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Population and Potential Spawning Sites of Bornean Endemic *Hampala bimaculata* in Betung Kerihun National Park, West Kalimantan Province, Indonesia

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Abstract

Understanding spawning habitat of the fish is an important consideration for the management of fish populations. Fish and environmetal variables data were undertaken in the Sibau Watershed, Betung Kerihun National Park in monthly from July 2013 to October 2013 and continued in bimonthly from July to November 2014. Environmental variables in the sampled areas were measured at each station sampling. A total 107 individuals of *H. bimaculata* were caught by anglings (76 individual) and gill nets (31 individuals) during sampling periods. The sex ratio for mature both sexes was 1.00: 2.37 (M:F). Relative abundance by angling method showed that population *H. bimaculata* was more abundant than other fish population.

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The potenstial spawning sites of the fish were in the upper Menjakan river and in the upper Apeyang river. Analysis of linier model showed that abundance of *H. bimaculata* is significantly positively correlated with water velocity, and negatively correlated with water depth.

Keywords: Spawning site; habitat; NPUE; environmental factor.

1. Introduction

Fish spawning takes place in spatially limited areas (or grounds) with attributes that favour reproductive success through higher egg survival [1,2]. There are numerous modes of reproduction in fishes, and broadcast spawning, which involves shedding the eggs and sperm into the water column, is one of the more frequent strategies [3]. The presence of eggs and larvae of broadcast spawners can be indicative of spawning grounds, although it should be noted that later larval stages may have been advected away from the spawning site [4,5]. Mature fish with running eggs or sperm can also be indicative of spawning grounds [4]. In addition, spawning can indeed be affected by, and reflect, adult stock depletion, habitat disturbance, climate change and other processes [6,7]. Many reviews on the spawning habitats have been also studied in fish. The authors in [8] revealed that egg production, based on abundance, size, and age composition of spawning cod, might vary extensively among different spawning areas. Meanwhile, choices of the geographical location of spawning might influence the offspring survival [9,10]. An understanding of the distribution of fish spawning and other ecologically important fish habitats is essential required to better fishery management. Information about the distribution of spawners, in conjunction with spatial variation and environmental conditions, might help understand recruitment processes critical for the assessment and management of important fish species [8]. Sibau Watershed is one of the six sub-watersheds in Betung Kerihun National Park. The watershed is a favorable habitat for the presence of the fish. There are 80 fish species, including 8 endemic species to Borneo. One of the endemic fish is *H. bimaculata* [11]. Preliminary observations indicate that these fish are sharing habitat with high economic fish *Tor*, but the environmental factors that specifically controls it have not been studied yet including potential spawning habitats of the fish. Information about *H.bimaculata* population in Betung Kerihun National Park is insufficient. Quantitative data on population size and environmental factor that control haven’t been also studied yet. Therefore, the objectives of this study were to estimate the population and identify the potential spawning sites of *H. bimaculata* based on distribution of mature fish with running eggs or sperm. We also determined the environmental variables that affect habitat used by the fish in Sibau Watershed.

2. Material and methods

The fish specimens were collected from Sibau Watershed (1°20’33.6”N-1°02’39.8”S and 112°53’23”-113°15’08.1” E) watershed during spawning season which is between July to October 2013 and continued between July to November 2014. Sampling method was done by using purposive sampling based on preliminary observation of habitat preference of the fish. Samples were taken by using angling and gillnet. Sampling area for angling method included Sibau up stream, Apeyang River, Menjakan River and Sibau downstream. Exception in Sibau downstream, each the river consists of two stations, thus the total stations were seven stations for sampling sites. While sampling area for gillnet method included Sibau upstream, Apeyang and Menjakan rivers.

