Evaluation of heritability and selection response of the growth in the first-generation population of gourami (*Osphronemus goramy* Lac.) originated from four populations

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**Abstract.** The genetic improvement program through selective breeding is one of the efforts to overcome the slow-growing constraints in gourami (*Osphronemus goramy* Lac.) farming. The selective breeding to improve the growth performance of gourami using the family selection method was first conducted by the formation of a base population using a diallele cross of four populations originating from Kalimantan (Borneo), Jambi, Majalengka, and Tasikmalaya. The best performing individuals were selected to produce the first generation (F1) population. This study aimed to evaluate the growth (body weight) and determine the heritability of the F1 population. Individuals selected from the base population were communally spawned using a half-sib mating with a male:female ratio of 1:2. The grow-out phase was carried out in earthen ponds with a stocking density of 5 fish/m², 7 families out of 14 families were kept until 13 months of age. The results showed that the body weight variation coefficient ranged from 12.36-18.65% with a selection differential of 70.75 - 112.56 g. The heritability of the body weight was 0.88, with a selection response of 11.18%. These results revealed the selection progress with increased body weight in F1 population. Thus, selective breeding is effective to be continued.

**1 Introduction**

The giant gourami *Osphronemus goramy* Lacépède (1801) is a freshwater fish native to Indonesia, and this species has been reared for decades in Java, Sumatra, and Borneo Islands as the main gourami producer. This fish has become one of the main species being farmed and is in great demand in the food aquaculture industry [17]. FishBase reports that there are native or introduced giant gourami in 20 nations. In 2017, Indonesia produced 145.300 tonnes of giant gourami, accounting for more than 98.4% of the overall production,
approximately nine times more than the 16.438 tonnes it had in 2002. Indonesia's major islands contribute to the production of giant gourami, but Java and Sumatra combined account for more than 94% of the nation's total production (60% and 34%, respectively) [5].

Despite the market's continued growth and stable prices, gourami production is fourth after tilapia, carp, and catfish. Increasing gourami production needs to be supported, among others, by the availability of superior fry to achieve national production targets. The application of breeding programs is also a key to continuing sustainable aquaculture to increase fish production, besides technological advances, and better disease management [13]. Gourami is known as a slow growing fish, and as the main problem in gourami farming, it becomes an obstacle in cultivating gourami development culture [1]. To overcome this problem, it is necessary to provide gourami fries with a fast growth rate in sufficient quantities. The program of providing superior seeds can be achieved through breeding efforts by utilizing gourami breeds that develop in society. Several types of gouramis are widely found in the community. However, the productivity of each type of fish is still being determined, so the possibility of getting the best product is still experiencing obstacles.

The breeding efforts to produce new strains of gourami that are superior in growth character were started in 2014 at the Sukamandi Research Institute for Fish Breeding under the Ministry of Marine Affairs and Fisheries were carried out through a breeding program entitled "Formation of Superior Varieties of Fast-Growing Gourami Fish". The breeding activity began with collecting gourami from several locations, namely Majalengka and Tasikmalaya in West Java Province, Jambi in Jambi Province, and Banjar in South Kalimantan Province. The results of morphometric characterization conducted by [16] showed that pure strains and crosses from South Kalimantan, Jambi, Majalengka, and Tasikmalaya gourami populations have long genetic distances. Hence, the populations of pure strains and crosses are different.

Based on the traits to be selected, selection activities are divided into 2 types: qualitative and quantitative. Qualitative selection is selection based on qualitative traits such as color in ornamental fish, while quantitative selection is based on quantitative traits such as weight and body length. Qualitative selection is usually easier because a single gene controls qualitative trait while multiple genes control quantitative traits.

The obstacle faced in the gourami spawning process is that it is difficult to get spawning simultaneously. So far, the spawning process of gourami occurs naturally; until now, artificial spawning has not been possible. Based on the above considerations, conditions, characteristics, and constraints in the gourami spawning process, the selection program applied to gourami is selection within the family (within family selection). By applying this "within family selection," a synthetic base population is hoped to be obtained from the best individuals from all targeted families.

Some genetic parameters that need to be known in the selection program include the level of heritability, breeding value, selection response, genetic improvement, and so on. Research of the heritability, selection response test, and production of the first-generation population aim to form the population of the first generation of giant gourami grow fast and know the value of selection response as part of a series of assembly research activities giant gourami grow fast strain.

