Morphometric analysis of the Atlantic species of *Bollmannia* (Teleostei: Gobiidae)

Tornabene, L. Van Tassell J.
Hofstra University

ABSTRACT

The genus *Bollmannia* Jordan is composed of fourteen nominal species, five from the Atlantic Ocean. Original descriptions of two of the Atlantic species, *B. boqueronensis* and *B. litura*, are inconsistent with the meristics of the respective holotypes, mainly in the counts of the second dorsal and anal fin elements. The original descriptions of these species were previously used to differentiate these species from *B. communis*, *B. eigenmanni*, and *B. jeannae*, but the meristics of the actual holotypes show overlapping between these species. These discrepancies have led to the American Fisheries Society invalidating *B. jeannae* and *B. litura* as unique species in the 6th Edition of Common and Scientific Names of Fishes, where as Fishbase and the California Academy of Science, Catalog of Fishes, still recognize *B. litura* and *B. jeannae* as valid. In this study, we used morphometric analysis to determine if anatomical differences exist between *B. communis*, *B. eigenmanni*, *B. litura*, *B. jeannae* and *B. boqueronensis*, which would allow us to reconcile the species status. Through the use of TPSdig software, we were able to place digital landmarks on photographs of cataloged specimens of each species, as well as the respective holotypes to make accurate morphological measurements for the basis of comparison. The results of this experiment should provide the information useful in resolving the status of the Atlantic species.

RESULTS

Table 1 - Tukey HD post-hoc test of 1-way ANOVA analysis

(I) specie	(J) specie	Sig.
B.litura	B.eigenmanni	*.808
	B.boqueronensis	.000
(C.F.)	B.communis	.029
	Panama goby	.000
B.eigenmanni	B.litura	*.808
	B.boqueronensis	.002
	B.communis	.014
	Panama goby	.000
B.boqueronensis	B.litura	.000
	B.eigenmanni	.002
	B.communis	.000
	Panama goby	.000
B.communis	B.litura	.029
	B.eigenmanni	.014
	B.boqueronensis	.000
	Panama goby	*.486
Panama goby	B.litura	.000
	B.eigenmanni	.000
	B.boqueronensis	.000
	B.communis	*.486

*Differences are significant at p<.05

Table 3 – MDA-1 Predicted Group Classification

species	B. litura	B. eigenmanni	B. boqueronensis	B. communis	unknown Panama goby	% of specimen classified correctly
B. litura*	11	1	1	1	0	73%
B. eigenmanni	1	9	0	0	0	90%
B. boqueronensis	1	0	9	0	0	90%
B. communis	1	1	0	7	2	64%
unknown Panama goby	1	1	0	5	4	45%

*Holotype classification falls within B. communis grouping

Table 2 - Single sample t-test comparing MDA-1 scores of *B litura* holotype to C.D. *B. litura* specimen

	Test Value = -1.536020			
	t	df	Sig. (2-tailed)	Mean Difference
Discriminant Scores from Function 2 for Analysis 1	11.878	14	*.000	2.3485722
	Test Value = - .50710			
	t	df	Sig. (2-tailed)	Mean Difference
Discriminant Scores from Function 1 for Analysis 1	1.573	14	*.038	.43988503

*Samples Significantly Different if p< .05

INTRODUCTION

The family Gobiidae contains over 2000 described species in 212 genera (FishBase 2006). Many of these species however, have little or no economic value and thus receive very little attention from researchers. As a result of this, little is known about the phylogenic relationships that exist within these genera and subfamilies.

One such genus, Bollmannia Jordan is made up of 14 nominal species. Five of these species were described from the Atlantic Ocean; *Bollmannia litura* Ginsburg 1935, *B. boqueronensis* Evermann 1899, *B. eigenmanni*(Garman 1893), *B. communis* Ginsburg 1942, and *B. jeannae* Fowler 1941. In the process of trying to identify 23 specimens of Bollmannia obtained of the Atlantic coast of Panama by J. Van Tassell aboard the R/V Uracca, discrepancies in the descriptions of the nominal species were noted. This project is an attempt to resolve those discrepancies.

In Fowler's description of *B. jeannae*, he stated that *B. jeannae* differed from the description of *B. boqueronensis* in coloration, pectoral fin length, and cheek scale size (Fowler 1941). In Ginsburg's description of *B. communis*, he stated that these differences that Fowler described do not hold up when *B. jeannae* is compared to actual specimens of *B. boqueronensis*, and that the illustrations of *B. boqueronensis* that accompany Evermann and Marsh's description are altogether inaccurate. He concluded that Fowler was almost certainly describing what appeared to be a member of *B. boqueronensis*. (Ginsburg 1942).

