Morphological Study to Improve Identification Toward Poeciliidae Family Based on Gonopodium Structures and Morphometric Analysis

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ABSTRACT

Poeciliidae family consists of small livebearer fishes with sexual dimorphic. These fishes are widely distributed across Indonesian archipelago, but biological studies on these fishes are very limited. The research is aimed at identifying the species of Peciliidae fishes living in Lake Sari, Pasuruan, based on gonopodium structures and morphometric analysis. A specific characteristic of Poeciliidae family is that its gonopodium structures are a modification of the third, fourth, and fifth rays of the male's anal fin. Each species are represented by 50 male and female samples from each type we found in the Lake, and they are measured in 26 characters (in mm). Cladogram based on morphometric measurements shows that sample 1 and 2 has 100 % similarity, sample 3 has 94 % similarity with sample 1 and 2, and sample 4 has 54 % similarity with sample 1, 2, and 3. Based on gonopodium structures, sample 1 and sample 2, included *Xiphophorus hellerii* Heckel, possess large claws on the terminus of the fifth ray, has a small crescent-moon shaped hook on the third ray, and lacks of *gonopodium palp*. Sample 3 possesses a *distal platform* with 11 *retrosse serrae*, and membranous hook; so we were able to identify sample 3 as *Poecilia mexicana* Steindachner. Sample 4 is *Poecilia reticulata* Peter having a long-pointed, comb-like spines on the third ray, and having a small hook on the tip of the fifth ray.

Keywords: Identification, Poeciliidae family, morphometric analysis, gonopodium structures

INTRODUCTION

Fresh water fishes include the order of Cyprinodontiformes, among which is Poeciliidae family. The Poeciliidae family consists of fishes which are widely distributed throughout the world. The fertilization of this family is internal. Members of this family can be used as an object or a model for biological studies, such as ecology, embryology, morphology, physiology, and behavioral study. Some members of the Poeciliidae family are able to control the spread of malaria by eliminating population of Anopheles larvae [1]. However, the systematic, diversity, and phylogenetic relationship between the genus is not yet studied comprehensively [2].

Sari Lake which is located in the borderline between Purwodadi and Lawang, East Java, Indonesia, has such biodiversity abundance. There are many species of fishes found in this

area. Among those species are fishes called *gatul* fish by the local people around Sari Lake area. Gatul fish in the Sari Lake have different morphological characteristics one to another, but their diversity have not known yet. Diversity knowledge is important to support information of biodiversity database of fishes in Indonesia.

Poeciliidae family consists of small fishes (4-20 cm total length). Their body is elongate to moderately deep. They have a flat head, a scaled and short snout, except in *Belonesox*. They have a wide, terminal, oblique, and protrusible mouth. These fishes have a single dorsal fin with 6 to 19 soft rays; their position are relative to anal fin variable. Their anal fin has nine soft rays. The third anal-fin ray is unbranched in males and females. The caudal fin is round or emarginate. The pectoral fins have 9 to 16 soft, short, and rounded rays, and inserted high on the side of the body. The pelvic fins have 6 soft rays; subthoracic position in females and thoracic position in adult males. Their body has large cycloid scales [3].

Poeciliidae are viviparous cyprinodonts in which the anal fin of the male is advanced and modified into an intromittent organ. Differences in the structure of this organ bring great sys-

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tematic importance [4]. Members of Poeciliidae are different in terms of gonopodium structures. These differences determine the genus and species [5]. Transfer of sperms into female reproduction tract is accomplished by a gonopodium, a generally highly modified anal fin. The anal fin of males is modified into a thin, elongate intromittent organ (gonopodium) which is not tubular, not scaled, and not enclosed as an extension of the sperm duct.

This paper describes the characteristics of Poeciliidae family based on gonopodium structure and morphometric analysis. The description is important to understand the correlation of each type of Poeciliidae family found in Sari Lake.

