted for 72% of total variance in the data (Table 4). The environmental variables that had relatively high relationships with PC1 (factor loading > 0.80) were mean depth, mean substrate size, percentage of substrate area (>boulder), percentage of over-lying substrate area (>boulder) and substrate numbers (>boulder). Percentage of substrate area (>pebble) was the only variable that had relatively strong influence on PC2 (factor loading > 0.80). The "persistent" sites (P5 and P6) and "less-persistent" sites (G1, R15, P4, P9, and P10) were plotted in the 1st quadrant and 2nd-3rd quadrants, respectively. The cluster analysis produced two clusters with the one composed of the "persistent" sites and the other composed of the "less-persistent" sites (Fig. 5). As the plots of the two habitat types ("persistent" and "less-persistent" sites were separated mostly along the PC1, environmental variables associated with the PC1 were considered important in characterizing the degree of habitat persistence over the floods. In fact, environmental variables that had high factor loadings showed exceedingly high values for "persistent" sites relative to "less-persistent" sites (Table 5). Other examples include substrate characteristics such as substrate size and the proportional area covered by relatively large substrate materials. The values of size (>40cm) and area

Table 4. The results of principal component analysis using the environmental variables measured for each observed site at post-flood survey occasion. The numbers in bold type denotes factor loadings greater than 0.80.

Variables		Factor loading	
		PC1	PC2
Depth	mean	**0.81**	0.12
	complexity	0.22	-0.45
Velocity	mean	-0.67	0.61
	complexity	-0.76	0.56
Substrate size	mean	**0.95**	0.04
	complexity	0.48	-0.34
Substrate area	>pebble	0.04	**0.87**
	>cobble	0.61	0.66
	>boulder	**0.95**	-0.13
Over-lying substrate area	>pebble	0.54	0.68
	>cobble	0.79	0.41
	>boulder	**0.96**	-0.11
Substrate numbers	>pebble	-0.07	0.79
	>cobble	0.45	0.64
	>boulder	**0.87**	-0.20
Percent of variance (cumulative %)		46.00	72.00

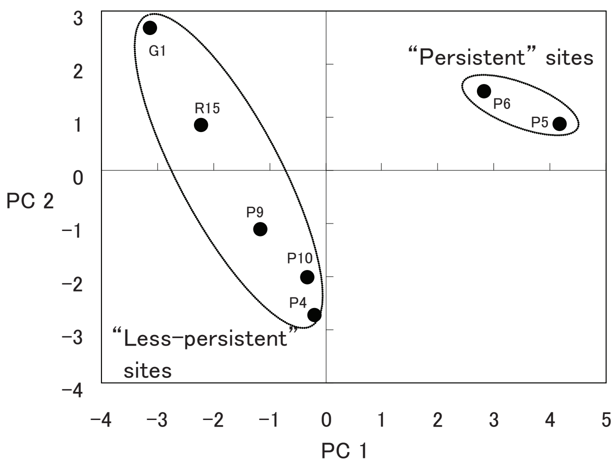

Fig. 5 The biplot of PC1 and PC2 using the 15 environmental variables measured for each observed site at the post-flood survey occasion. The cluster analysis produced two clusters, each of which was enclosed with elliptical shaped lines.

Table 5. Comparisons of environmental variables between "less-persistent" and "persistent" sites. The ranges of values were shown for "less-persistent" sites.

