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Morphological divergences among three sympatric populations of Silver Sharkminnow (Cyprinidae: *Osteochilus hasseltii* C.V.) in West Sumatra

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ABSTRACT

Roesma DI, Santoso P. 2011. Morphological divergences among three sympatric populations of Silver Sharkminnow (*Cyprinidae: Osteochilus hasseltii* C.V.) *in West Sumatra. Biodiversitas 12: 141-145.* Silver sharkminnow (*Osteochilus hasseltii* C.V.) named by local people as Asang is one of potential Cyprinid fishes species found in several different ecosystems in West Sumatra. The differences of habitat types and another ecological factor among populations may have significant influences on variation and differentiation of morphological characters of this species. In order to elucidate the pattern of morphological divergence, meristic and morphometric characters of *O. hasseltii* in Singkarak and Dibawah Lake and adjoining river were compared. Phenogram based on cluster analysis showed specific morphological divergence among populations. There were 23 characters significantly different among all compared populations, the highest degree of differentiation was found between Singkarak and Dibawah Lake population (22 characters significantly different) and the most similar population were Singkarak Lake and Ombilin an outlet river of lake (only six characters significantly different).

Key words: fish, *Osteochilus hasselti,* meristic, morphometric.

INTRODUCTION

Silver sharkminnow (*Osteochilus hasseltii* C.V) is known as one of widely distributed cyprinids species in many freshwater ecosystems in Sundaland, Indochina, Burma, and introduced to Sulawesi, inhabitant of lakes, river streams and ponds. They could be distinguished morphologically from the other species of the genus by having 12-18 branched dorsal rays; 6-9 rows of spots along scale rows (not always distinct), and a large round blotch on the caudal peduncle, no black midlateral stripe; sometimes with a spot above a pectoral fin (Kottelat et al. 1993).

In West Sumatra, *O. hasseltii* is common cyprinid species in the lakes and rivers, named by local people as Asang Fish. It is frequently catched by fishermen and traded intensively in the traditional markets as potential comodity of freshwater fisheries. Intensive use of small mesh gill nets, electrofishing and dynamite or poisons for catching fishes has given impacts on stability of the number of natural populations for several decades. At least, it has limited the maximum reached size of remaining fishes.

There are Singkarak and Dibawah lake as the natural habitat of *O.hasseltii* among several aquatic ecosystems in West Sumatra. Singkarak is the second largest lake in Sumatra after Toba lake with 107.8 km^2 of surface area and located at 362 m above sea level. The natural outlet is Ombilin river which flows to the Malacca strait. This lake has been experienced by antropogenic polutions continuosly for long period such as organic and anorgnic polutants, pesticides, detergens and another things from people around or run off from the inlet rivers. Naturally, it is connected to Dibawah lake by Batang Lembang river which flows from Dibawah lake into Singkarak. Dibawah lake has 11.2 km^2 of surface area and located at higher altitude than Singkarak (1462 m above sea level) (Lehmusluoto et al. 1997). Differ from Singkarak, Dibawah lake has better quality of water with limited polutant sources. Surroundings area are dominated by farmlands and underbrushes. The fishermen activities are less in compared with Singkarak, make it possible to state that the natural populations of fishes stay in relatively stable.

Although Singkarak and Dibawah lakes are included to sympatric category, the differerences in altitude, surface area, and some ecological aspects would be possible forces generate the differences in fish species variation and differentiation living within. These external factors usually have a great influences on species divergence morphologically (Naesje et al. 2004) or ecologically (Fraser et al. 2005). From Mauguit et al. (2010), it was concluded that environmental forces are proposed to be significant strength to form fundamental morphological, physiological and physical changes of fish from hatcling to adulthood. Therefore, in term of some stated reasons, it is evident that there will be a specific pattern on morphological differences among fish populations in Singkarak and Dibawah lakes. This study is aimed to observe the degree of intraspecific diversity of *O. hasseltii* among those sympatric populations based on morphological characters. These informations are expected to be one of important baseline data in prepararation of biodiversity conservation policies.

