DESCRIBING BODY SHAPE OF GOBY, *Glossogobius giuris* (HAMILTON, 1822), FROM LAKE MAINIT, SURIGAO DEL NORTE USING LANDMARK-BASED GEOMETRIC MORPHOMETRICS

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Abstract

Glosssogobius giuris (Hamilton, 1822) is a native fish in Lake Mainit, Surigao del Norte, Philippines. Its size can reach up to 30 cm. In this study the size of *G. giuris* ranges 10.5- 23.5 (female) and 10.5-27.0 (male). It is aimed in this study to determine morphological variations in body shapes between sexes of *G. giuris* which could be important biological information useful in biodiversity studies and implementations of proper fishery management practices. Twenty-five landmark points were assigned on the specimens to quantify its body shape. The relative warp scores were used in Discriminant Function Analysis (DFA) to test the variations of body shapes between sexes of *G. giuris*. DFA, PCA scatter diagram and MANOVA suggest no sexual dimorphism of the species on the basis of body shape (Wilk's lambda = 1; p< 0.0001). Yet, some morphological variations were observed as displayed on the Box and Whisker's plot. Females have a deep body and broader abdomen related to males to cater its reproductive role in carrying and laying eggs and males have broader caudal peduncle compared to females.

Keywords: Geometric morphometrics, landmarks, discriminant, MANOVA

Introduction

Glosssogobius giuris belongs to the family Gobiidae. Gobiidae is one of the largest groups of fishes distributed in the world in marine, fresh and brackish water having more than 2000 species in more than 200 genera being known (Nelson, 1994 in Fishbase 2010; Berra, 2007; Sazima et al., 2008; Gerlach and Gerlarch, 2008; Hoese and Allen, 2009; Sanda and Kovacic, 2009; Bogorodsky et al, 2010; and Nip, 2010). They are characterized by having a tubular body, with two distinct dorsal fins and fused pelvic fins.

G. giuris was distinguished originally by Hamilton (1822) by having numerous fin rays of 22 (Akihito and Meguro, 1975). It has elongate slender body laterally compressed, with a deep flat caudal peduncle and a very large, wide, and long head (Herre, 1927).

G. giuris is a native and considered important fish in Lake Mainit, Surigao del Norte, Philippines. It is locally known as *pijanga*. Its size can reach up to 30 cm. It is one of the major fishes caught in large amount by fishermen in everyday basis. It is of minor commercial value unlike tilapia, carp, catfish, etc. because of its abundance in the lake.

But overfishing, catching of its fingerlings and of course exploitation (sewage disposal, chemical leaching from farms and mines, etc.) of the lake could pose great threats to the population of the *G. giuris* in the lake.

Thus, this study was conducted to gather information on variations of the morphology on body shape between sexes of *G.giuris* found in Lake Mainit with the use of landmark-based geometric morphometrics.

Glossogobius giuris is a suitable candidate for artificial culture in the future thus, many aspects of its biology are considered as per requisite (Joadder, 2009). Studying the morphological variations in body shapes of fishes using landmark-based geometric morphometrics provides better understanding on the genetic structure of fish species and provides scientific basis in formulating a comprehensive management plan for fisheries (de Guzman et al, 2009 and Dorado, 2010).

Methodology

Sample Collection

The *Glossogobius giuris* specimens were collected from Lake Mainit (Figure 1). The Lake is a shared resource of Agusan del Norte and Surigao del Norte in Mindanao Islands, Philippines. It is considered as the fourth largest (17,060 ha) lake and distinguished as the deepest lake having the maximum depth of 219.35 meters (Tumanda et al., 2005). There are twenty-eight river tributaries that contribute to the water volume of Lake Mainit and drained by a single outlet, the 29-km Kalinawan River that flows into Butuan Bay. The Lake has a total shoreline measurement of 62.1 km long and a watershed area of 87,072 hectare.

A total of 137 samples were collected from the lake by fishermen using seine. Eighty-two of which are females and 55 are males. The freshly caught samples were then sexed and put separately on different containers.

Figure 1 Map showing Lake Mainit in the Northeastern part of Mindanao (left) and scenic view of the lake (right).