		"Less-persistent" sites (N = 5)		"Persistent sites (N = 2)		
				P5		P6
Water depth (cm)	mean	25-88	<	104	-	147
	complexity	16-56	inc.	50	-	21
Current velocity (cm/sec)	mean	1-12	inc.	2	-	2
	complexity	58-136	>	50	-	57
Substrate size (cm)	mean	8-34	<	71	-	43
	complexity	51-109	inc.	87	-	81
Substrate area (%)	>pebble	44-80	inc.	78	-	72
	>cobble	39-60	<	70	-	64
	>boulder	0-33	<	52	-	40
Over-lying substrate area (%)	>pebble	33-52	inc.	65	-	52
	>cobble	28-40	<	61	-	44
	>boulder	0-22	<	48	-	28
Substrate numbers (inds)	>pebble	8-18	inc.	12	-	17
	>cobble	7-10	inc.	10	-	14
	>boulder	0-6	inc.	6	-	8

inc.: the range of values measured for "persistent" sites were included in or overlapped with the range of values for "less-persistent" sites.

covered by boulders (>40%) at "persistent" habitats (P5 and P6) were concurrently higher than those at "less-persistent" sites. In particular, the value at P5 was exceedingly high with substrate size of 71cm and percentage of boulder substrate of 52%, respectively (Table 5).

Discussion

Effects of catastrophic floods on bagrid catfish

The effects of high flow events on fishes have been studied at relatively large spatial scales. For example, individuals were perished or displaced to downstream areas (Harrell, 1978; Matthews, 1986; Fritz et al., 2002; Tew et al., 2002), and changes in abundance and species richness of assemblages occurred (Taylor, 1997; Taylor and Warren, 2001; Franssen et al., 2006). In our study, however, reach and channel-unit scale analyses indicated that there were no statistically significant changes in total abundance at both scales before and after the events, suggesting that the effects of the floods on catfish were negligible. Although we are aware that our sample size was quite low and the interpretation of PCA results must be carefully made, the results indicate that the study reach was provided with sufficient refuge functions for individuals to persist through the catastrophic events. Intriguingly, we observed bagrid catfish of all three size categories to have inhabited together the same interstitial spot at P5 characterized by having single substrate material (median particle diameters: 71 cm) remaining in the same small area over the events. Furthermore, the maximum depth of this pool was >5 m and its volume was the greatest in the entire tributary (Sagawa, unpublished). We also observed no sediment deposition in this pool after the events, which probably resulted in no significant alteration of the channel morphology or water depth. These observations suggest that a large and deep pool, especially in a small stream with interstitial spaces formed by large substrate materials, is crucially important as a refugia for the catfish.

Bagrid catfish abundance and spatial distribution

Before and after the floods, bagrid catfish were more abundant in the pool that included shelters provided by cobble and boulder substrates. Our finding is similar to that of Shimizu and Shimizu (1982) and Shimizu (1988), who reported that bagrid catfish inhabited the moderate pools with cobbles of various sizes during the daytime. Furthermore, at finer scales (observed-site scales), we found no bagrid catfish in areas such as shore vegetation and crevices on rock that have been described as preferred microhabitats (e.g. Watanabe, 1994a). The absence of individuals in previously reported types of habitats can be partly explained by the fact that habitats such as shore vegetation is naturally uncommon in the study reach where alluvial characteristics keep shore vegetation from colonizing (Fig. 2). Overall, all individuals were found underneath substrate materials, providing further evidence that bagrid catfish is highly dependent on interstitial habitats.