Gill nets used in each river consisted of three units (1 and 1.5 inch mesh size each), covering an area of ~150 m^2. The gill nets were positioned horizontally to the mouth of the river at 18.00 and left in place until 6.00 the following morning (a total of 12 hours). Sampling by 4 anglings were done along up to downstream from 8.00 to 12.00 and continued from 13.00 to 16.00 (a total ~6 hours). Immediately photographs were taken prior to preservation. Fishes collected were identified by using [12], counted and fixed in 10% formalin. After 48 hours, the fishes were transferred to 70% alcohol. Enviromental factors were measured at each sampling site i.e. water temperature (°C), pH, dissolved oxygen (DO), turbidity (ntu), velocity (ms^{-1}), and total dissolved solids ($mg.L^{-1}$), water depth (cm), nitrate ($mg.L^{-1}$), and phosphate ($mg.L^{-1}$). All measurements were collected during sampling time with three times repeated on each site. Catches were analyzed separately for each site and each catch method. The total number of specimens per species was reported. Population of the fish using gillnet method was estimated by CPUE and with a relatif abundance. CPUE was calculated as number (NPUE) of the individuals of each species caught in 150 m^2 gill net area [13]. For angling method, fish population was estimated using catch rate and relative abundance. Catch rate was calculated by mean of ratio estimator. The method consists in calculating the average of the individual catch rates for all angles reported a given day [14]. The sex ratio was expressed as (the number of males)/(number of both sexes combined) and analyzed by Chi-square test, in order to verify whether the proportion of males and females based on size classes differed from the expected ratio 1:1 [15]. To confirm potential spawning sites, we determined by the distribution of mature fish with ripe eggs or sperms during spawning season [4]. We used linier model analysis to relate environmental variables and NPUE of the species [16]. *H. bimaculata* NPUE is as response, water variables are as predictors. The final model used was: *H. bimaculata* NPUE ~ turbidity + depth + velocity. Potential spawning sites were also analyzed by using distribution of maturity stage.

3. Results

3.1. Population of H. bimaculata

A total 107 individuals (juvenils and adults) of *H. bimaculata* caught by anglings (76 individual) and gill nets (31 individuals) during sampling periods. Population consists of 37 males and 70 females ranged 250 to 620 mm. Calculation sex ratio for mature males and females which reproductive females dominant to reproductive males (1.00:2.37) (Table 1).

Table 1: Chi-square for mature males and females *H. bimaculata*

Months	No of fish examined		Total	p-value
	Male	Female		
July	2	8	10	0.058
August	1	2	3	0.564
September	3	6	9	0.317
October	2	3	5	0.655
Total	8	19	27	0.034*
Sex ratio (M/F)			1.00:2.37	

Calculations of abundance based on catch rate by anglings method showed that populations *H. bimaculata* were higher than other fish which the highest population is upper Apeyang River (A1) followed upper Menjakan river. In contrary, low abundance of the fish was encountered at Sibau downstream with catch rate 0.18, where the station was dominated by tinfoil barb, *Barbonymus schwanenfeldii* (Table 2).

Table 2: Catch rate of the fish caught by angling at each the sampling sites during sampling periods

Species	Catch rate of species (sampling duration: 3 h)						
	SU1	SU2	A1	A2	M1	M2	SD
H. bimaculata	0.68	0.71	0.83	0.58	0.75	0.50	0.18
H. macrolepidota	0.04	0.04	0.00	0.00	0.17	0.00	0.29
Tor tambra	0.17	0.11	0.08	0.08	0.25	0.17	0.00
Tor tambroides	0.29	0.14	0.33	0.33	0.25	0.33	0.07
Barbonymus schwanenfeldii	0.14	0.14	0.08	0.08	0.00	0.25	0.61
Luciosoma setigerum	0.07	0.14	0.08	0.08	0.00	0.08	0.04
Macrochirichthys macrochirrus	0.09	0.09	0.00	0.00	0.00	0.00	0.29
Puntioplites bulu	0.00	0.00	0.00	0.00	0.00	0.00	0.29
Hemibagrus nemurus	0.00	0.00	0.00	0.00	0.00	0.00	0.21
Chromobotia macracanthus	0.00	0.00	0.00	0.00	0.00	0.00	0.04

*SU= Sibau upstream; A= Apeyang River;M3= Menjakan River; SD= Sibau downstream

A total 25 species of fish were caught by gillnets at the three sampling sites during sampling periods. The fishes were dominated by 2 cyprinds (*Lobocheilus bo* and *Rasbora volzy*) and Bagridae (*Hemibagrus nemurus*). Relative abundance of *H. bimaculata* at each the sampling sites ranged between 1.30.-2.24% (Table 3). No mature both sexes were caught by gillnets, fish catches consist of 77.42% immature stage and 22.58% maturing stage.