Data Acquisition

Each sample was flanked on a Styrofoam and pinned its fins to show its points of origin. It was then measured and photographed capturing the left side of its body using a 12.1 megapixel Sony digital camera. The images were processed for the digitization of the body shape and further statistical analysis.

The images were digitized using TPSDig version 2.12 software (Rohlf, 2001) with 25 landmarks shown on Figure 2.

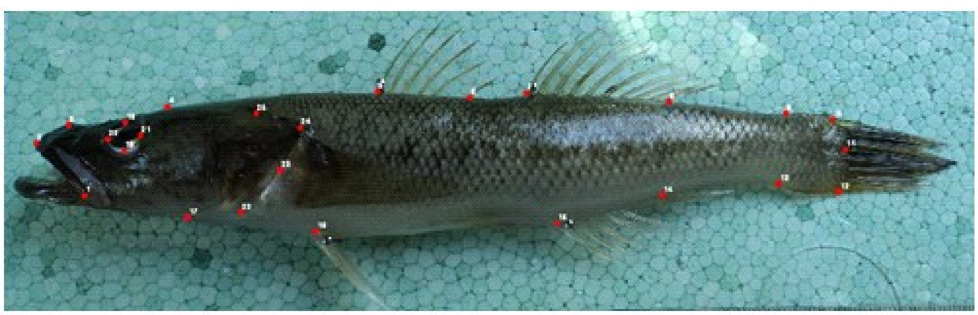

Figure 2 Location of landmarks used in the body shape analysis of *Glossogobius giuris*. Line diagram of the left flank of the sample, showing the locations of 25 landmarks that were used for body shape analysis. These landmarks corresponds to: (1) the axis of the jaws; (2) the tip of the snout (3-4) dorsal portion of the head (5-6) anterior-and-posterior-most edges of the first dorsal fin, (7-8) anterior-and-posterior-most edges of the second dorsal fin, (9-13) caudal (14-15) the posterior and anterior-most edges of the anal fin, at the points where it emerges from the ventral surface, (16) the pelvic fin, (17) ventral portion of the head, (18-21) orbital, and (22-25) edges of the gill feature.

Morphological Analysis

The 25 landmarks were used to analyze the body shape using landmark-based geometric morphometrics.. Using the TPS software developed by Rohlf, (2001), the x and y coordinates (using TPSdig program) were captured and the resulting coordinates were superimposed by means of Generalized Procustes Analysis (GPA) using the TpsRelW software that preserves all information about shape while removing only the information not related to shape (e.g., position and orientation) (Rohlf and Slice 1990; Dryden and Mardia, 1998; and Mitteroecker and Gunz, 2009). In this procedure, the landmarks of each specimen will be translated, scaled to unit centroid size, and it will be rotated to minimize Procrustes distance between all landmarks. The resulting Procustes distances were used to compute in Multivariate Analysis of Variance (MANOVA) using PAST software (Hammer et al. 2001) to evaluate whether differences in body shape between sexes of *G. giuris* presenting sexual dimorphism.

Discriminant Function Analysis (DFA) was also used to assess the total amount of variation between sexes of *G. giuris.* The Box and Whisker plot and Principal Component Analysis (PCA) scatter diagram were also used to visualize the degree of variation between sexes of the specimen. In these methods, the average body shape is displayed between sexes included in the analysis.

Results and Discussion

In this study, there is no significant difference (Table 1: MANOVA: Wilk's lambda = 1; $p< 0.05$) presenting no sexual dimorphism on the basis of the body shape between sexes of *G. giuris*. It is illustrated in Figures 3 and 4 the overlapping of characters that determines the degree of similarities of both sexes. A total of only 49.78% correctly classified male versus female.

Table 1 Results of MANOVA test for body shape between sexes of *G. giuris*.