MATERIALS AND METHODS

Sample collection

Samples of fish were collected by following standard procedures according to Cailiet et al. (1996) using nets and backpack electro fishing apparatus (12 volt) depending on the site where samples are collected (Singkarak Lake, Ombilin River as an outlet of Singkarak, and Dibawah Lake). Unstable characters (especially coloration) which might be lost after preservation were noted and photographed. Each of samples were labeled and fixed in 10% of formalin and later preserved in 70% ethanol. The identification key of Cyprinids species from Weber & de Beaufort (1916) and Kottelat et al. (1993) was used to confirm the validity of fish species. All specimens are at present lodged in the Laboratory of Genetics and Cytology Universitas Andalas, Padang, West Sumatra but the majority will be deposited later at the Museum Zoologicum Bogoriense Fish collection, Cibinong, Bogor, Indonesia.

Morphological characters (morphometric and meristic)

Morphometric measurments and meristic counts were conducted by following Cailiet et al. (1996) and Costa et al. (2003). All counts and measurements were made from specimens preserved in 70% ethanol. Morphometric measurements and meristic count were taken point to point from left side of fishes using digital calipers to the nearest 0.1 mm. Small meristic characters were examined under binocular microscope. Of 28 morphometric and meristic characteristics that have been analyzed, the measurements taken are as follows: Total length (TL), Standard length (SL), Depth of caudal peduncle (DCP), Length of caudal peduncle (LCP), Length of predorsal (LPr), Length of dorsal spine (LDS), Length of anal spine (LAS), Body depth (BD), Brachiostegal rays (BR), Length of pectoral (Lpec), Length of pelvic (Lpel), Length of longest dorsal spine (LLDS), Head length (HL), Head width (HDW), Snout length (SnL), Sub-orbital width (SOL), Orbit to preopercle distance (OPD), Eye diameter (ED), Upper jaw length (UJL), Dorsal fin spines (DS), Dorsal soft ray (DSR), Anal spines (AS), Anal soft ray (ASR), Total pectoral rays (TPR), Scales along lateral line (SALL), Scales above lateral line (SabLL), Scales below lateral line (SBLL), Scales before dorsal fin (SBGF). In addition we also measured 21 body proportions (truss) according to Strauss and Bookstein (1982).

Statistical analysis

In order to standardize the different of overall body size among specimens, all morphometric measurements data were divided by standard length (SL) and presented as ratio. Cluster analysis using Unweighted Pair Group Method Arithmetic Average (UPGMA) with NTSYSpc Ver.2.02i obtained from Herbarium ANDA, Padang, West Sumatra, was conducted to examine the relations among characters across all populations. The result of cluster analysis were used to produce a phenogram of which cluster of similar characters could be identified. Taxonomic distance from each population was estimated by Euclidean distance (Rohlf 2001). Non parametric Kruskall-Wallis test was used to identify the morphological variations among populations, and Mann-Whitney *U* test was used to observe the differences between populations. Both of the test were generated by using SPSS statistics software for PC.

RESULTS AND DISCUSSION

A total of 111 specimens have been analyzed morphologically, representing Singkarak Lake (60 ind.) Dibawah Lake (39 ind.) and Ombilin River (12 ind.). The characters of *O. hasseltii* are rather compressed body; subinferior mouth; upper lip continuous with skin of the snout by a groove; but coninuous with the skin of the snout; 33-38 lateral line scales; plaint caudal fin; 5-7 scales in between lateral line and origin dorsal fin; 5 scales in between lateral line and origin pelvic fin; flat abdomen and rounded; lateral line extending onto median caudal ray; simple ray/anal fin spine posterior edge non serrated; anal fin with 5-6 soft rays and 1 spinous;15-18 soft rays on dorsal fin; nostrils with membrane; no tubercles on snout; large round spot on caudal peduncle; large round spot on caudal peduncle.

The phenogram which was constructed base on 49 morphological characters by using UPGMA cluster analysis show the specific pattern of phenetic relationship among three populations of *O. hasseltii* as in Figure 1. Dibawah Lake population separated significantly with Singkarak Lake and Ombilin River by 10.35 euclidean coefficient. Both of Singkarak Lake and Ombilin River populations were the closest sympatric populations phenetically, expressed the higher degree of similarities in their morphological structures.