3.2.Potential spawning sites

Potential spawning habitat was determined by using the distribution of mature with running eggs or sperm. The distribution of each maturity stage showed that the main spawning habitats of *H. bimaculata* were in the upper of Menjakan River and the upper Apeyang River. The presence of mature fish with running eggs (ripe stage) or sperm can be indicative of spawning ground. The most number of ripe stage were found in the upper Menjakan river and in the upper of Apeyang river.The most number of mature males were caught in Sibau upstream and upper Apeyang river, while the spent stage of males were caught in upper Menjakan River only (Figure 1). The grounds where all sexually immature life history (immature, resting and maturing stages) are found at higher density are termed nursery grounds. They were found in Sibau upstream, down of Menjakan river and down of Apeyang river.

Table 3: NPUE and relative abundance of the fish caught by gill nets in sampling areas

No	Familia and Species	NPUE per sampling unit			Relative abundance of each species		
		SU	A	M	SU	A	M
	Family: Cyprinidae						
1	H. bimaculata	0.89	0.89	0.56	2.10	2.24	1.30
2	Tor tambra	0.72	0.56	0,67	1,70	1,40	1,56
3	Tor tambroides	0,72	0,44	0,44	1,70	1,12	1,04
4	Barbonymus schwanenfeldii	1,11	0,89	1,11	2,62	2,24	2,60
5	Anematicthys armatus	2,11	2,11	2 ,44	4,98	5,32	5,71
6	Garra borneensis	1,00	1,11	1,22	2,36	2,80	2,86
7	Labiobarbus festivus	1,94	2,22	2,44	4,59	5,60	5,71
8	Luciosoma setigurum	2,44	1,89	2,56	5,77	4,76	5,97
9	Osteochilus wandersii	3,78	3,67	4,11	8,91	9,24	9,61
10	O. kappeni	1,44	1,33	1,67	3,41	3,36	3,90
11	O. microcephalus	0,94	0,89	1,11	2,23	2,24	2,60
12	O. enneaporus	0,22	1,33	0,78	0,52	3,36	1,82
13	Lobocheilus bo	4,67	4,33	4,44	11,01	10,92	10,39
14	Puntius bramoides	1,22	1,44	1,44	2,88	3,64	3,38
15	Barbodes binotatus	1,06	1,44	1,11	2,49	3,64	2,60
16	Rasbora volzy	6,11	5,44	6,11	14,42	13,73	14,29
17	Schimastorhynchos heterorhynchus	1,17	0,89	0,78	2,75	2,24	1,82
18	Crossocheilus oblongus	1,56	1,78	2,22	3,67	4,48	5,19
	Family: Bagridae						
19	Hemibagrus nemurus	5,67	4,56	4,78	13,37	11,80	11,17
	Family: Gyrinochelidae						
20	Gyrinocheilus pustulosus	2,89	1,89	2,33	6,82	4,76	5,45
	Family:Cobitidae						
21	Chromobotia macracanthus	0,00	0,00	0,11	0,00	0,00	0,26
	Family: Mastacembelidae						
22	Mastacembelus unicolor	0,11	0,33	0,11	0,26	0,84	0,26
	Family: Osphronemidae						
23	Osphronemus septemfasciatus	0.17	0.00	0.00	0.39	0.00	0.00
	Family:Sisoridae						
24	Bagarius yarelli	0.11	0.00	0.00	0.26	0.00	0.00
	Family: Tetraodontidae						
25	Tetraodon leiurus	0.33	0.56	0.22	0.79	1.4	0.52
	Total individuals	42.9	39.67	42.78	100	100	100
	Total species	24	21	23			

Overall, the range values of environmental variables in the study areas showed that these are still suitable for fish life [17]. Desirable range of temperature is 24-30, DO for average or good production it should be above 5.0 ppm. pH ranging between 6.5 to 8.5 is ideal for biological productivity, fishes can become stressed in water with a pH <4 and >11(Table 4). Meanwhile, the favourable nitrate range was 0.1 mg L^{-1} to 4.0 mg L^{-1}. The analysis of linier model shows that abundance (catch rate) is significantly positively correlated with velocity, and negatively correlated with depth (Table 5).

