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Variations in Scale Morphology between Sexes of the Spotted Barb, *Puntius Binotatus* (Valenciennes, 1842) (Actinopterygii: Cyprinidae)

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Abstract. Scale morphology provides new and useful information for systematics. Scales have numerous hidden details in their structures that contribute effectively to fish identification and classification. A total of 574 female scales and 583 male scales have been examined from 7 different regions of the spotted barb, *Puntius binotatus*. Characteristics such as scale type, shape and size, position of the focus, circuli appearance, type of radii and shape of the posterior margin were the distinguishable features considered in describing the scales. The scales examined have the general morphological characteristics of a cycloid type. The circuli were distinct and disrupted and the radii were found to be of primary type. Significant variations in shapes were observed within and between sexes of the fish. This study demonstrated that scale characteristics can provide useful taxonomic information on the morphological differences between sexes of *P. binotatus*.

Keywords: Scale, Morphology, Variation, *Puntius binotatus*

1. Introduction

The environment is recognized as a powerful force in modeling the morphology of an organism during ontogeny. Scales, the dermal derivatives of fish body are important structures used as a versatile research material for morphological studies [1]. Scales have numerous hidden details in their sculptural design that contribute effectively to fish identification and classification. Detailed structure of the fish scale can be helpful in describing the species, phylogeny, sexual dimorphism, age determination; past environment experienced by the fish, migration, discriminating between hatchery-reared and wild populations. It is also important in understanding the pathology of a fish scale due to pollution of a water body. Since most of the lepidological studies are on commercial fishes [2], we investigated the scale morphology of a threatened cyprinid fish species, the spotted barb *Puntius binotatus* collected from a lake in Zamboanga del Sur, Philippines. We qualitatively describe the scales of the male and female *P.binotatus* following the procedures of Lippitsch [3]. Cyprinid fishes form one of the important links in the fish community structure in different water bodies hence, the standardization of the scale structure of these fishes shall help in the understanding of their bionomics [4].

2. Material and Methods

Puntius binotatus were obtained from Salug Valley River of Zamboanga del Sur, Philippines. Sexes were identified through the removal of fish gonads. The scales of fishes on different specific regions A, C, E, G, I, J and scales under the pectoral fin were selected (Fig. 1).

The scales were allowed to air dry and a dilute solution of detergent was prepared to clean the scales and then mounted in a pair of glass slides. The prepared slides were examined under the light microscope where the digital image of each scale in different regions was taken using a 14.1 megapixel GE digital camera. The digital images of fish scale samples were identified according to its scale characteristics including (1) type of scale; (2) overall scale shape; (3) scale size; (4) position of focus; (5) type of radii; (6) circuli appearance;

and (7) the appearance posterior fields. A total of 574 female scales and 583 male scales have been examined from 7 different regions.

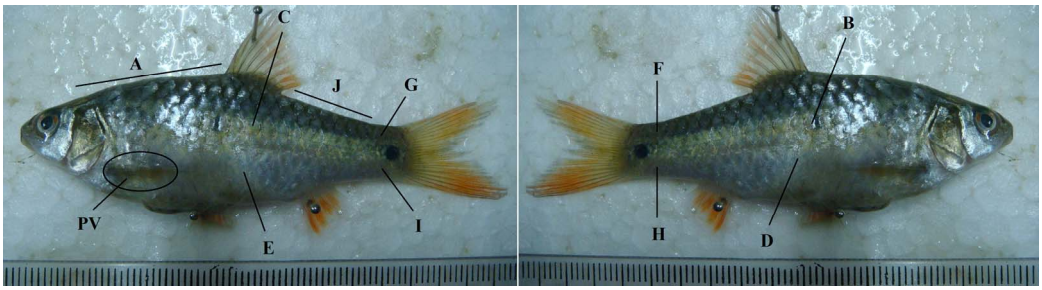

Fig. 1: Photograph of the *Puntius binotatus* fish showing the various selected regions where scales of interest are located. (A) antero dorsal (upper head to dorsal fin region), (B-C) scale region above and on the lateral line canal, (D-E) antero-ventral scale region (before pectoral fins), (F-G) postero-dorsal region (above the peduncle), (H-I) postero-dorsal region (below the peduncle), (J) postero-dorsal region (after the dorsal fin), and (PV) pectoral fin region (under the pectoral fin).