Another inconsistency was found in the species description of *B. litura*. Ginsburg stated in his description that *B. litura* differed from the previously described Bollmannia in the Atlantic primarily in fin ray count. However, the description of *B. litura* differs from the holotype in the number of anal fin rays and 2nd dorsal fin rays. His description states that *B. litura* has 12 rays in the 2nd dorsal and anal fins, whereas the holotype has 14 rays for both fins. In addition to this error, Ginsburg also stated that because of the unavailability of actual specimen of *B. eigenmanni*, he was unable to compare the two types side by side, thus he was forced to rely solely on the *B. eigenmanni* description for comparison between the two species (Ginsburg 1935).

These problems raise questions about to the validity of these species. The American Fisheries Society has excluded *B. jeannae* and *B. litura* from its 6th Edition of *Common and Scientific Names of Fishes from the United States, Canada, and Mexico* (Nelson 2004). Other sources such as the ichthyology database of the California Academy of Science and FishBase, list all five species as valid (Fishbase 2006, CAS Catalog of Fishes 2005). Because of these inconsistencies the status of species in the genus Bollmannia is somewhat of an unknown.

In an unpublished manuscript, Ginsburg described patterns in sensory papillae of Bollmannia that appeared to be helpful in clarifying the status of the species. He used the patterns of papillae that multiple species shared to divide the genus into three sub-genera, but on an inter-species level, he admitted that many of the patterns were inconsistent. Ginsburg also mentioned difficulties in analyzing the patterns of papillae because of significant damage done to the facial region of fish during collection. Other than this unpublished manuscript, little work has been done since 1935 to resolve these species, particularly those in the Atlantic

The purpose of this research was to obtain and analyze data that would help clarify the status of the Atlantic species of Bollmannia, and ultimately help lead to the creation of a phylogeny for the species. Simple qualitative characteristics like body and fin coloration alone cannot be used as effective tools in determining if differences truly exist, because some of these initial descriptions were vague and most of the color has faded from the preserved fish. Location of where the specimens were found can be somewhat useful when combined with other quantitative data, but very little is known about these species' biogeography. Quantitative data from the fish themselves must be collected and interpreted to determine if any significant differences exist between the described species. To do this, we used digital x-rays and morphometric software to make measurements that could be analyzed to determine if significant variation exists between the cataloged specimens of each of the species, as well as their respective holotypes.

Figure 1 – *B. litura* holotype

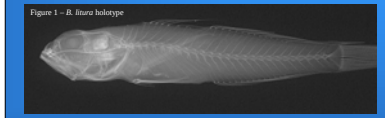


Figure 2 – digital landmarks on *B. communis* x-ray

Figure 3 – unknown specie of *Bollmannia* from Panama.

Figure 4 – Multiple discriminant function analysis using eye measurements only.

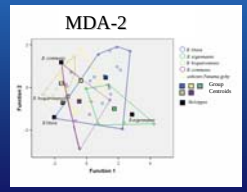


Figure 5– Multiple discriminant function analysis using all measurements

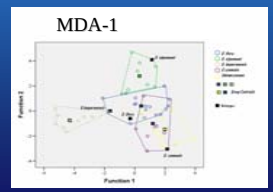
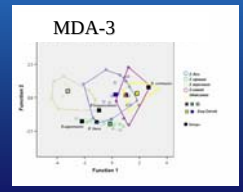


Figure 6 – Multiple discriminant function analysis excluding eye measurements.



METHODS

Methods

I. Obtaining Specimen

A minimum of 10 specimens that have been identified as *B. litura*, *B. communis*, *B. eigenmanni*, *B. boqueronensis* and the unknown specimen from the Atlantic coast of Panama were obtained. The specimens used were borrowed from the American Museum of Natural History, the Florida Museum of Natural History, Louisiana State University, and The Smithsonian National Museum of Natural History. Radiographs of the holotypes for *B. litura*, *B. communis*, *B. boqueronensis*, and *B. eigenmanni* were obtained from the National Museum of Natural History.

II. Data Acquisition

Digital x-rays were taken of most of the specimen, and the remaining specimen underwent normal x-rays, which were then scanned or photographed to convert into digital form. We used TPSdig software to place digital landmarks at positions on each x-ray. Many of the species descriptions refer to body depth and eye diameter as sources of variation between the species, therefore multiple landmarks were chosen in the cranial region of the fish (Figure 2). The landmarks were then used to make measurements that were analyzed to determine the amount of variation between the identified specimen of each species, as well as their respective holotypes.