The divergences of morphological characters among all compared populations were relatively high with 23 characters significantly different based on Kruskall-Wallis test ($p \leq 0.05$) (Table 1). The characters consisted of 18 morphometric characters and five meristic characters. It indicated the significant degree of morphological variations among individual of fishes both of intrapopulation and interpopulation. From Mann-Whitney *U* test (Table not showed) we have the specific information (Table 2) which showed that the degree of morphological divergences were varies and it strongly supported the phenetic pattern found from the previous cluster analysis. The highest degree of morphological differentiations was Singkarak versus Dibawah lake (22 characters significantly different), followed by Dibawah lake versus Ombilin river (13 characters significantly different) and the most similar were Singkarak and Ombilin populations (only six characters significantly different). There was nothing among 49 analyzed characters performance the consistency of differentiation for all comparisons.

The divergences on morphological structures among populations of fishes species are common biological phenomenon, but the pattern of their differentiations are usually unique related to the strength of affecting factors experienced (Keeley et al.2005). Manel et al.(2003) stated that divergences may has genetic based pattern in allopatric populations but it is rare for sympatric populations.

Table 1. Comparison of *O. hasseltii* interpopulation by Kruskall-Wallis test of standard length (SL) and of ratio of measurements. For each sample, mean and standard deviation, minimum and maximum values are given below each character, n = sample size; *significance level p≤0.05