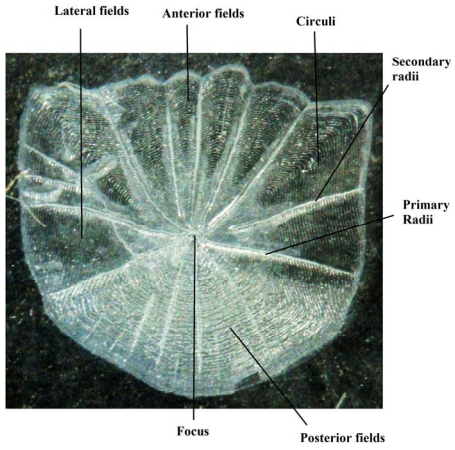

Fig. 2: Photograph of a typical cycloid scale of *Puntius binotatus* (Valenciennes, 1842) showing the anterior, lateral, and posterior fileds, circuli, primary and secodary radii, and the focus of the scale.

The seven characteristics of scales that have been considered in the study were carefully observed on each scale in every region and data observed were recorded. Each characteristic was given corresponding code as shown in table 1 below.

Table 1: Characteristics used to describe the different types of scales of *P. binotatus*.

Scale Characteristic	Type	Scale Characteristic	Type
Scale Shape	Rectangle, Pentagonal, Round, Square, Oblong, Triangle	Type of Radii	Primary, Secondary
Scale Size	Small, Moderate, Large	Circuli Appearance	Distict;Disrupted Not Distinct; Disrupted
Position of Focus	Centrally located, Posteriorly located	Shape of the Posterior Margin	Tongue like, Triangular

3. Results and Discussion

Fish scale shapes were observed to be elliptic, oblong, pentagonal, rectangular, rounded, square, triangular and cycloid (Fig. 3).

Variation in scale shapes do occur between and within body regions (Table 2). Scales collected from *P. binotatus* is a cycloid since a smooth, thin, disc-like appearance was observed. The anterior field is embedded in the skin and overlapped by the posterior side of the proceeding scale. This arrangement of

overlapping scales gives the fish greater flexibility than in those species with cosmoid and ganoid scales [11]. It is important to note however that it is very evident that within a specific region of both the male and female bodies show variability in scale shapes. It was observed in this study that variations among and within regions of the fish scale of both sexes can be observed (Fig. 5). Based on the shape, size, position of focus, appearance of circuli, and the number and distribution of radii of the scales, variations within and among regions can be observed. The shapes of the scale vary from either rectangular, square, pentagonal and oblong. The shape of the posterior margin varies from tongue-like to triangular. Scale size varies from small to moderate to large sizes. The number and distribution of the radii were also observed to vary within regions. Two types of radii were commonly observed. These are the primary radii originating from the focus reaching the margin of the scale and the secondary radii originating midway between the focus and the margin [4].

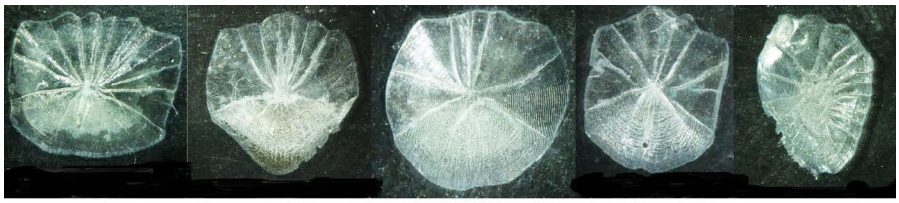

Fig. 3: Fish scale shapes commonly observed in the male and female *P. binotatus* (Valenciennes, 1842).

The position of the focus was mostly centrally located. From the focus lines of growth (the ridges) or circuli start appearing as the scales increase in size. Circuli are distinct, and disrupted in the anterior part (Fig. 4). These disruptions might be due to the exposure of the fish to environmental and biological factors such as spawning, stunted growth or abundance of food [5].

The circuli are partitioned by deep and narrow grooves or radii that run radially towards the focus categorized into primary and secondary types. The number of primary radii is commonly observed in the scales of both sexes than the secondary radii. Not all scales observed have a secondary radii and the presence of the said radii could only be observed in about 2 to 3 scales per region except regions J and I in both sexes. The observed higher number of radii is correlated with the better nutritive conditions of the fish [6] [7] and also represent scale flexibility [2]. The number of radii present per scale varies from about 10 to 25 for both sexes. It is argued that the higher number of radii is correlated with the better nutritive conditions of the fish which could be abundant in their habitat [6] [7]. It is important to note however that the variation in number of radii has nothing to do with the scale size. Studies have shown that there is no significant relationship between the number of radii and the scale size, as the numbers of radii depend on the location of the scale on the fish body [4].

There is no apparent differences exist on both sexes based on the position of focus since focus positions are found to be centrally located in all regions of the fish body. The focus is the part of the scale that developed first during ontogenesis. The position of the focus on the scale remains the same throughout the life of the individual species [7] [8].