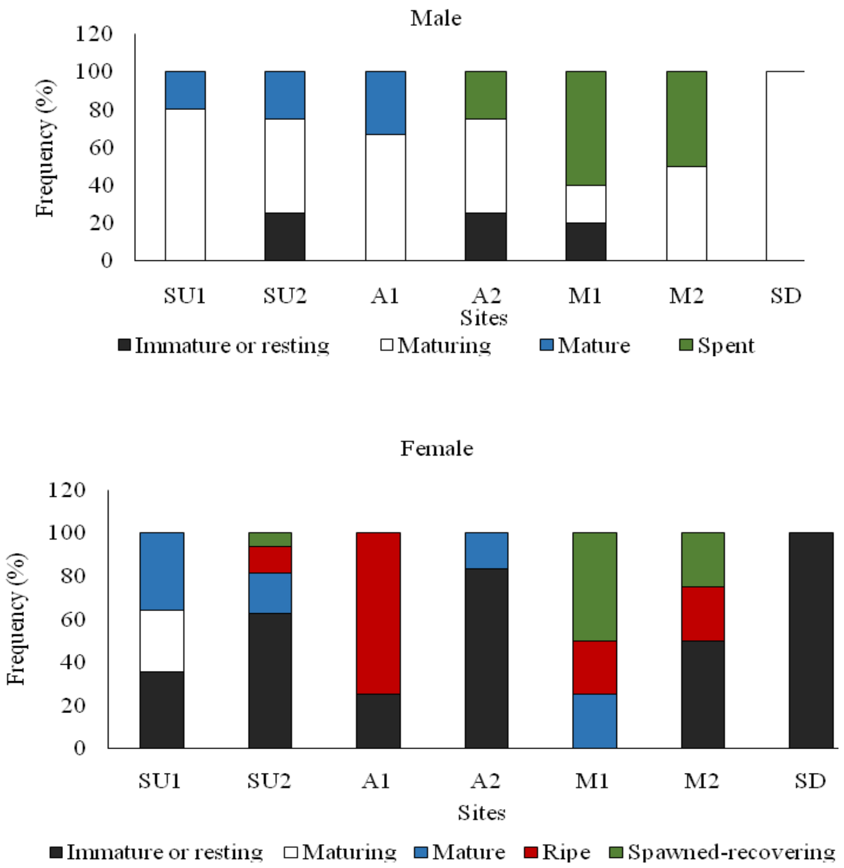

Figure 1: Distribution of each maturity for population male and female *H. bimaculata* using angling method, SU= Sibau upstream, A=Apeyang river, M=Menjakan river, SD=Sibau downstream

Table 4: Range of environmental variables in the study areas

Environmental Factors	SU1	SU2	A1	A2	M1	M2	SD
Temperature (°C)	26-28	27-28	26-27	27-27.5	26-27	27-28	28-29
Turbidity(ntu)	2.03-3.25	3.00-4.03	2.60-3.56	3.15-4.89	2.17-2.30	2.3-2.6	2.3-3.07
Total dissolved suspence (mg.L^{-1})	11.2-13.7	12.2-13.7	12-14.3	12.5-14.3	11.3-12.8	11.8-12.7	11.3-13.8
Depth (cm)	70-110	110-175	40-75	60-90	40-80	70-100	150-240
Velocity (ms^{-1})	0.80-1.7	0.6-0.9	0.9-1.1	0.6-0.9	0.8-1.1	0.5-0.8	0.6-0.9
DO (ppm)	6.40-7.20	6.60-7.2	6.7-7.0	6.6-7.0	6.5-7	6.5-6.9	5.7-6.4
pH	6.8-7.4	6.5-7.0	7-7.2	7.0-7.2	7-7.2	6.8-7.2	5.8-6.8
Nitrate (mg.L^{-1})	0.7-1.3	0.8-1.1	0.9-1.2	0.9-1.1	1.1-1.4	1.0-1.2	0.5-1.1
Phosphate (mg.L^{-1})	0.13-0.44	0.3-0.4	0.22-0.83	0.4-0.6	0.17-0.35	0.2-0.3	0.13-0.43