	Wilk's Lambda	df1	df2	F	p(same)
Between Sexes of *G. giuris*	1	6	668	1.762E-06	**1**

Although the total body shapes of *G. giuris* shows no significant differences between sexes, some morphological variations were observed as shown on Figure 5. Relative warp (RW) scores revealed some significant morphological variations between the two sexes. It shows that RW1 (29.71%), RW2 (15.66%), RW3 (8.45%), RW4 (6.81%), RW5 (6.53%) and RW6 (5.24%) accounted to 72.4% total variance.

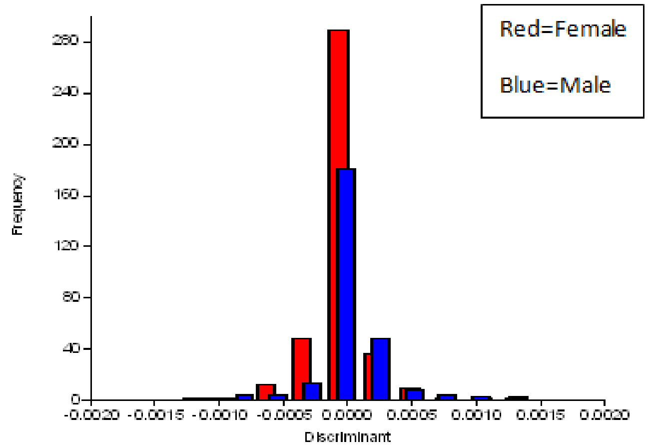

Figure 3 DFA graph showing the results of the computed relative warp scores of body shape of female(red) and male(blue) *G. giuris.*

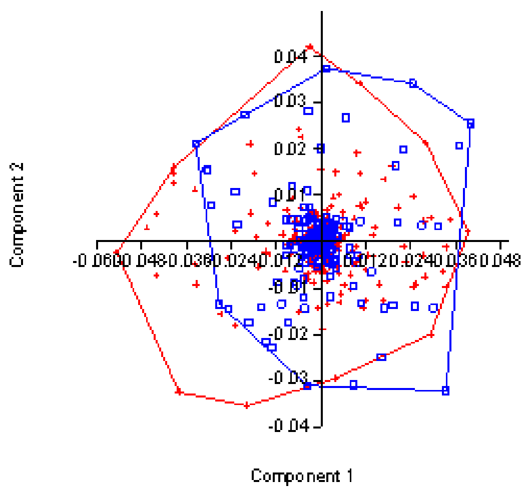

Figure 4 PCA scatter plot showing the distribution of female and male *G. giuris* based on body shape. *Legend: Red=female; Blue= Male.*