Char-acters	Population			Kruskall-Wallis test *O. hasseltii*
	***O. hasseltii* Dibawah Lake**	***O. hasseltii* Singkarak Lake**	***O. hasseltii* Ombilin River**	
	n = 39	**n = 60**	**n = 12**	
TL	1.28±0.04	1.29±0.03	1.27±0.04	X^2=7.161
	1.46-1.22	1.37-1.21	1.37-1.24	*p*=0.028*
SL	118.79±15.96	127.35±25.17	130.80±26.18	X^2=2.574
	178.03-92.99	183.06-96.18	174.79-102.98	*p*=0.276
DCP	0.14±0.01	0.14±0.01	0.14±0.02	X^2=8.515
	0.15-0.13	0.15-0.12	0.21-0.13	*p*=0.014*
LPr	0.47±0.01	0.46±0.02	0.46±0.07	X^2=17.391
	0.52-0.45	0.53-0.43	0.68-0.42	*p*=0.000*
BD	0.36±0.01	0.35±0.02	0.36±0.05	X^2=6.484
	0.39-0.34	0.39-0.32	0.51-0.33	*p*=0.059
BR	0.03±0.02	0.03±0.01	0.03±0.01	X^2=1.563
	0.04-0.02	0.04-0.02	0.04-0.01	*p*=0.458
Lpec	0.19±0.01	0.19±0.01	0.20±0.02	X^2=3.782
	0.24-0.16	0.22-0.15	0.28-0.19	*p*=0.151
Lpel	0.19±0.01	0.19±0.01	0.20±0.02	X^2=4.236
	0.21-0.17	0.21-0.16	0.26-0.18	*p*=0.120
LLDS	0.24±0.02	0.24±0.02	0.23±0.03	X^2=2.484
	0.29-0.21	0.28-0.19	0.31-0.21	*p*=0.289
HL	0.22±0.01	0.23±0.01	0.24±0.03	X^2=5.809
	0.24-0.20	0.25-0.21	0.32-0.22	*p*=0.055
HDW	0.12±0.01	0.12±0.01	0.13±0.01	X^2=2.831
	0.13-0.11	0.14-0.11	0.16-0.11	*p*=0.243
SnL	0.05±0.01	0.05±0.01	0.05±0.01	x^2=4.946
	0.06-0.04	0.07-0.02	0.07-0.03	*P*=0.084
SOL	0.09±0.01	0.09±0.01	0.08±0.01	x^2=0.608
	0.11-0.07	0.11-0.06	0.11-0.06	*P*=0.738
OPD	0.06±0.01	0.06±0.01	0.07±0.01	X^2=7.132
	0.07-0.05	0.08-0.05	0.08-0.05	*p*=0.028*
ED	0.05±0.01	0.05±0.01	0.05±0.01	X^2=1.948
	0.06-0.04	0.06-0.04	0.07-0.04	*p*=0.378
UJL	0.06±0.01	0.06±0.01	0.06±0.01	X^2=1.188
	0.08-0.04	0.08-0.04	0.08-0.05	*p*=0.552
GW	0.14±0.01	0.14±0.01	0.15±0.02	X^2=13.447
	0.18-0.12	0.16-0.13	0.22-0.14	*p*=0.001*
DS	1.00±0.00	1.00±0.00	1.00±0.00	X^2=0.000
	1.00-1.00	1.00-1.00	1.00-1.00	*p*=1
DSR	16.35±0.68	15.92±0.70	16.17±0.72	X^2=7.384
	18.00-15.00	17.00-15.00	17.00-15.00	*p*=0.025*
AS	1.00±0.00	1.00±0.00	1.00±0.00	X^2=0.000
	1.00-1.00	1.00-1.00	1.00-1.00	*p*=1
ASR	5.00±0.00	5.05±0.22	5.00±0.00	X^2=3.726
	5.00-5.00	6.00-5.00	5.00-5.00	*p*=0.155
TPR	12.18±0.77	12.67±0.84	12.83±0.83	X^2=9.839
	14.00-11.00	15.00-11.00	15.00-12.00	*p*=0.007*
SALL	34.58±0.81	35.26±0.88	35.33±0.98	X^2=10.616
	36.00-33.00	38.00-34.00	37.00-34.00	*p*=0.005*
SAbLL	6.00±0.00	5.97±0.28	6.00±0.00	X^2=0.627
	6.00-6.00	7.00-500	6.00-6.00	*p*=0.731
SBLL	5.00±0.00	5.00±0.00	5.00±0.00	X^2=0.000
	5.00-5.00	5.00-5.00	5.00-5.00	*p*=1
SBDF	11.08±0.56	10.46±0.63	10.67±0.65	X^2=12.931
	12.00-11.00	12.00-9.00	12.00-10.00	*p*=0.002*
SASP	6.95±0.22	6.55±0.42	6.67±0.49	X^2=13.780
	7.00-7.00	7.00-5.00	7.00-5.00	*p*=0.001*
CFR	16.78±0.56	16.85±0.53	16.83±0.39	X^2=0.521
	18.00-15.00	18.00-15.00	17.00-16.00	*p*=0.770
T1	0.18±0.01	0.18±0.01	0.19±0.03	X^2=9.998
	0.22-0.16	0.20-0.16	0.29-0.17	*p*=0.670
T2	0.29±0.02	0.28±0.02	0.30±0.04	X^2=5.231
	0.32-0.26	0.34-0.25	0.40-0.26	*p*=0.073
T3	0.39±0.02	0.37±0.03	0.39±0.05	X^2=19.563
	0.46-0.35	0.41-0.36	0.55-0.37	*p*=0.000*
T4	0.20±0.02	0.22±0.02	0.23±0.03	X^2=35.324
	0.24-0.17	0.26-0.18	0.28-0.19	*p*=0.000*
T5	0.14±0.01	0.15±0.01	0.17±0.02	X^2=47.872
	0.16-0.12	0.18-0.13	0.24-0.14	*p*=0.000*
T6	0.15±0.02	0.16±0.01	0.16±0.03	X^2=6.789
	0.19-0.12	0.18-0.14	0.25-0.14	*p*=0.034*
T7	0.11±0.01	0.10±0.01	0.10±0.01	X^2=5.789
	0.11-0.11	0.12-0.09	0.14-0.09	*p*=0.055
T8	0.22±0.01	0.23±0.02	0.25±0.04	X^2=10.219
	0.26-0.19	0.28-0.19	0.35-0.22	*p*=0.006*
T9	0.06±0.01	0.06±0.01	0.06±0.01	X^2=8.736
	0.08-0.05	0.07-0.04	0.09-0.06	*p*=0.013*
T10	0.24±0.01	0.224±0.02	0.27±0.04	X^2=8.258
	0.27-0.20	0.30-0.20	0.37-0.22	*p*=0.016*
T11	0.27±0.02	0.27±0.02	0.27±0.03	X^2=2.139
	0.30-0.22	0.30-0.20	0.36-0.25	*p*=0.343
T12	0.23±0.01	0.22±0.01	0.23±0.03	X^2=4.697
	0.27-0.21	0.27-0.21	0.33-0.21	*p*=0.096
T13	0.42±0.01	0.42±0.02	0.44±0.04	$X^2$2.817
	0.45-0.39	0.48-0.36	0.59-0.40	*p*=0.244
T14	0.35±0.01	0.34±0.02	0.37±0.05	X^2=9.804
	0.38-0.33	0.38-0.31	0.53-0.33	*p*=0.011*
T15	0.35±0.01	0.35±0.02	0.36±0.04	X^2=2.500
	0.39-0.33	0.39-0.31	0.49-0.33	*p*=0.286
T16	0.36±0.01	0.35±0.02	0.37±0.04	X^2=7.274
	0.40-0.34	0.39-0.31	0.49-0.34	*p*=0.026*
T17	0.39±0.02	0.38±0.02	0.40±0.06	X^2=11.061
	0.44-0.37	0.42-0.35	0.57-0.37	*p*=0.004*
T18	0.36±0.02	0.34±0.02	0.36±0.05	X^2=16.892
	0.39-0.33	0.40-0.30	0.49-0.33	*p*=0.000*
T19	0.23±0.01	0.21±0.01	0.22±0.03	X^2=43,215
	0.26-0.21	0.24-0.19	0.30-0.19	*p*=0.000*
T20	0.18±0.01	0.18±0.01	0.19±0.03	X^2=2.835
	0.21-0.14	0.21-0.16	0.27-0.17	*p*=0.242
T21	0.22±0.01	0.23±0.01	0.23±0.03	X^2=18.897
	0.25-0.17	0.27-0.20	0.33-0.21	*p*=0.000*

