AN EVALUATION OF FLUCTUATING ASYMMETRY FOR IDENTIFYING IMPERILED MAHSEER (*Tor tambroides)* POPULATIONS

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ABSTRACT

The growth of human populations has led to an increase in habitat loss and degradation through activities such as land conversion for agriculture, urban growth, deforestation and overfishing, potentially impacting species viability. All of these factors can have negative impacts which may result in reduced performance of fitness components. The developmental stability represents an integral component of individual fitness and is most often estimated by their level of fluctuating asymmetry. The aim of this study was to test whether levels of fluctuating asymmetry, reflect developmental stress caused by overfishing due to the absence and the presence of the regional mahseer conservation strategies. If imperiled populations could be identified early and management actions taken to prevent declines, the benefit to the conservation of biodiversity is profound. Three bilateral meristic characters were counted on each side of the fish: number of gill rakers on the lower first branchial arch, eyes diameter, and number of pectoral-fin rays. The result showed that adverse conditions found in unprotected environments such as Manna River affect morphological development of trait of functional importance for fish. There were differences in fluactuating asymmetry among mahseer, Manna River mahseer exhibited higher value of fluactuating asymmetry for almost all characters studied with the significant reduced development of locomotive (fins length) character. Fluctuating asymmetry appears to be a useful indicator for stress-induced developmental instability in mahseer.

Key words: Fluctuating asymmetry, mahseer, Manna and Batang Tarusan

INTRODUCTION

Presently fish populations are incurred to numerous anthropogenic impacts which are not previously faced during their evolutionary history. The growth of human populations has led to an increase in habitat loss and degradation through activities such as land conversion for agriculture, urban growth, deforestation and overfishing, potentially impacting species viability. All of these factors can have negative impacts on wildlife that can lead to a reduction in population size, and a loss of genetic diversity through inbreeding and genetic drift (Rouke, 2004) which may result in reduced performance of fitness components (Clarke, 1995; Møller and Swaddle, 1997).

Clarke (1995) recognized that developmental stability represents an integral component of individual fitness. Developmental stability is the capacity of an individual to buffer its development against random errors (Moller and Swaddle, 1997). This has the effect of reducing the phenotypic variation of characters that could be expressed within a population (Clarke, 1995). In an ideal, stress-free environment, bilaterally symmetric characters (e.g. right vs. left arms in humans) would be produced that are morphometrically identical. In reality, no such system exists, as there will always be some element of randomness in an organism's development, resulting in asymmetry (Leamy, 1984, Moller and Swaddle, 1997).

Developmental instability of individuals and populations is most often estimated by their level of fluctuating asymmetry (FA), which occurs when otherwise bilateral traits show small random variations in the size of the two sides of the character around a bilateral symmetry axis (Palmer and Strobeck, 1986). The underlying assumption of FA is that the same genetic and developmental programs control the left and right sides of bilaterally symmetric traits (Whitlock, 1996). Therefore, individual asymmetry scores within a population can be used as a measure of an organism's ability to buffer its development against both genetic and environmental perturbations and can be considered an indirect measurement of individual fitness (Moller and Swaddle, 1997, Clarke, 1995). Since the metrics for conducting fluctuating asymmetry analysis are derived from taking the difference between right and left traits of bilaterally symmetric organisms, they are often simple and straightforward to measure, and can be statistically very powerful at detecting differences among populations (Moller and Swaddle, 1997).

The spread of the distribution of the individual asymmetry scores for a population can be used as a robust measure of the stability of the population as a whole (Moller and Swaddle, 1997). The population of the mahseer (*Tor tambroides)* has declined dramatically in its natural habitat in the face of anthropogenic and environmental problems. Some local and government have been establishing a conceive effort to prevent future degradation and extinction of imperilled mahseer species, however in most areas that do not have the conservation strategy. Manna River has been well known as a natural mahseer habitat, although local and government recognising importance of these species, however there is no concerted effort to manage their sustainable potential. Where as Batang Tarusan River in West Sumatra Province is an important example of a conservation area for mahseer species in Sumatra. The expansion of mahseer population has been reported from the area and may in fact have a healthy or stable population.

In this regard, the aim of this study was to test whether levels of fluctuating asymmetry, reflect developmental stress caused by overfishing due to the absence and the presence of the regional mahseer conservation strategies. If imperiled populations could be identified early and management actions taken to prevent declines, the benefit to the conservation of biodiversity is profound.

MATERIALS AND METHODS

Fish were collected from Manna River (the absence of conservation areas) and Batang Tarusan River (the presence of conservation areas) (Figure 1). Mahseer from the Manna River were expected to show sign of stress due to overfishing caused by the absence of conservation areas and strategies.