MATERIAL AND METHODS

Morphological observations were done on 50 male and female samples from each type we found. We did very careful observation on the gonopodium structure, because it is one of the important keys to identify the genus and species level. We identified the gonopodium structures on the third, fourth, and fifth rays of the male's anal fin from each type of male fish.

Figure 1. Gonopodium structure observation of Poeciliidae

The third rays of the gonopodium structure were claw, segment edge, *retrose serrae*, and *gonopodium palp*. The fourth rays of the gonopodium structure are ramus and distal serrae, 4 proximal serrae (p) rays gonopodium edge segment, proximal serrae and the fifth rays are claw and hook, 5p ray and a sub distal gonopodium like in Figure 1 [4].

The morphometrics measurement included *Total length* (TL), *Standard length* (SL), *Pre Dorsal Length* (PreDL), *Pre Orbital Length* (PreOL), *Pre Pectoral Length* (PrePL), *Pre Pelvic Length*, *Pre Anal Length* (PreAL), *Eye Length* (EyeL), interorbital length, depth of body, depth of head, length of

caudal peduncle, depth of caudal peduncle, length of dorsal fin, length of anal fin, length of pectoral fin, length of pelvic fin, length of caudal fin, length of sword, length of snout, height of dorsal fin, height of pectoral fin, height of caudal fin, height of pelvic fin, height of anal fin [6], and length of gonopodium [7].

Each species was represented by 50 male and female samples from each type we found and measured 26 characters (in mm). To standardize the different body sizes among the sample, each measurement was divided by the SL (standard length) and converted to percentage. The converted data was transformed into log10 value before being subjected to principal component analyses and clustering analyses based on Euclidean distances using PAST software.

RESULTS AND DISCUSSION

A specific characteristic of the Poeciliidae is on its gonopodium structures, that is modification of the third, fourth, and fifth rays of the male's anal fin. Sample 1 and 2 (Figure 2A and B), possess large claw on the terminus of the fifth ray (orange arrow), have a small crescent-moon shaped hook on third ray (green arrow), and lack of *gonopodium palp* (blue arrow). Compared to sample 1 and 2, sample 3 and 4 possess a *gonopodium palp* (blue arrow). Sample 3 (Figure 2C) possesses a *distal platform* with 11 *retrose serrae* (purple arrow), membranous hook (red arrow), and well developed membranous tissue on the third ray around the distal tip (light green arrow). Sample 4 (Figure 2D) has a long-pointed comb-like spines on the third ray (white arrow), and has a small hook on the tip of 5p ray (pink arrow).

Figure 2. Gonopodium structure. A) Sample 1; B) Sample 2; C) Sample 3; and D) Sample 4. Description) 1) *distal serrae*; 2) *claw*; 3) *hook*; 4) *comb*; 5) *membranous tissue*; 6) *blade*; 7) *retrose serrae*; 8) *membranous hook*; 9) *gonopodium palp*; 10) *cephalic ramus*; 11) *distal platform*

Identification key of Poeciliidae family

Based on morphological characteristics (morphometric and gonopodium structure), we concluded this characters into identifications key of this family:

1. a. Membranous hook and membranous tissue on the third ray..... *Poecilia mexican*
- b. Does not have membranous hook and membranous tissue on the third ray.....2
2. a. Possess large claw on the terminus of the fifth ray, have a small crescent-moon shaped hook on third ray, and lacks of gonopodium palp *Xiphophorus hellerii*
- b. Does not have claw on the tip of the 5a ray segment, have a small hook on the tip of the 5p ray and has gonopodium palp.....*Poecilia reticulata*

Figure 3. Gonopodium structure sketch, 1) distal serrae; 2) claw; 3) hook; 4) comb; 5) membranous tissue; 6) blade; 7) retrose serrae; 8) membranous hook; 9) gonopodium palp; 10) cephalic ramus; 11) distal platform