While the shape of fish scales is to a considerable extent species-specific and is also useful in the determination of stock membership, morphological variation between sexes as observed in this study can be argued to be a result of selection for phenotypes that provide energetic or functional advantages with local hydraulic variation for the fish [1]. While some of the variations observed in scale character between sexes can be attributed to the portion of the body which they are attached to [11], such differences may well reflect adaptations of the species to different functions and swimming characteristics, or adaptations to varying hydrodynamic conditions [12]. It cannot be disregarded however that environmental influences might also influence fish scale morphology defining fish stocks characterized by phenotypic differences [13].

4. Acknowledgements

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Fig. 4: An image showing the distinct and disrupted circuli of *Puntius sirang.*

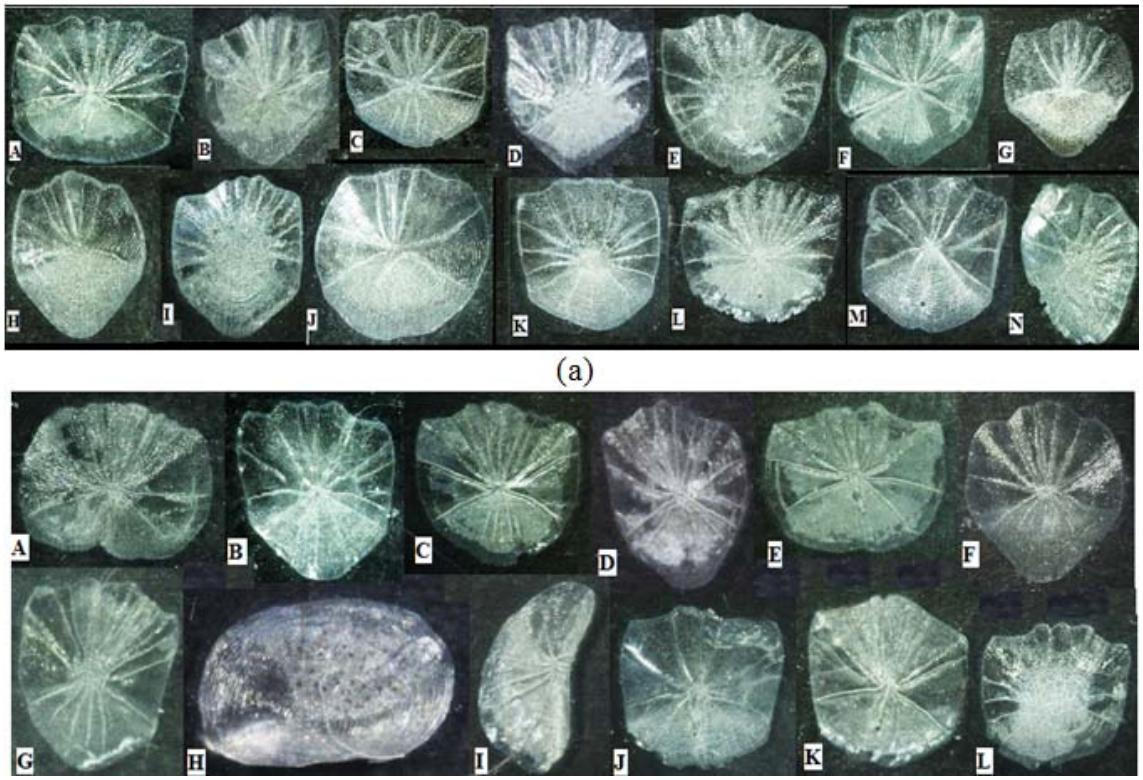

Fig. 5: Images of the variants extracted from the (a) female and (b) male scales of *P. binotatus*.

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Table 2: Variation in the descriptive characteristics of scales within and among seven different regions of the three samples of female *Puntius binotatus* (Valenciennes, 1842).