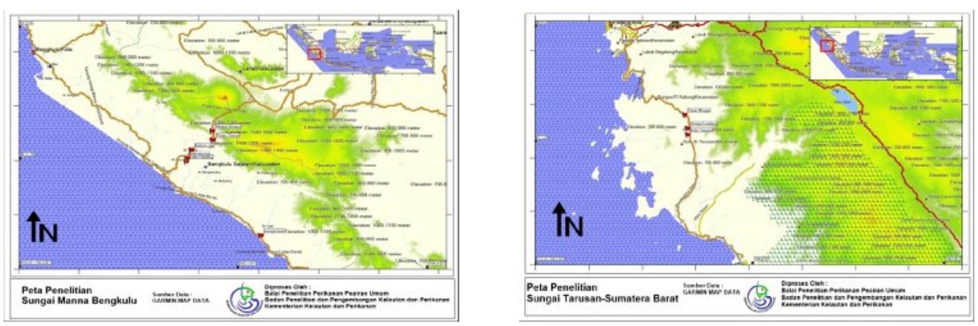

Figure 1. The geographic locations relating to the mahseer (*T. tambroides)* (Manna and Tarusan River).

A total of 81 mahseer (Manna, total length range 200 to 380 mm, n=40 and Tarusan, standard length range 155 to 230, n=41) were collected from during February-November 2012 from the littoral zone using a variety of methods including gill net (300 cm x 100 cm x 2 mm mesh), cast net (200 m x 60 m x 0.5 – 3 mm mesh) and hook and line. The fish were preserved in 10% formalin solution and latter in ethanol 70% for subsequent analysis.

Pectoral fins, pelvic fins and first gill branchial arches were dissected from the fish, cleaned and dried, and examined using a dissecting microscope and magnifying glass. Left and right sides of three meristic and morphometric bilateral characters were counted and measured: length of pectoral fin length, length of pelvic fin length, number of gill raker. These three characters were selected due to their functional importance as locomotive (fins) and feeding (gill rakers) and they were easy to measure. Morphometric bilateral characters were measured to the nearest 0.01 mm. The measurements were taken with no reference to previous values and the same person conducted all measurements. In order to avoid error with the measurement process, all variables of these samples were counted and measured twice.

Paired measurements were entered for each individual as the average between both sides and transformed into signed asymmetry values according to the formula right–left. All the calculated were subject to estimate both the value of fluctuation asymmetry magnitude and number according to formulation by Leary *et al.* (1983):

$$\mathbf{Fam} = \frac{\sum(L-R)}{N} \qquad \mathbf{Fan} = \frac{\sum Z}{N}$$

Keterangan :

Fam = Fluctuating asymmetry magnitude

Fan = Fluctuating asymmetry number

L = Number of left's organ

R = Number of right's organ

Z = Number of asymmetry for certain characters.

N = Sample number

We also estimated the overall fluctuating asymmetry (FO); the latter is calculated as the sum of the fluctuating asymmetry number (Fan) and fluctuation asymmetry magnitude (Fam) (FO = Fan + Fam) (Wagner, 1996).

The comparison of the mean level of fluctuating asymmetry between the two populations over all periods was compared with an independent *t*-Test as in the SPSS

11.5 program. Before independent *t*-test was first applied; the F test (*Levene's test)* assesses the hypothesis homogeneity. If the length distributions at sex were homogeny then *t*-test will use equal variance assumed and equal variance not assumed if the variance is unequal across the groups (Sokal and Rohlf, 1995). Spearman correlations were performed between absolute values of fluctuation asymmetry for significant difference characters and character size of standard length (Fessehaye *et al*., 2007).

RESULTS AND DISCUSSION

Mahseer was the most abundant in Tarusan River than that of fish from Manna River; its visual biomass clearly shows the high overcrowding occurring in the conservation area. The analysis shows there were differences in fluactuating asymmetry among mahseer, Manna River mahseer exhibited higher value of fluactuating asymmetry for almost all characters studied (Fig. 2).

There was a significant difference between Manna River and Tarusan River mahseer in the mean level of fluctuating asymmetry for pectoral fin length (F_{levene}= 17.76 (all the variables have the different variance), Independent t-test=2.512, $P<0.05$). A spearman correlation between means of bilateral characters and standard length was not significant for the pectoral fin length, so it is not possible at this stage to confirm that there is correlation between those two characters within the mahseer species.

Meanwhile the mean level of fluctuating asymmetry was not significantly different between Manna and Tarusan mahseer for pelvic fin length ((F_{levene}= 3.06 (all the variables have the same variance), Independent t-test=0.538, $P<0.05$) and number of gill raker ((F_{levene}= 3.00 (all the variables have the same variance), Independent t-test=1.459, $P<0.05$). The low level of asymmetry found in meristic characters is agreed with previous study. Swain (1987) has suggested that meristic characters are not as accurate as indicators of developmental stability as metric traits, because they only become asymmetric once stress reaches a threshold level.