Based on those gonopodium characters, we propose to classify these samples in a hierarchy as follows [5]:

Kingdom : Animalia
 Phylum : Chordata
 Class : Actinopterygii
 Ordo : Cyprinodontiformes
 Family : Poeciliidae
 Sub-family : Poeciliinae
 Genus : *Xiphophorus* (sample 1 and 2)
 Poecilia (sample 3 and 4)
 Species : *X. hellerii* Heckel (sample 1 and 2)
 P. mexicana Steindachner (sample 3)
 P. reticulata Peter (sample 4)

The most common morphological characters of the fish species studied are that they have a single dorsal fin with soft rays, anal fin rays on the female mounted A9, three rays are not branched with anal fin, pelvic fin rays have V6, indicating sexual dimorphism of the body size and color pattern, and have cycloid scales. These characters indicate that these fishes actually are

Figure 4. Dendrogram based on morphometric characters in Sari Lake, Purwodadi, Pasuruan

members of Poeciliidae [1].

Cladogram based on morphometric measurements showed that *X. hellerii* (orange) and *X. hellerii* (grey) have 100 % similarity, *P. mexicana* has 94 % similarity with orange and grey *X. hellerii*. *P. reticulata* has 54 % similarity with the others. The dendrogram based on Euclidian distance shows that the Poeciliidae can be divided into two clusters, the *X. hellerii* group and the second cluster was divided into two sub-clusters (Figure 4). This clustering was based on data which derived from 26 characters measurements (Table 1, supplement 1).

The male and female fishes have different body color patterns. Sexual dimorfi in color pattern follows the character of Poeciliidae. Type 1 has a lot of carotenoids pigment (orange), type 2 has a lot of melanocytes pigment (grey), and type 3 has a lot of carotenoid pigments in the body with orange spots on the abdominal area and neatly arranged rows in antero-posterior part of the body. The character of color pattern is similar to *Poecilia* (Mollenesia) *rositae* [8]. Type 4 has melanocytes pigment in the females, while the males have yellow, black, and metallic pigment creating different spots. There is a black-spotted color pattern for the members of *Poecilia*, Poeciliidae family, as well as on the species of *P. reticulata*—each has a black spot on the body of the male fish. These colors are indeed owned by the members of *Poecilia*, such as *Poecilia wingei* and *P. reticulata* [9].

CONCLUSION

Based on gonopodium characteristics, there were three different species. Those are *X. hellerii*, *P. mexicana*, and *P. reticulata*. Then, the results of cladogram based on the morphometric measurements showed that sample 1 and 2 had 100 %

similarity; sample 3 had 94 % similarity with sample 1 and 2; and sample 4 had 54 % similarity with sample 1, 2, and 3.

