RESEARCH ARTICLE

REVISED Growth, production and feed conversion performance of the gurami sago (Osphronemus goramy Lacepède, 1801) strain in different aquaculture systems [version 3; peer review: 2 approved, 1 approved with reservations]

Azrita Azrita[1], Netti Aryani[2], Ainul Mardiah[3], Hafrijal Syandri[4]

[1]Department of Biology Education, Faculty of Education, Bung Hatta University, Padang, 25133, Indonesia
[2]Department of Aquaculture, Faculty of Fisheries and Marine Science, Riau University, Pekanbaru, 28293, Indonesia
[3]Department of Aquaculture, Faculty of Fisheries and Marine Science, Nahdlatul Ulama University of West Sumatera, Padang, 25176, Indonesia
[4]Department of Aquaculture, Faculty of Fisheries and Marine Science, Bung Hatta University, Padang, 25133, Indonesia

v3 **First published:** 03 Mar 2020, **9**:161
https://doi.org/10.12688/f1000research.22201.1
Second version: 23 Apr 2020, **9**:161
https://doi.org/10.12688/f1000research.22201.2
Latest published: 27 Jan 2021, **9**:161
https://doi.org/10.12688/f1000research.22201.3

Abstract

Background: Giant gourami (*Osphronemus goramy, Osphronemidae*), belonging to gurami sago strain, is an important economic fish species that was newly released for domestication in 2018 in Indonesia. The present study aimed to determine the growth, production and feed conversion efficiency of gurami sago strain in different aquaculture systems.

Methods: A mean of 240 juveniles were stocked (initial weight mean, 54.53 g and length 13.88 cm) into concrete ponds, floating net cages and earthen freshwater ponds (12 m^3) with three replicates of each. The juveniles were fed a floating commercial pellet diet containing 30% crude protein and 5% crude lipids. Feed was supplied at 3% of fish biomass per day throughout the 90 days of the experiment. The research was conducted in the area surrounding Lake Maninjau of Indonesia.

Results: After 90 days, the mean weight of fish reared in concrete ponds was 166.86 g, floating net cages was 179.51 g and earthen freshwater ponds was 149.89 g. The mean final biomass was 37.64 kg for concrete ponds, 41.27 kg for floating net cages, and 33.72 kg for earthen freshwater ponds. The specific growth rates (%/day) for concrete ponds, floating net cages and earthen freshwater ponds were 0.67, 0.75 and 0.62, respectively. The feed conversion rates were 1.45 for concrete ponds, 1.30 for floating net cages and 1.87 for earthen freshwater ponds. The net yields (kg m^{-3}) were 2.05 for concrete ponds, 2.27 for floating net cages, and 1.73 for earthen

Open Peer Review

Reviewer Status ? ✓ ✓

	Invited Reviewers		
	1	**2**	**3**
version 3 (revision) 27 Jan 2021	? report		
version 2 (revision) 23 Apr 2020	? report	✓ report	✓ report
version 1 03 Mar 2020	? report	? report	

1. **Simon Pouil**, INRAE, Jouy-en-Josas, France
2. **Peter Vilhelm Skov**, Technical University of Denmark, Hirtshals, Denmark
3. **Rudy Agung Nugroho**, Mulawarman University, Samarinda, Indonesia

Any reports and responses or comments on the article can be found at the end of the article.

freshwater ponds. The exponents (b) of the length–weight relationship were calculated for concrete ponds (1.0146), floating net cages (1.2641), and earthen freshwater ponds (1.0056).
Conclusion: The study showed that the growth performance, production and feed conversion efficiency of the gurami sago strain were the best found in floating net cages and considered a new aquaculture system in the future.

Keywords
Giant gourami, aquaculture systems, juveniles, growth, environment factors

Corresponding author: Hafrijal Syandri (syandri_1960@yahoo.com)

Author roles: Azrita A: Conceptualization, Data Curation, Methodology, Project Administration, Writing – Original Draft Preparation; **Aryani N**: Data Curation, Resources, Validation, Writing – Review & Editing; **Mardiah A**: Methodology, Supervision, Writing – Review & Editing; **Syandri H**: Conceptualization, Data Curation, Formal Analysis, Methodology, Validation, Writing – Original Draft Preparation

Competing interests: No competing interests were disclosed.