Table 2. Differentiated morphological characters among compared populations of *O. hasseltii* based on Mann-Whitney *U* test statistical analysis

Characters	Compared populations		
	Dibawah Lake vs Singkarak Lake	**Dibawah Lake vs Ombilin River**	**Singkarak Lake vs Ombilin River**
TL	-	+	+
DCP	+	-	+
LPr	+	+	-
BD	+	-	-
HL	+	-	-
GW	+	+	-
DSR	+	-	-
TPR	+	+	-
SALL	+	+	-
SBDF	+	+	-
SASP	+	+	-
T2	+	-	-
T3	+	-	-
T4	+	+	-
T5	+	+	-
T6	+	-	-
T7	+	-	-
T8	-	+	-
T9	-	+	+
T10	-	+	+
T14	+	-	+
T16	+	-	+
T17	+	-	-
T18	+	-	-
T19	+	+	-
T21	+	-	-
Total diff. char.	22	13	6

Note: (+) indicated significant differentiation, (-) no differentiation

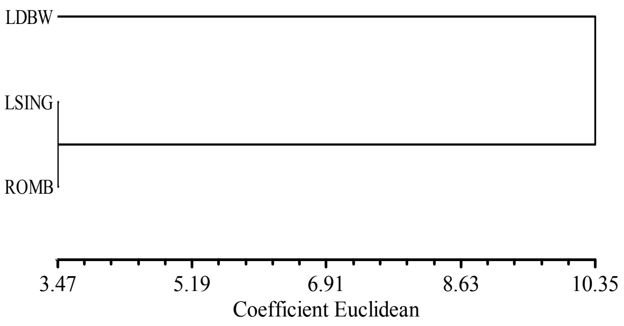

Figure 1. Phenogram of three populations of *O. hasseltii* based on morphological data: LDBW (Dibawah Lake), LSING (Singkarak Lake), ROMB (Ombilin River, outflow of Singkarak Lake).

Taking deduction from of those evidences, the pattern of morphological differentiation of *O. hasseltii* among three sympatric populations confidently related to ecological or environmental forces than the genetic based changes. As populations within each lake and river are not completely isolated by physical barrier to gene flow, other factors must be involved in the variation. At least the selective force might have contributed to the divergences those *O. hasseltii* was selection on ecological traits. Szalai et al. (2003) observed that there were the density-dependent growth regulation generated the morphological divergence of *Coregonus hoyi* in lake Michigan. Hjelm et al. (2003) also found that the feeding performance and the diet shift in fish species related to change in functional morphology over ontogeny. Naesje et al. (2004) stated that the variation among populations of fish characters could be induced by ecological factors interacted with fundamental genetic roles. According to Rutaisire et al. (2005), variations and differentiations among fish populations, notably in morphological characters, should be drived by the differences in environmental conditions during ontogeny, level of food and predators availablity, difference in spawning area, and the level of polutants intensity and antropogenic stresses. According to Nakamura (2003), and Naesje et al. (2004), there were significant differences in the mean number of dorsal fin rays and diameter of pupil and the body of nature fish is determined by food availability and physical environment during ontogeny between rivers system. Langerhans and Makowicz (2009) found the unique morphological variations in live bearing fish (*Gambusia caymanensis*) forced by presence of predators and historical island effects in Cayman islands.