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Supplement 1

Table 1. Morphometric measurements of Poeciliidae family

No.	Morphometrics Characters (n=50)	Type 1 (cm)		Type 2 (cm)		Type 3 (cm)		Type 4 (cm)	
		♂	♀	♂	♀	♂	♀	♂	♀
1	TL (<i>Total Length</i>)	7,03-8,75	6,06-7,36	7,03-9,05	6,06-7,40	4,59-5,85	5,70-6,84	2,18-2,50	2,37-2,87
2	SL (<i>Standart Length</i>)	3,30-4,92	4,75-5,91	3,69-4,85	4,79-5,91	3,68-4,82	4,42-5,36	1,58-1,78	1,62-2,12
3	Pre. D.L (<i>Pre Dorsal Length</i>)	2,03-2,45	2,48-2,98	1,85-2,33	2,49-2,99	1,91-2,41	2,63-3,11	0,91-1,05	0,83-1,17
4	Hd.L (<i>Head length</i>)	0,95-1,19	0,99-1,19	0,75-0,97	1,0-1,20	0,80-1,00	0,90-1,12	0,4	0,34-0,46
5	Pre.O.L (<i>Pre Orbital Length</i>)	0,3	0,28-0,38	0,30	0,29-0,37	0,30	0,28-0,36	0,1	0,1
6	Pre.P.L (<i>Pre Pectoral Length</i>)	1,13-1,37	1,21-1,47	1,08-1,30	1,23-1,47	1,07-1,23	1,15-1,35	0,41-0,53	0,45-0,53
7	Pre.Pelvic.L (<i>Pre Pelvic Length</i>)	2,09-2,39	2,02-2,92	1,75-2,23	2,03-2,93	1,57-1,91	2,03-2,39	0,68-0,82	0,67-0,83
8	Pre. A.L (<i>Pre Anal Length</i>)	2,52-2,80	2,67-3,67	2,17-2,69	2,68-3,72	1,77-2,29	2,66-3,18	0,81-0,95	0,81-1,03
9	Eye diameter	0,10	0,31-0,41	0,3	0,34-0,44	0,3	0,3	0,2	0,2
10	Eye Length	0,30	0,11-0,21	0,1	0,12-0,22	0,1	0,1	0,1	0,1
11	Body lenght	1,42-1,66	1,60-2,20	1,08-1,54	1,59-2,27	1,22-1,44	1,32-1,74	0,31-0,41	0,29-0,49
12	Head depth	0,74-0,98	0,86-1,14	0,73-0,91	0,86-1,14	0,91-1,03	0,87-1,13	0,21-0,31	0,23-0,35
13	Caudal peduncle lenght	1,88-2,24	1,35-1,75	1,58-2,06	1,32-1,76	1,65-2,15	1,51-1,85	0,76-0,88	0,72-0,84
14	Caudal peduncle high	1,01-1,19	0,97-1,21	0,78-1,00	0,95-1,19	0,64-0,86	0,77-1,01	0,26-0,32	0,22-0,32
15	Dorsal fin lenght	1,18-3,94	1,23-1,41	0,83-1,15	1,17-1,39	0,58-0,82	0,63-0,77	0,2	0,20-0,30
16	Pectoral fin lenght	0,92-1,18	0,85-1,11	0,84-1,08	0,89-1,15	0,76-0,94	0,85-1,15	0,4	0,34-0,42
17	Pelvic fin lenght	1,03-1,27	0,75-0,99	0,92-1,1	0,71-0,97	0,70-0,88	0,54-0,76	0,39-0,49	0,41-0,53
18	Caudal fin lenght	3,31-4,23	1,02-1,68	3,13-4,37	1,03-1,71	0,73-1,21	1,11-1,65	0,56-0,74	0,53-0,93
19	Anal fin lenght	-	1,02-1,68	-	0,85-1,07	-	1,02-1,68	-	0,34-0,54
20	Dorsal fin high	1,19-1,29	0,74-0,92	0,86-1,04	0,73-0,93	0,68-0,88	0,62-0,86	0,28-0,36	0,22-0,32
21	Anal fin high	-	0,39-0,49	-	0,38-0,48	-	0,34-0,54	-	0,26-0,32
22	Pectoral fin high	0,18-0,28	0,29-0,39	0,14-0,24	0,28-0,36	0,30-0,40	0,29-0,39	0,1	0,2
23	Caudal fin high	1,01-1,19	1,96-2,18	0,79-1,01	0,95-1,19	0,66-0,88	0,75-1,11	0,3	0,23-0,31
24	Pelvic fin high	0,1	0,1	0,12-0,22	0,1	0,08-0,16	0,34-0,54	0,1	0,09-0,18
25	SWL (<i>Length of Sword</i>)	3,31-4,23	-	3,13-4,39	-	3,13-4,39	-	0,38-0,52	-
26	Snouth lenght (SNL)	0,3	0,3	0,3	0,3	0,3	0,3	0,1	0,1
27	Gonopodium lenght	0,9-1,18	-	0,77-0,99	-	0,77-0,99	-	0,39-0,53	-