Table 5: Water parameters affecting *H. bimaculata* abundance

Variables	Coeffisien regression	Standart error	t value	Prob> t
Intercept	0.0897750	0.0852674	1.053	0.30714
Depth	-0.0008330	0.0003102	-2.686	0.01564 *
Velocity	0.1796317	0.0488205	3.679	0.00186 **

4. Discussion

The fish assemblage in Sibau watershed was dominated by the cyprinids, most of which either prefer living in the flowing water or migrate upstream to spawn. Population of *H. bimaculata* in Sibau watershed was relatively high compared with other *Hampala*: *H. macrolepidota.* We had similar findings in Mendalam watershed [18]. Specifically, the largest population was found in Apeyang river followed by Sibau upstream and Menjakan river which is characterised by relatively swift flowing waters.

The authors in [19] stated that the relationship between species composition, both richness and abundance, and local variables is a reflection of adaptation of the fish species to the physical environment for survival. Meanwhile, [20,21] revealed that the fish species collected at a site usually reflect the physical and chemical conditions of the river. In addition, [22] stated that each aquatic system has peculiar characteristics that act as filters to determine which species are apt to occupy the habitats, and the patterns of abundance and distribution are a result of the ways in which the species adjust to local environmental conditions.

In this study, the analysis of linier model showed that *H. bimaculata* NPUE is significantly positively correlated with velocity, and negatively correlated with depth. The preferred habitat of *H. bimaculata* was most in water depths ranging from 40 to 175 cm and water velocity in the range of 0.5-1.7 ms^{-1}. Similar findings were also encountered on the stream fish, *Sinogastromyzon puliensis* distribution which suggest that depth and velocity need to be included in fish habitat models [16]. Physical habitat is a primary factor influencing the structure and composition of faunal stream communities [23]. The importance of environmental variables to fish communities is dependent on the scale of analysis. On a small scale, biotic factors play an important role in community organization; however in large-scale studies, biogeography and abiotic factors are the main determinants of fish communities [24].

In lotic ecosystem, water velocity is an important habitat factor. The habits and swimming capabilities of the species help determine the preferred water velocity. Variations in velocity, and shelters from fast velocities provided by variations in the substrate, substrate particles or other in stream objects, are important in providing suitable habitat and refuges from other species. Water velocity generally decreases with depth [25].

Water depth can determine the amount of a particular habitat variable, which is available in the water column. Water depth is an important factor in avoidance of terrestrial predators, and in conjunction with water velocity it determines the stream habitat type such as pool or riffle. Depth and velocity gradients provide the major component for fish microhabitat use in many stream fish assemblages [26]. Depth can provide relatively stable, sheltered areas whereas shallow areas are particularly sensitive to reductions in water levels. With increasing depth, light penetration decreases and hence visibility is reduced, providing protection from predators.

Many fish species aggregate to spawn. There are numerous modes of reproduction in fishes, and broadcast spawning, which involves shedding the eggs and sperm into the water column, is one of the more frequent strategies [3]. Based on observations distributions of each maturity stage, we suggest that *H. bimaculata* often prefer to spawn in areas of accelerating current, such as in transitional pool to riffle zones as in upper Menjakan river and upper Apeyang river. In these areas, downwelling currents are likely to provide well oxygenated water to developing embryos over the incubation period. Both upper Menjakan and upper Apeyang has velocity rapid. Spawners had the most associations with riffle and rapid habitats. Spawners was also associated with shallow depth (40-80 cm). Meanwhile, all sexually immature life histories were highly associated with most low velocity habitat types (< 1.0 m/s) including pools and riffles habitats.

5. Conclusion and recommendation

Behaviour adaptation of *H. bimaculata* has shown spawning seasonal migration from the main river to the tributaries, which the potential spawning sites are in the upper Menjakan river and the upper Apeyang river. In order to complete the spawning sites data obtained, we recommend the presence of eggs and larvae observation, which will be used to manage for protecting *H. bimaculata.*

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