Grant information: This study was funded by a competitive grants scheme called the Productive Innovative Research (Policy/Governance) 2019 from the Indonesia Endowment Fund for Education, Ministry of Finance, Republic of Indonesia with the contract number: PRJ-99/LPDP/2019.
The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

How to cite this article: Azrita A, Aryani N, Mardiah A and Syandri H. **Growth, production and feed conversion performance of the gurami sago (Osphronemus goramy Lacepède, 1801) strain in different aquaculture systems [version 3; peer review: 2 approved, 1 approved with reservations]** F1000Research 2021, **9**:161 https://doi.org/10.12688/f1000research.22201.3

First published: 03 Mar 2020, **9**:161 https://doi.org/10.12688/f1000research.22201.1

REVISED **Amendments from Version 2**

We have added some information to complete our article:

ABSTRACT

Conclusion: The best aquaculture system was found in the floating net cages.

CONCLUSION

In conclusion, our study showed that gurami sago strain can be efficiently reared in concrete ponds, earthen freshwater ponds and floating net cages. For all tested parameters, the best aquaculture system was found in the floating net cages.

Any further responses from the reviewers can be found at the end of the article

Introduction

Aquaculture activities have been responsible for the supply of fish for human consumption. To meet the demand for food from aquaculture production arises competition use natural resources, such as land and water[1–3], included species, and aquaculture system[4–6].

The giant gourami *Osphronemus goramy* Lacepède (1801) is one of the main freshwater commodities of economic importance. This species has been produced in small-scale farms for decades in Indonesia[7,8]. However, only contributed as much 6.96% of the total freshwater aquaculture production. Meanwhile, *Nile tilapia*, *Clarias* catfish, *Pangasius* catfish, and common carp has been contributed 37.93%, 33.35%, 12.38%, and 9.28% of 3,374,924 metric tons freshwater fish production[9]. Therefore, there are still important gaps of knowledge in its aquaculture of giant gourami.

Although the contribution from giant gourami was lowest (6.96%), but the local gurami tambago and gurami galunggung strain have been cultured in semi-intensive[7,8]. The giant gourami belongs to the local gurami sago strain has never been cultured intensively. This species is the result of newly released domestication in 2018[10], which still limited in West Sumatera Province of Indonesia[11]. Gurami sago is an herbivorous species which can consume a variety of plants such as sente leaves (*Alocasia macrorrhiza*), kale (*Brassica oleracea*), cassava leaves (*Manihot esculenta*), and others young land plants. In addition, this species can eat commercial pellets, and tolerate crowded aquaculture production systems, such as earthen freshwater ponds and artificial ponds lined with membranes[8,11,12].

The gurami sago strain has been detected as candidate species for production in middle-scale farm in Indonesia[11]. This species grows well in nursery ponds and reach a market size of 200 to 300 g per fish and a size of 50 to 100 g per fish as ornamental fishes. This characteristic creates commercial interest as a new species in an effort to develop freshwater fish farming in the future. Concrete ponds and floating net cages were options in the development of gurami sago culture. Many studies have found that continuous water flow systems in concrete ponds, artificial ponds lined with membranes, tanks, canvas tanks, pens and many other systems could be an alternative for fish aquaculture because these systems provide a high degree of control that can allow for high production[5,12–16].

In the last decade, cage systems have received more attention from both researchers and producers. Fish farming in cages can be practiced intensively[17,18]. High production can be achieved at a low cost[19,20]. Fish farming in cages can achieve maximum growth with a high survival rate[18,21,22]. However, cage fish farming has advantages and disadvantages that must be considered before choosing a production system. The main disadvantages of fish farming in the floating net cages of lakes are that they are not ideal for land use and may cause massive fish deaths[23,24]. Meanwhile, the advantages of floating net cage aquaculture include high water circulation, solid waste not accumulating near cages, low water quality variation, and no electrical power required for water aeration[18,21,22,25,26].

Fish production systems in many countries use a variety of methods, e.g., carp in earthen freshwater ponds[27], giant gourami in earthen freshwater ponds and artificial ponds lined with membranes[7,12]. *Nile tilapia* in the ponds and cages[28], and golden pompano in the floating cages[29]. Because the rearing of the gurami sago strain is relatively new, there are no parameters or best methods available to predict the growth performance, survival and feed conversion efficiency in a commercial rearing system. Therefore, knowledge about the contribution of gurami sago to each aquaculture system is very important to analyze. The current study was conducted to assess the growth performance, production, economic food conversion rate and waste load of feed of gurami sago strains in different aquaculture systems namely, concrete ponds, floating net cages and earthen freshwater ponds.