### 2 Material and methods

Implementing selection activities aimed at increasing genetic diversity to overcome the abovementioned problems requires the input of new genes by introducing gourami fish from nature (wild population). As a basic material for forming the fast-growing synthetic
base population of gourami, the Research Institute for Fish Breeding introduced gourami from nature in 2014 and 2015 from the Majalengka (M), Tasikmalaya (T), South Kalimantan (K) and Jambi (J) regions. The results of the 2014 study obtained 12 families as F0-forming parents, namely the families KK, JJ, MM, TT, KJ, KM, KT, JK, JM, MK, MJ, and TJ. The results in 2015 were obtained by 7 families: KK, JJ, KM, JK, MK, MT, and TJ. The results in 2016 obtained information that male and female gourami had matured gonads at the age of 23 months.

The stages of research on the formation of gourami through the selection route include the stages of spawning F0-forming broods, seeding I, seeding II, and enlargement. The following is a research design for the stages of research carried out: Communal or mass spawning in gourami selection is carried out by spawning six ponds consisting of KMX♂TJ or MKX♂TJ, ♂TJX♀MK or TJX♀KM, ♂MJX♀KT or ♀MJX♂KT, ♀KJX♂MT or ♂KJX♀MT, ♂MTX♀KJ or ♀MTX♂KJ, and ♀MKX♂TJ or ♂MKX♀TJ. Mass spawning is carried out in a 400 m³ soil pond, partitioned into two (@200 m³) with a ratio of 1:2 parents (male: female) with 30 fish per pond. The six spawning ponds are spawned by selecting brood first. The weight of the brood used ranges from 2-3 kg with a lifespan of 24-32 months. Before spawning, resting the broodstock is carried out first.

Each spawning selects as many as 4 best families, and the eggs are raised for two weeks in the hatchery. In seeding stage I, after releasing the yolk, the larvae are given artemia feed every three hours starting from 08.00-23.00 for three days. On the 11th day, it begins to be adapted to the feeding of Tubifex sp. until 21 days old. Seeding stage II seeds aged 21 days are degraded into a concrete pond measuring 25m² to 3 months old (30 families @ 400 seeds approximately 5-10 g in size). Gourami measuring 5–10 grams as many as 30 families (@ 400 seeds) are kept in separate ponds in ponds measuring 50 m². The enlargement stage in a 50 m² pond lasts 9 months until it measures 150-175 g. After that, 30 fam (@ 200 gourami) was selected. The enlargement stage is carried out in an earthen pond measuring 100 m². After 17 months of age, as many as 30 families (@15 fish were selected (5 males and 10 females). Therefore, from 30 families, we obtained 450 fish consisting of 150 male fish and 300 female fish.

Breeding is carried out communally using the halfsib spawning method with a ratio of male and female parents of 1:2. The number of families kept until the age of 13 months is 7 out of 14 families. Enlargement activities are carried out in ponds with a dense stocking of 5 fish/m². The parameters observed are weight coefficient variation, differential selection, heritability value, and selection response.

### 3 Results and discussions

Growth performances of the first-generation population (F1) at the age of 13 months are shown in Table 1.

<table>
<thead>
<tr>
<th>Population</th>
<th>Weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base population (F0)</td>
<td>441.10±33.14</td>
</tr>
<tr>
<td>The first-generation population (F1)</td>
<td>490.84±77.84</td>
</tr>
</tbody>
</table>

The value of genetic quality improvement and heritability analysis of the body weight of the first-generation population (F1) gourami is shown in Table 2.
Table 2. Analysis of heritability and selection response of the first-generation population (F1) and the base population (F0) gourami for 13 months.

<table>
<thead>
<tr>
<th>Selection parameters</th>
<th>F0</th>
<th>F1</th>
<th>F1 Vs F0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coefficient of variation (%)</td>
<td>7.51</td>
<td>15.86</td>
<td>-</td>
</tr>
<tr>
<td>Selection differential</td>
<td>56.22</td>
<td>104.42</td>
<td>-</td>
</tr>
<tr>
<td>Selection response (g)</td>
<td>-</td>
<td>-</td>
<td>49.74</td>
</tr>
<tr>
<td>Selection response (%)</td>
<td>-</td>
<td>-</td>
<td>11.28</td>
</tr>
<tr>
<td>Heritability</td>
<td>-</td>
<td>-</td>
<td>0.88</td>
</tr>
</tbody>
</table>

The water quality parameters observed during the experiment are presented in Table 3.

Table 3. Water ponds quality of the first-generation population gourami (F1).