	FEMALE							
	Scale Characteristics							
Body Regions	*Type of Scale*	*Scale Shape*	*Scale Size*	*Position of Focus*	*Type of Radii*	*Circuli Appearance*	*Shape of the Posterior Margin*	*Number of Scales*
Region A1	Cyc	Rec & Pen	Lar	20 Cent; 3 Post	23 Pri	Dist; Disr	Tri	23
Region A2	Cyc	Sq & Rou	Mod	33 Cent; 2 Post	35 Pri	Dist; Disr	T-L	35
Region A3	Cyc	Pen & Rec	Mod	14 Cent	14 Pri	Dist; Disr	Tri	14
Region C1	Cyc	Rec	Lar	30 Cent	30 Pri	Dist; Disr	T-L	30
Region C2	Cyc	Rec & Sq	Lar	36 Cent	36 Pri	Dist; Disr	T-L	36
Region C3	Cyc	Rec	Mod	37 Cent	37 Pri	Dist; Disr	T-L	37
Region E1	Cyc	Sq & Rec	Lar	36 Cent	36 Pri	Dist; Disr	T-L	36
Region E2	Cyc	Rec	Lar	35 Cent; 1 Post	36 Pri	Dist; Disr	T-L	36
Region E3	Cyc	Rec	Lar	38 Cent	38 Pri	Dist; Disr	T-L	38
Region G1	Cyc	Pen & Sq	Sml	30 Cent	30 Pri	Dist; Disr	Tri	30
Region G2	Cyc	Rec & Sq	Sml	27 Cent	27 Pri	Dist; Disr	T-L	27
Region G3	Cyc	Rec & Pen	Sml	17 Cent	17 Pri	Dist; Disr	Tri	17
Region I1	Cyc	Rec & Pen	Sml	20 Cent	20 Pri	Dist; Disr	T-L	20
Region I2	Cyc	Rec	Sml	27 Cent	27 Pri	Dist; Disr	T-L	27
Region I3	Cyc	Sq & Rec	Sml	20 Cent	20 Pri	Dist; Disr	T-L	20
Region J1	Cyc	Pen & Rec	Mod	21 Cent	21 Pri	Dist; Disr	Tri	21
Region J2	Cyc	Rec & Sq	Mod	21 Cent	21 Pri	Dist; Disr	Tri	21
Region J3	Cyc	Pen & Rec	Mod	24 Cent	24 Pri	Dist; Disr	Tri	24
Region PV1	Cyc	Rec	Mod	21 Cent	21 pri	Dist; Disr	T-L	21
Region PV2	Cyc	Rec	Mod	35 Cent	35 Pri	Dist; Disr	T-L	35
Region PV3	Cyc	Rec & Sq	Mod	26 Cent	26 Pri	Dist; Disr	T-L	26
				MALE				
Region A1	Cyc	Pen & Rec	Mod	17 Cent	17 Pri	Dist; Disr	Tri	17
Region A2	Cyc	Rec & Pen	Mod	37 Cent	37 Pri	Dist; Disr	Tri	37
Region A3	Cyc	Rec & Pen	Mod	24 Cent	24 Pri	Dist; Disr	T-L	24
Region C1	Cyc	Rec	Mod	36 Cent	36 Pri	Dist; Disr	T-L	36
Region C2	Cyc	Rec & Sq	Lar	31 Cent	31 Pri	Dist; Disr	T-L	31
Region C3	Cyc	Rec	Mod	33 Cent	33 Pri	Dist; Disr	T-L	33
Region E1	Cyc	Rec	Mod	34 Cent	34 Pri	Dist; Disr	T-L	34
Region E2	Cyc	Rec	Mod	30 Cent	30 Pri	Dist; Disr	T-L	30
Region E3	Cyc	Rec	Mod	28 Cent	28 Pri	Dist; Disr	T-L	28
Region G1	Cyc	Rec	Sml	30 Cent	30 Pri	Dist; Disr	Tri	30
Region G2	Cyc	Pen &Rec	Sml	26 Cent	26 Pri	Dist; Disr	Tri	26
Region G3	Cyc	Rec	Sml	15 Cent	15 Pri	Dist; Disr	T-L	15
Region I1	Cyc	Rec	Sml	27 Cent	27 Pri	Dist; Disr	T-L	27
Region I2	Cyc	Rec & Pen	Sml	40 Cent	40 Pri	Dist; Disr	T-L	40
Region I3	Cyc	Rec	Sml	13 Cent	13 Pri	Dist; Disr	T-L	13
Region J1	Cyc	Rec & Pen	Mod	29 Cent	29 Pri	Dist; Disr	T-L	29
Region J2	Cyc	Pen &Rec	Mod	35 Cent	35 Pri	Dist; Disr	Tri	35
Region J3	Cyc	Pen & Rec	Mod	24 Cent	24 Pri	Dist; Disr	Tri	24
Region PV1	Cyc	Rec	Mod	25 Cent	25 Pri	Dist; Disr	Tri	25
Region PV2	Cyc	Rec	Mod	29 Cent	29 Pri	Dist; Disr	T-L	29
Region PV3	Cyc	Rec	Mod	20 Cent	20 Pri	Dist; Disr	T-L	20

Legend: Cyc – cycloid, Obl – oblong, Pen – pentagonal, Rec – rectangular, Rou – rounded, Sq – Square, Sml – small, Mod – moderate, Lar – Large, Dis – Distict, Cent – centrally, Post – posteriorly, Pri – primary, Sec – Secondary, T-L – tongue like, Tri – triangular.