Methods

Ethical considerations

There are no required permits from the government of the Republic of Indonesia to culture the gurami sago (*O.goramy*) strain in this study in concrete ponds, floating net cages and earthen freshwater ponds in the area surrounding Lake Maninjau of West Sumatera Province of Indonesia. The study was founded by LPPM (Research and Community Service) University of Bung Hatta under the Indonesia Endowment Fund for Education, Ministry of Finance, Republic of Indonesia, through the competitive grants scheme called the Productive Innovative Research (Policy/Governance) 2019 with the contract number PRJ-99/LPDP/2019. This grant included ethical approval and permits to collect fish samples including permission to rear this species. The animals used in this study did not suffer during the experiment. Gurami sago was transported to concrete ponds, floating net cages and earthen freshwater ponds for rearing for 90 days, fed commercial pellets and measured for growth performance every 30 days. At the end of the experiment, the gurami sago were still in good condition.

Study area

The study was conducted at the Research Center of Faculty of Fisheries and Marine Science, Bung Hatta University located in the area of Lake Maninjau, Koto Malintang village, Tanjung Raya sub-district, District Agam of West Sumatera

Province, Indonesia. The geographical coordinates were S:00°12'26.63"-S:00°25'02.80" and E:100°07'43.74"-E:100° 16'22.48" and the altitude was 461 m above sea level. At the location, concrete ponds, earthen freshwater ponds and floating net cages were available.

Experimental design

Each concrete pond has a size of 4×2 m, a depth of 1.5 m and a volume of 12 m^3. It has 50 mm of middle drainage, which is covered with a net of 0.5 cm mesh to prevent juveniles from escaping and predators from entering. The water was pumped from borehole wells at a velocity of 5 litres per minute.

Each floating net cage has a size 4 × 2 m, a depth of 1.5 m and a volume of 12 m^3, and these cages were built from resistant PVC plastic. Each cage was constructed using a monofilament net with 10 mm mesh. The floating net cages were set up in Lake Maninjau near the fish farm (maximum depth of 9 m and an average water current of 25 cm per sec). The surface of the floating net cages was covered with nets stretched (25 mm mesh) to avoid bird predators.

Each earthen freshwater pond has a size of 4 × 2 m, a depth of 1.5 m and a volume of 12 m^3. It had 50 mm of central drainage and was covered with a net of 0.5 cm mesh to prevent fish jumping and predator entry during the rearing activity. The water was pumped from wells at a velocity of 5 litres per minute.

Sampling design

The experiment ran for 90 days beginning on 01 April and ending on 29 June 2019. Approximately 3,000 gurami sago juveniles weighing approximately 50 g were obtained from a hatchery in the Luhak sub-district in the district of Lima Puluh Kota. Fish were acclimatized with 1000 juveniles per each pond (concrete pond, floating net cages and earthen freshwater pond). Fish were acclimatized to the floating net cages (5 × 5 × 3 m) for one month prior to the experiment. In the initial growth phase, three concrete ponds, three floating net cages and three earthen freshwater ponds of 12 m^3 (three replicates) were stocked with 240 juveniles each, with a density of approximately 20 fish/m^3. The average initial weights and lengths of juveniles were 54.51±0.45 g and 13.81±0.02 cm (mean ± SD), respectively. The length was measured using a ruler with an accuracy level of 0.1 cm. The weight of each individual was measured with an electronic balance (OHAUS, Model CT 1200-S, USA).

Fish were fed twice daily (09:00 AM and 17:00 PM) with commercial floating pellet feed (JapfaComfeed Indonesia Ltd; 30% crude protein, 5% crude lipids, 6% crude ash and 13% crude fibre)[18]. The amount of feed provided was as much as 3% per day based on fish biomass during the experiment. Every 30 days, samples were taken from ponds to monitor fish growth and to adjust the feed amount. Twenty-four fish samples were obtained from each concrete pond, floating net cage and earthen freshwater pond. 10% of the fish were sampled every month for each aquaculture system, due to giant gourami is sensitive to handling. Fish were captured at 07.00 AM with gillnets, which have a net bag with a suitable mesh size. Then, fish were anaesthetized orally with tricaine methanesulfonate (MS-222, ethyl 4-aminobenzoate methanesulfonate 98%, Sigma Aldrich Co, USA, MO; 50 mg L^{-1}), based on the dosage used for *Hemibagrus wyckii*[30].

Water quality

Water parameters were recorded weekly in the concrete ponds, floating net cages and earthen freshwater ponds. The water temperature (ºC) and dissolved oxygen (DO; mg L^{-1}) were measured with an oxygen metre (YSI model 85). The pH values were determined using a pH metre (Digital Mini-pH Metre, 0-14PH, IQ Scientific, Chemo-science (Thailand) Co., Ltd, Thailand). The levels of ammonia (NH_3; mg.L^{-1}), nitrite-nitrogen (NO_2-N; mg L^{-1}), nitrate-nitrogen (NO_3-N; mg L^{-1}), chemical oxygen demand (COD; mg L^{-1}), biological oxygen demand (BOD_5; mg L^{-1}), alkalinity (mg L^{-1}), hardness (mg L^{-1}), total dissolved solids (TDS; mg L^{-1}) and total suspended solids (TSS; mg L^{-1}) were measured in each aquaculture system with replication according to standard procedures[31]. The nets of the floating cages were cleaned routinely to maintain water circulation in the fish rearing areas. The walls of the floating net cages were cleaned by divers in the water.