<table>
<thead>
<tr>
<th>Parameters</th>
<th>F0</th>
<th>F1</th>
<th>References [6]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature (°C)</td>
<td>25.0 – 30.5</td>
<td>26.6 – 31.0</td>
<td>25.0 – 32.0</td>
</tr>
<tr>
<td>pH</td>
<td>6.8 – 8.1</td>
<td>7.7 – 8.4</td>
<td>&gt;5</td>
</tr>
<tr>
<td>DO (mg L⁻¹)</td>
<td>3.2 – 8.0</td>
<td>3.6 – 8.5</td>
<td>6.5 – 9.0</td>
</tr>
<tr>
<td>Amonnia (mg L⁻¹)</td>
<td>0.07 – 1.08</td>
<td>0.09 – 1.32</td>
<td>&lt;0.5</td>
</tr>
<tr>
<td>Nitrite (mg L⁻¹)</td>
<td>0.01 – 1.24</td>
<td>0.02 – 1.67</td>
<td>&lt;1.0</td>
</tr>
</tbody>
</table>

One of the indicators of success in fish cultivation is growth. Furthermore, the evaluation of growth performance, particularly on weight characteristics, can be considered as a factor that indicates the success or failure of the breeding program through selection, transgenesis, and hybridization methods. Internal and external factors can influence growth differences. During the larval rearing period, food and temperature factors play more roles in influencing growth increase. This is due to the change of feed for larvae from endogenous to exogenous and from natural to artificial feed. According to [14], growth is influenced by both internal factors and external factors. Factors include heredity, age, sex, diseases, and parasites. At the same time, external factors consist of food, temperature, salinity, and water pH.

Some breeding efforts were carried out by utilizing the gourami breeds that developed in the community. The results of [12] research using the enzyme electrophoresis method showed that, in general, gourami races that developed in communities such as Blusafir, Soang, Bule, Batu, and Bastar had relatively low genetic diversity. After a decade, the characterization results conducted by [10] show that genetic diversity between gourami breeds cultivated in the community is still relatively low. Implementing selection activities aimed at increasing genetic diversity to overcome the abovementioned problems requires the input of new genes by introducing gourami fish from nature (wild populations). Research Institute for Fish Breeding introduced gourami as a basic material for forming the fast-growing synthetic base population of gourami from nature in 2014 and 2015, originating from the Majalengka, Tasikmalaya, South Kalimantan and Jambi regions.
Although selection does not generate new genes, additive genetic variation can alter the frequency of genes to increase genetic quality qualitatively and quantitatively to obtain superior parents as elders. Table 1 shows that the F1 seed population had a better average individual weight development than the F0 seed population in the previous period. Progress in mean weight over 13 months of maintenance resulted in a final mean weight difference between the two populations of 49.74 g, and it indicates an increase in the growth performance of the F1 giant gourami population by 11.28% of the F0 population. [8],[9],[11],[20] estimated that selection activities in each parent generation would result in an average genetic quality improvement of 10%. Based on this statement, the genetic quality improvement of 11.28% in this study's F1 giant gourami population was above the average standard of selection activities. It shows that boosting genetic quality (genetic gain) in parents through selection will improve the average of the offspring population.

In this study, the evaluation of the performance of F1 seeds is more precisely carried out through a heritability approach in a real sense (realized heritability). This analysis is based on real performance obtained through a field test. Realized heritability is obtained after the implementation of selection activities, and such heritability is actual [2],[3]. Heritability analysis, in a real sense, involves additive genetic variation alone without considering dominant genetic variation or epistasis variation in populations. Due to the power of the decline of dominant genes epistasis is not as absolute as the action of additive genes [15]. After thirteen months of enlargement in this study, the realized heritability of weight characters amounted to 0.88. The results showed that genetic diversity additives influenced 88% of the weight diversity. According to [15], heritability levels are divided into three categories: low, medium, and high. Heritability is low if the value is between 0-0.20; medium if the value is between 0.2-0.4; and high if the value is greater than 0.4, whereas [10] quantitative character h values in fish are divided into three levels: low (0-0.1), medium (0.1-0.3), and high (0.3-1.0). [18] states that heritability is one of the most useful parameters in animal breeding. Heritability indicates the proportion of phenotypics derived from genetic factors. It goes on to say that the magnitude of the heritability value needs to be known when planning a breeding program and when predicting selection responses. The data shows a high heritability value. A high heritability value indicates that individual selection programs are effective when applied in the giant gourami breeding programs [4],[7],[19].

4 Conclusion

The weight difference (selection response in g) between F1 gourami and F0 gourami was 49.74 g, or equivalently, genetic performance improvement (selection response) from F0 to F1 is 11.28%. The heritability value (h2) of weight characters in gourami populations is included in the high category of 0.88. These results revealed the progress of selection with an increase in body weight in F1 population. Thus, selective breeding is effective to be continued.

Acknowledgments

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References