Outline Based Geometric Morphometric Analysis in Describing Shape Variation in Suckermouth Armoured Catfishes (*Pterygoplichthys* spp.): Basis for the Development of Automated Species Identification System

Loren Grace F. Jaranilla, Joel M. Chavez, and Jose Santos R. Carandang VI

***Abstract*—**The scientific community is facing taxonomic crisis. With still a huge number of species yet to be discovered, there is a great challenge to classify Earth's biodiversity. Computer-based automated species recognition has been suggested as a prospective technology to aid in the quick identification of species, especially taxa that form part of routine investigation. Most automated species recognition systems mainly used geometric morphometric-based techniques. The present study investigates whether suckermouth armoured catfishes (*Pterygoplichthys* spp.), locally known as janitor fish, can be differentiated based on the shape of its head, using outline based geometric morphometric analysis.The variation in shapes is further determined and described. Specifically, we look at *Pterygoplichthys* spp., being an invasive species in the Philippines, which may establish negative effects in the freshwater environments. A total of 150 closely connected points were made along the outline of the head using tpsDig 2. Relative warp scores generated were used for the analysis of shape variations. Relative warp analysis demonstrated variation in the outline of the head. The four significant relative warps jointly accounted for 87.34% and 80.51% of the variation in the dorsal view and lateral view, respectively. This suggests that shape could be a potential character for the differentiation of *Pterygoplichthys* species, which would serve as the basis for the development of an automated species identification system.

***Keywords*—**geometric morphometrics, Janitor fish, outline analysis, *Pterygoplichthys*, TPS

I. Introduction

A TAXONOMIC crisis is impending in the scientific community. The challenge is to classify the Earth's biodiversity amidst a decline in the number of trained taxonomists [1] and the acceleration of species extinction [2]. The traditional approach in identifying species requires that specimens be examined and assigned taxonomic labels [3] by trained taxonomists. However, not too many scientists are enamored such a task thus a shortage of experts on different species groups has risen; a problem that has come to be known in biology as the "taxonomic impediment"[4].

To address this challenge faced by taxonomy, computer-based automated species recognition has been suggested. The system aims to be a tool in the quick identification of species especially taxa that form part of routine investigations [5]. A number of automated species recognition systems have been developed and many of these systems used geometric morphometric-based techniques [6, 7, 8, 9, 10]. Geometric morphometrics can either be a landmark-based analysis (using a set of landmarks to describe the object or specimen), or an outline-based analysis (using the margin of the specimen) [11]. Geometric morphometric analysis has been successfully applied to differentiate shape in diverse specimens such as bluefin tuna [12], white stem borer [13], snakehead fish [14], soybean [15] and bamboo species [16], to name a few.

The need for species identification is also crucial in the study and mitigation of biological invasions. Biological invasion is a worldwide phenomenon attributable to anthropogenic activity that results in species extinction. In the Philippines, species of *Pterygoplichthys* spp., common name suckermouth armoured catfishes (SACs) and locally known as janitor fish, have become invasive. Over a decade, the fish has established populations in freshwater environments and has shown a potential to occupy various habitats [17]. In areas where SACs have been introduced, fishermen have blamed the fish for the decline in their fish catch and the decrease in their income. Two species are known to inhabit some major freshwater ecosystems in the Philippines. These are the *P. pardalis* and *P.disjunctivus* [18, 19]. *P. pardalis* and *P. disjunctivus* are differentiated by the pattern of spots and vermiculations in the abdomen [19, 20, 21]. However,

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variation in abdominal patterns between species suggests that this character may not be a reliable basis to differentiate the two species [23].

The present study investigates whether SACs can be differentiated based on the shape of its head. Specifically, this study determines and describes the variability in the shape of SAC species. Accordingly, this study would provide basis in the development of automated species identification that would be able to distinguish SAC species.

II. Materials And Methods

The file photographs of the SAC specimens in the Chavez and Carandang collection were used in the study; the specimens are currently deposited in the De La Salle University (DLSU) Zoological Collection. These specimens were collected from Marikina River and Laguna de Bay, and were previously photographed using a digital camera (Sony DSCW50, Minolta and HPS500) by Chavez (2012) prior to storage. Seventy digital images for the dorsal view and 70 images for the lateral view were loaded in tpsUtil 1.38 [24], which were used for digitization. The outline of the head up to the pre-dorsal spine of the fish was traced by laying closely connected points (Fig. 1) using tpsDig 2.12 [24].

Thin-plate spline deformation grids [25] were produced to visualize the shape differences in *Pterygoplichthys* spp using tpsRelw 1.46 [24]. Relative warps were analyzed using tpsRelw 1.46 [24] and PAST 2.17 software [26].

III. Results And Discussion

The relative warp analysis demonstrated variation in the outline of the head. However the variation generated does not separate the two species of *Pterygoplichthys*.

Visualization of the variations in head shape is based on the region of the skulls where the outline points are located (Fig. 2). The location of the outline points is based on the region of the skulls of *Pterygoplichthys* described by Moldez [27].