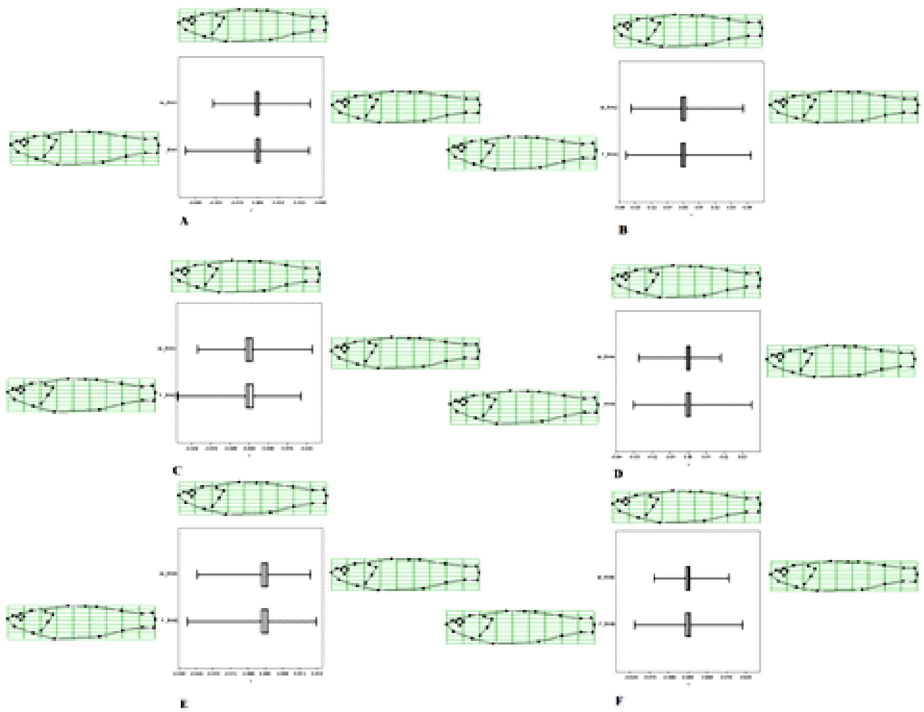

Figure 5 Box and whiskers plot showing the concensus body shape of female (left) and male (right) *Glossogobius giuris* (Hamilton 1822). *Legend: (A) RW1=29.71%; (B) RW2=15.66%; (C) RW3=8.45%; (D) RW4=6.81%; (E) RW5= 6.53% and; (F) RW6=5.24%.*

Females have deeper bodies and broader abdomen compared to the slender body of males. Males have a broader caudal peduncle compared to female. Relative study of Dorado (2010) on *G.giuris* revealed females which have deeper-bodies relative to a slender body outline of the male populations and some morphological variations has been observed between the two sexes. The observed morphological variations were the curvature of the body length observable in females, the position of pelvic fin, the location of pectoral fin and length of the caudal region, the body depth, the length of the trunk region (location of the pectoral fin and width of the anal fin) and the head region and location of the anal fin.

Morphological variations on body shapes of fishes usually conforms its habit and habitat. In the study of Nacua et al (2010), an observable large head and large mouth of *G. giuris*, with sharp teeth would be advantageous in capturing their prey. A deep body shape favors the consumption of benthic prey by increasing maneuverability of the body, while a shallow body shape is more likely beneficial in foraging plankton (Corse et al, 2009). Parallel results were observed in the study cichlid fish of Binning and Chapman (2010), cichlids with mollusk diet have larger pharyngeal jaws and muscles, compared to those cichlids of soft-food diet.

Moreover, habitat influences the body shape of the fishes. In this study, a deep body of *G. giuris* is related to its still environment in Lake Mainit. Relatively, impounded fishes displayed a deep-bodied and a smaller head, a more anterior dorsal fin, a shorter dorsal fin compared with the same species inhabiting adjoining rivers in relationships between flow regime (Haas et al, 2011).

Morphological variations in fishes can be attributed to sexual dimorphism. Wiley et al (2008) said that sexual dimorphism can be caused by evolutionary and ecological forces as the two sexes have different habits conforming their functional adaptations like in goby fishes, the females spawn (lay eggs) and males will protect the eggs from any predators.

Sexual dimorphism is determined by the genetic makeup of an organism as a well as environmental factor. It is known that variations in morphological characteristics of fishes are due to species variations within and between populations, genetically and phenotypically. When no physical barriers to gene flow, morphological variations are less likely driven by significant genetic differences (Webster et al, 2011). But if there gene flow barrier such as geographic separation more likely variations are caused by differences in water quality and other environmental conditions. Sometimes phenotypic discreteness would suggest a direct relationship between the extent of phenotypic divergence and geographic separation, which indicates that geographic separation, is a limiting factor for gene flow (Hossain et l, 2010).

Thus, geographically isolated fish populations are expected to possess variations in morphological characteristics as fishes are able to adapt by changing necessary morphometrics (Hossain et al, 2010). In the Study of Elmer et al (2010), they showed the non-overlapping morphospace of Cichlids species, in which Midas cichlids from different lakes have their own body shape characteristics significantly different from all others and distinguished as different species. Their results showed the effects of environmental conditions and adaptations to local environment.

Conclusion

While landmark-based geometric morphometric analysis did not reveal sexual dimorphism on the basis of body shape some morphological variations however were observed indicating that the method is useful in describing quantitatively these variations. A deep-bodied female was observed when compared to a slender males. A broad caudal peduncle of males compared to females. Morphological differences observed between sexes can be attributed to the habits and habitat of the fish species. Environmental conditions and adaptations are great factors that can affect body shape and morphological variations of within species. Knowing biological attributes of this species is useful in biological diversity studies and proper fishery management practices.

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