III. Data Analysis

The measurements from the specimens we obtained were analyzed using a multiple discriminant function analysis (MDA). The MDA converted the measurements into two primary discriminant function scores that accounted for the majority of the variation that exists between species (MDA-1). Additional separate MDA's were performed for the measurements around the eye (MDA-2), as well the remaining measurements of the cranial region (MDA-3). These discriminant function scores were used to further explain the source of the variation between species. Once the specimens for each species were analyzed, the holotypes were then entered into the MDA to compare them to the centroids for each group. The results from the three MDAs were plotted to illustrate the relationships between groups as well as holotypes (Figure 4,5,6). A one-way ANOVA and post-hoc Tukey HD test were also performed with the scores of MDA-1 to quantify the significant difference between the groups of specimen (Table 1). A single sample t-test was performed comparing the discriminant function score of the *B. litura* holotype with the mean scores for the other identified specimen of *B. litura* (Table 2).

CONCLUSIONS

•The holotype of *B. litura* and the specimens identified as *B. litura* appeared to be different. Aside from the discrepancies in fin counts between the 2nd dorsal and anal fins (Figure 1), the single sample t-tests of MDA-1 scores showed that they are significantly different (Table.2). The one-way ANOVA of MDA-1 scores showed that specimen identified as *B. litura* do not differ significantly from specimen identified as *B. eigenmanni* (Table 1).

•*B. communis* and the unknown *Bollmannia* from Panama showed significant similarities. The post-hoc Tukey HD test of MDA-1 scores showed that specimen identified as *B. communis* do not differ significantly from the specimen of Bollmannia from Panama (Table 1). 64% of *B. communis* fell within the predicted group range according to MDA-1, whereas 18% of *B. communis* fell within the group range for the unknown *Bollmannia* from Panama (Table 3). 45% of the unknown *Bollmannia* from Panama fell within the predicted group range, whereas 36.4% fell within the range of *B. communis* (Table 3). M. Taylor recently performed molecular analysis on specimens from each species and determined a 5% genetic difference between the two (personal communications). However, photos of the specimens from Panama taken at the time of collection differed in coloration from the description of *B. communis*. The description of *B. communis* states that it has a dull color and faint dark bars along the sides and a dark dorsal fin, which is not the case with the specimen from Panama, which lacks the bars and has a dorsal fin with bright orange spots (Figure 3).

•Future research goals

While the MDA's we performed helped show the variation that exists between the Atlantic species of Bollmannia, many questions remained unanswered. The additional discrepancies discovered between the *B. litura* holotype and the species identified as *B. litura* stress the need for more clarification of this species. Additional specimen of *B. litura* collected in multiple regions for a larger morphometric analysis would help create a more definitive range of measurements that could possibly include the holotype. If future analyses show more evidence that separate the holotype from the identified specimen, then consideration should be taken in combining the species.

The status of the unknown species of *Bollmannia* from Panama remains unresolved. The differences and similarities between these specimen and *B. communis* are not significant enough to determine whether the species are the same or different. Sampling a larger number of *B. communis* from different regions of the Atlantic for morphometric analysis could create a more definitive range that may not show as much overlap with the unknown specimen from Panama. Comparison of photography of new *B. communis* specimen at the time of collection and photographs of the specimen from Panama would also be a more accurate comparison than using the original species description. Further molecular analysis on all of the Atlantic species of *Bollmannia* is also a goal we wish to reach for determining the degree of genetic variability, and ultimately forming a phylogeny for the species.

BIBLIOGRAPHY

Eschmeyer, W.N. 2005.: The Catalog of Fishes. Online version http://calacademy.org/research/ichthyology

Evermann, B.W. and Marsh, M.C. 1898(1899). Descriptions of new genera and species of fishes from Puerto Rico. Report of Commisioner of Fish and Fisheries: 24 351-362.

Fowler, H.W.1941 Notes on Florida fishes with descriptions of seven new species Proceedings of The Academy of Natural Sciences of Philadelphia XCIII: 81- 108.

Froese, R. and D. Pauly. Editors. 2006. FishBase. World Wide Web electronic publication. www.fishbase.org, version (05/2006).

Garman, S. 1896 Report on the fishes collected by the Bahama Expedition, of the State University of Iowa, under Prof. C.C. Nutting, in 1893. Bulletin from the Laboratories of Natural History of the State University of Iowa. 4(1): 76-93.

Ginsburg, I. 1935. Bollmannia litura, a new species of goby. Smithsonian Miscellaneous Collections 91 (20): 1-4.

Ginsburg, I. 1942. Seven new American fishes. Journal of the Washington Academy of Sciences 32(12): 364-370.

Nelson, J.S., E.J. Crossman, H. Espinosa-Pérez, L.T. Findley, C.R. Gilbert, R.N. Lea, and J.D. Williams. 2004. Common and scientific names of fishes from the United States, Canada, and Mexico. American Fisheries Society, Special Publication 29, Bethesda, Maryland.