Interstitial microhabitats as a flood refuge for bagrid catfish

The microhabitats, which persistently supported the catfish over the floods, were limited to only two sites (20%) among all the observed sites. In particular at P5, the abundance increased by more than 3-fold over the events whereas most of the other sites where fish were previously observed no longer held fish individuals after the floods within the reach. It is difficult to fully attribute this pattern to certain mechanisms; however, one possibility is that certain microhabitats (i.e. "less-persistent" sites) were more prone to floods relative to those with more persistent physical characteristics (i.e. "persistent" sites). Although our sample size was quite low and the PCA conducted may not be powerful enough, these two types of observed sites seem to be distinguished by their physical characteristics; the "persistent" sites were characterized by greater areas covered by relatively large-sized substrate materials and greater water depth compared to the "less-persistent" sites (Fig. 5 and Table 5). Although we have little quantitative information as to the responses of riverbed materials to the floods, the substrates of "persistent" sites P5 and P6 (median particle diameters: the former 71 cm, and the latter 43 cm) remained in the same position over the events whereas there were apparent signs of bed movement in the riffle and glide (cleansing of particle surfaces and tumbling of certain particles). This agrees with the view that the riverbed materials in the riffle and glide (8-34 cm), where all the "less-persistent" sites were found, moved during the event, taking into consideration that the critical diameter for sediment movement was 50 cm in the study tributary (Tashiro et al., 2005). Furthermore, the increase in the catfish abundance at P5 over the floods may imply that individuals might have aggregated at P5 to avoid the impacts of events. The importance of habitat availability within interstitial spaces underneath boulders has been reported for the bagrid catfish (Shimizu and Shimizu, 1982; Shimizu, 1988; Watanabe, 1994a; Watanabe, 2008). However, these interstitial cobbles and boulders habitats had not been studied with regard to their function during floods. Our findings suggest that a stable riverbed with boulder clusters is important in providing hydraulic refugia for catfish of various ages.

Management implications for the conservation of bagrid catfish

Persistence of catfish abundance over the events seemingly contrasts with the report that decreasing trends of abundance and distribution of bagrid catfish is related to the occurrence of severe floods (Board of Education of Mie Prefecture and Tokai Research Association of Freshwater Ecology 1993, Board of Education of Mie Prefecture and Mie Prefectural Science and Technology Promotion Center 2003, Board of Education of Mie Prefecture 2006). This disparity is probably related to the occurrence of flood-caused sedimentation processes. In our study reach, the changes in channel morphology were subtle, suggesting that passages of sediment pulse and movements of relatively large substrate materials over the events were not substantial. In contrast, the main-channel of the Miya River experienced tremendous changes in channel morphology such as burial of pools and scouring of riffles in places largely because of sediment movements originating from landslides and debris flow this particular year (e.g. Hayashi et al. 2004), which caused habitat loss and decreased bagrid catfish individuals by as much as 50 percent in the main-channel of the river (Kitamura 2008). Furthermore, similar habitat degradation after the same event diminished the adult bagrid catfish in the upstream reaches of the same tributary (Mizuno et al. 2007). These results indicate that the presence of the uncommonly large pool functioned as a critically important microhabitat to prevent the catfish's local population from declining against the catastrophic floods. If streams are to be restored for the conservation of bagrid catfish, creation of deep pools with substrate materials of sizes that are larger than critical diameters for movement during severe floods might be effective. Furthermore, large substrate materials could be placed in spatial arrangements with which the plugging of interstitial habitats by sedimentation would be minimized. Lastly, proper management of land use activities at the watershed scale is advisable to prevent excessive sedimentation in remaining distribution areas of bagrid catfish.

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摘　要

河川の大出水がネコギギの昼間の隠れ家に与える影響

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三重県宮川支流の自然河道区間において，絶滅の恐れの高いネコギギの昼間の生息場所特性を甚大な大出水の前後で調査した．対象の出水は平水位の 15 倍の高さに至ったが，本出水がネコギギ個体群に及ぼす影響は，河道および流路区間スケールでは検出されなかった．ネコギギは淵で卓越し，大礫および巨礫の隙間に潜んでいた．河道スケールおよび流路区間スケールでは影響が検出されなかったのに関わらず，微生息場所スケールでみると，出水後には生息場所の空間配置が変化しており，出水前後で恒常的に生息が確認された箇所は全確認箇所の内 20% に限定された．それらの恒常的生息場所は，対象河川でも稀な 5m 以上の水深および大容積を有する極めて大きな淵に存した巨礫下の隙間であった．そこでは異なるサイズ（年級群）のネコギギが同所的に生息し，出水後には生息個体数が 3 倍に増加していた．以上より，ネコギギの生息場所保全および個体群存続のためには，独特な恒常的生息場環境が極めて重要であることが示唆される．

キーワード：巨礫，ギギ科，避難場所，微生息場所，夜行性

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