The degree of developmental instability observed in mahseer for morphological character may be related to its functional importance. Manna River mahseer showed a significant reduced development of locomotive (fins length) characters, but not in term of pelvic fin length. Asymmetry in functionally important traits for fish such as fins probably makes locomotion less efficient, as has been observed for some domesticated animals (Møller and Swaddle, 1997; Knierim *et al*., 2007). The increased asymmetry in locomotive traits observed in Manna River mahseer perhaps a reflection of the decreased for a reduction in population size and effective population size (Wibowo, 2014). Moreover, Sato (2006) found that the occurrence of deformities in small, isolated populations of Kirikuchi charr *Salvelinus leucomaenis japonicus* Oshima was an important ecological indicator which reflected the decline in fitness. Furthermore, traits that are functionally important, such as fins, seem to exhibit extremely stable developmental trajectories and hence very small levels of fluctuating asymmetry (Møller and Höglund, 1991), which was not the case in the present study.

Mahseer is an active fish, this fish may be subjected to greater energy demands. The energy is needed both for their development needs. Some energy is needed to be allocated for maintaining homeostasis. If available energy is not sufficient to buffer the stress effects, homeostasis may be impaired, resulting in abnormal development (Mitton *et al.,* 2004). Consequently higher levels of asymmetry were evident in mahseer.

Results from this study are agreed with the hypothesis under overfishing that in unprotected Manna River mahseer increases the level of fluctuating asymmetry in fish. Individual asymmetry scores within a population can be used as a measure of an organism's ability to buffer its development against both genetic and environmental perturbations and can be considered an indirect measurement of individual fitness (Moller and Swaddle, 1997; Clarke, 1995). Thus, fluctuating asymmetry appears to be a useful indicator for stress-induced developmental instability in mahseer.

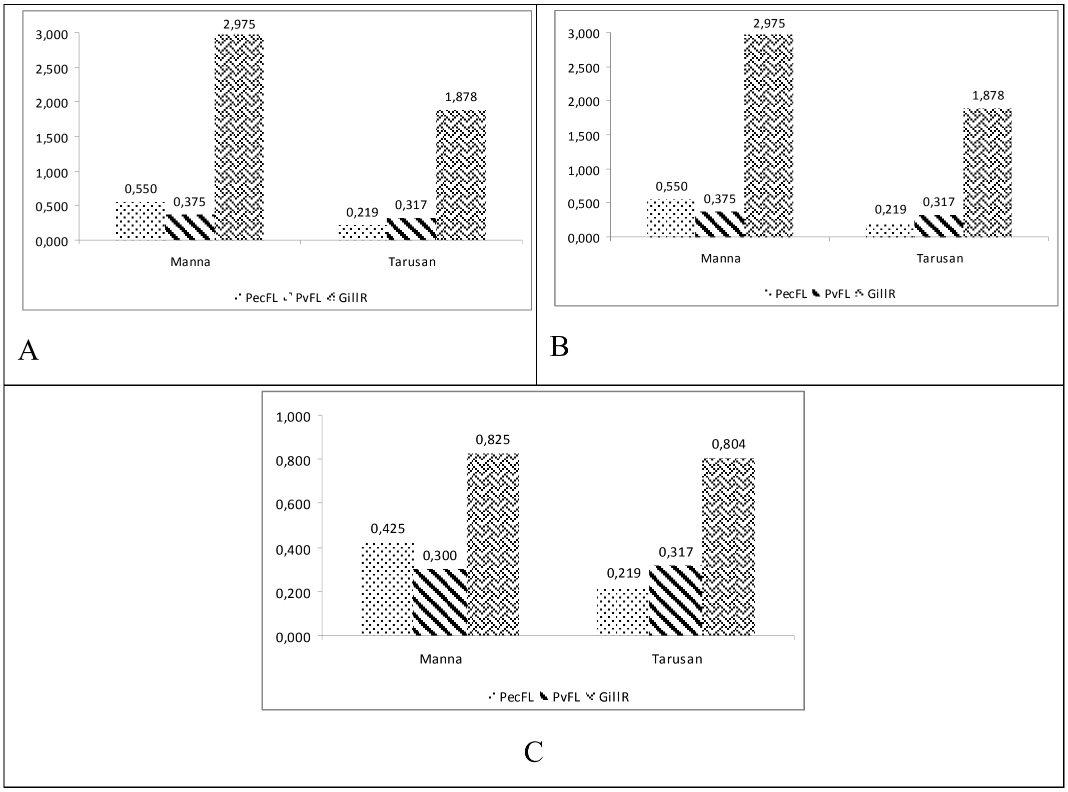

Figure 2. Variation in fluactuating asymmetry for several bilateral characters of mahseer group in Manna River and Tarusan River; A). fluctuating asymmetry magnitude, B). fluctuating asymmetry number and C). overall fluctuating asymmetry

CONCLUSION

Adverse conditions found in unprotected environments such as the Manna River affect morphological development of trait of functional importance for fish. The analysis show there were differences in fluactuating asymmetry among mahseer, Manna River mahseer exhibited higher value of fluactuating asymmetry for almost all characters studied with the significant reduced development of locomotive (fins length) character. Fluctuating asymmetry appears to be a useful indicator for stress-induced developmental instability in mahseer.

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