The four significant relative warps jointly accounted for 87.34% of the variation in the dorsal view. There was variation in the shape of the oslatero-ethmoideum , pterotic bone, compound pterotic bone, ospra-eoperculare and osmetaprygoideum portion in the dorsal view.

About 80.51% of the significant relative warps contributed to the variation in the lateral view. There was consistent variation in the oslatero-ethmoideum and compound pterotic bone portion.

This study is an assessment of variation between *Pterygoplichthys* species using outline-based geometric morphometric analysis, utilizing digital images of SAC samples. We utilized the outline-based method primarily because identification of specimens, in both field and lab, is

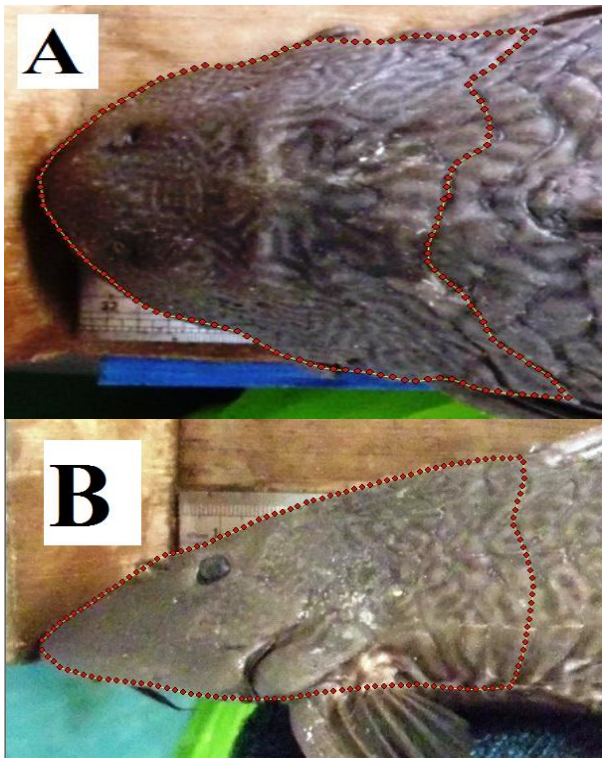

Fig. 1 Digitized image of *Pterygoplichthys* spp. showing the outline points in dorsal view (A) and lateral view (B).

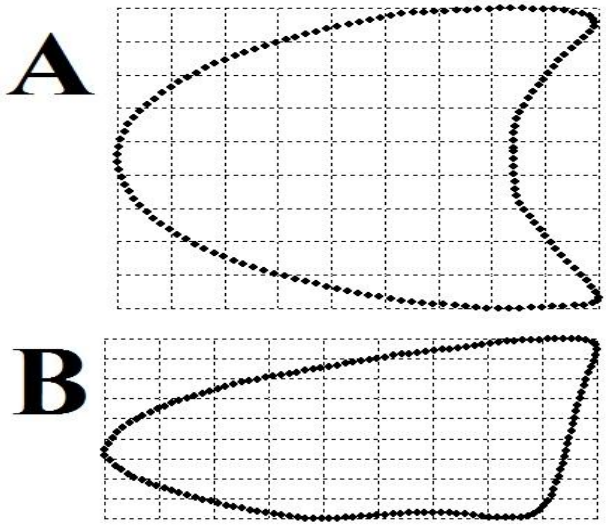

Fig. 2 Visualization of the variations in the head shape of *Pterygoplichthys* in dorsal view (A) and lateral view (B).

based on appearance of external shape. In the study of Moldez [27], he used the skull of SACs collected from Iligan City, Lanao del Norte, Philippines and applied landmark-based geometric morphometric analysis [27]. He was able to describe variations in the shape of the skull among species of *Pterygoplichthys*.

In the study by Jumawan et al.,[23] which involved DNA barcoding to identify *Pterygoplichthys* spp,, they proposed that abdominal pattern differences may not be a stable and reliable trait to differentiate between *P. pardalis* and *P. disjunctivus*.

They mentioned inconsistencies between the number of haplotypes and the minimal base pair differences they found in DNA barcodes. They concluded that the genetic values do not support species distinction and that the DNA barcodes do not complement the morphology-based identification of the two species. They mentioned as well the possibility of introgressive hybridization between *P. pardalis* and *P. disjunctivus*, and the need to reassess taxonomic assignment of the two species using abdominal pattern as basis for species distinction.

It is evident in our study that variation in shape is observed in the head of *Pterygoplichthys*, suggesting that shape could be a potential character to differentiate specimens. Variation found in this case however needs to be explored further to determine if such variations are due to ontogenetic or phylogenetic sources. And this is the caveat in developing a system to automate species identification, the selection of the strongest characters that should distinguish species using the most appropriate methods.

IV. CONCLUSION

Outline-based geometric morphometric analysis showed variation in the shape of the head of *Pterygoplichthys* spp. Our results suggest that shape could be a potential character to differentiate *Pterygoplichthys* specimens, and this could serve as the basis for the development of an automated species identification system.

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