Concerning with *O. hasseltii* in three studied populations, there are some ecological factors proposed as the complex of morphological divergences inducers. Firstly, difference in water temperature may play the significant roles on rate of individual growth. Notably in Dibawah lake, lies in higher altitude than Singkarak lake and Ombilin river, the water temperature is almost extremely lowest among others. According to Kassam et al. (2003), it should be given an impact on fish early from their ontogeny development to adult stage. Samaee et al. (2006) as well as Krabbenhoft et al. (2009) described that other environmental factor also underlying morphological changes such as water clarity, water depth and flow, food availability and physical complexity. Second, polutant intensity of Dibawah lake is distinctly lower in comparing to the others, whereas Singkarak and Ombilin river are experienced with so many kind of polutant sources directly or undirectly produced from dwellers surroundings and pesticides and fertilizer recidues of farmlands. It conducts the differences in cascading effects of environmental stress to comunities and populations. Schaack and Chapman (2003) and Keeley et al. (2005) mentioned that the level of environmental stress to the species including polutions would be acted as one of the main forces toward the species divergences in case of specific adaptive change in characters.

The variations of morphological characters of *O. hasseltii* among sympatric populations also proposed to be induced by the impact of species composition of whole fishes communities. Singkarak lake and Ombilin river consist more diverse of fish species than Dibawah lake, promote the differences of cascading manifestation of intraspecific and interspecific competition among fishes, notably for food sources and space. Salsabila (1987) identified 29 species, members of 11 families in Singkarak lake. Usman and Amir (1995) reported seven species of fishes in Dibawah lake. The complexity of comunities composition of fishes combined with spatial scale of habitat types and landscapes promoted the species divergences (Wang et al. 2003). Layman et al. (2005) also proposed that the combination of fish assemblage composition in combination with commercial netting has been taken an important role on morphological differences.

The effect of current in aquatic ecosystem between lake and river is commonly found to be the significant factor on fishes morphological divergence. Many organisms can modulate their morphology in response to environmental cues. Body morphology of an individual has a great importance for its performance in prevailing environment. Robinson and Parson (2002) stated that morphological plasticity of fishes species may play a role in the notably high rate of divergences. According to McGuigan et al. (2003) there appears a clear relationship between shape and function in adaptations of Rainbow fish (*Melanotaenia* spp.) inhabited rivers and lake. The body form correlates with the swimming performance of an individual. Turan et al. (2004) concluded that the major of morphological characters at the intraspecific levels i.e. phenotypic variation is not directly under genetic control but is subjected to environmental modification. It is the apropriate way to understand the dissimilarities of morphological characters of Singkarak and Dibawah lake compared to Ombilin river's population.

Even though the study on species diversity of *O. hasseltii* was only limited for its morphological aspects, there were some important informations concerning the signs of specific patterns of species adaptation toward the environmental forces. It has significant morphological variations and divergences among sympatric populations and seems to be dominated by ecological aspect as discussed above. The clear confirmation based on genetic analysis must be conduct on the same species and locations for the future researches.

CONCLUSION

There were 23 characters significantly different among Singkarak and Dibawah Lake and adjoining river populations, the highest degree of differentiation was found between Singkarak and Dibawah Lake population (22 characters significantly different) and the most similar population were Singkarak Lake and Ombilin an outlet river of the lake (only six characters significantly different). Concerning with *O. hasseltii* in three studied populations, there are some ecological factors proposed as the complex of morphological divergence inducers. The genetic analysis must be conducted on the same species and locations for the future researches. The information will define the importance of the lakes and rivers in diversity.

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