Measurement parameters

The gurami sago were reared for 90 days, and the survival rate was estimated by checking the aquaculture systems every day and recording the results. Dead fish were removed immediately. The survival rate percentage was calculated by subtracting the number of dead fish from the initial number of the stock. The parameters were analyzed according to Aryani *et al.*[8], Kibra and Haque[27] and Mokoro *et al.*[32] with the following equations:

- Absolute growth rate (AGR; g day^{-1}) or $(Wt\text{-}Wi)/t$, where Wt = final weight, Wi = initial weight, and t = time (day);
- Specific growth rate (SGR, % day^{-1}) = $(ln W_1\text{-}ln W_2/t \times 100)$
- Gross yield (kg m^{-3}) = total number of fish at harvest × average final weight/cage capacity
- Net yield (kg m^{-3}) = (harvested biomass - stocked biomass/cage capacity)
- Feed conversion efficiency (FCE) = [fish weight gain (g)/total feed ingested (g)]
- Apparent feed conversion rate (AFCR) = supplied feed/increase fish weight
- Economic AFCR = cost/kg of fish weight × feed cost
- Waste load of feed = [feed intake (kg)] × [waste load/kg of feed]

For each aquaculture system, the final total length (cm) and final total weight (g) were used to determine the relationship of $W = aL^b$, where W is the total wet weight (g), L is the total length (cm) and a and b are variables of the length–weight relationships (LWRs) equations. These variables were estimated by the least square regression method. A t-test was used for comparison of the b values obtained in the linear regressions with the isometric value by equation[33]: $t_s = (b - 3)/S_b$, where t_s is the t-test value, b is the slope and S_b is the standard error of the slope (*b*). The comparison of the obtained values of the t-test with the respective table critical values allowed for the determination of whether the *b* values were statistically significant as well as their inclusion in the isometric range (*b*=3) or allometric range (negative allometric; *b*<3 or positive allometric; *b*>3). The degree of correlation between the variables was computed to determine the coefficient, R^2. Fulton's condition index was calculated as $K=100(W/L^3)$[33], where K = Fulton's condition index, W = weight, and L= length.

Data analysis

The data were analyzed using SPSS software (version 16.0 for Windows; SPSS Inc., Chicago, IL). Kolmogorov-Smirnov statistics were used to test data normality. Then, Levine's test was used to analyse the absolute residuals from homogeneity. One-way ANOVA was used to analyze the effect of each treatment, followed by post hoc Duncan's multiple range tests[34]. The 95% confidence level ($p<0.05$) was considered as the threshold to identify significant differences. All means are given with ± standard deviation (±SD). The canonical discriminant functions were used to analyze the water quality grouping between rearing systems.

Results

The overall survival rate of fish in different aquaculture systems was greater than 89.44%. The culture system had a significant effect ($p<0.05$) on the mean final body weight (g), final biomass (kg), weight gain (g), gross yield (kg m^{-3}), net yield (kg m^{-3}), absolute growth rate (g day^{-1}), specific growth rate (% day^{-1}), AFCR, and economic food conversion rate (US$/kg gain) after 90 days of culture (Table 1). In contrast, the culture system did not significantly ($p>0.05$) affect the mean final total length, feed intake (kg) or Fulton's K. The economic AFCRs were US$1.45 for concrete ponds, US$1.30 for floating net cages and US$1.87 for earthen freshwater ponds.

During the 90 days of the experiment, the gurami sago reared in floating net cages grew faster than those reared in concrete ponds and earthen freshwater ponds (Figure 1). At the end of the experiment, the fish reared in the floating net cages had

Table 1. Growth performance of gurami sago in three aquaculture systems over 90 days.

Variable	Aquaculture system mean ± SD		
	Concrete ponds	Floating net cages	Earthen freshwater ponds
Mean initial TL (cm)	13.81±0.02	13.88±0.02	13.88±0.02
Mean final TL (cm)	19.87±1.05	22.49±2.41	19.93±1.73
Mean initial body weight (g)	54.53±0.09	54.53±0.32	54.54±0.53
Mean final body weight (g)	166.86±7.95[a]	179.51±2.52[b]	149.89±4.79[c]
Initial biomass (kg)	13.00±0.11	12.97±0.10	13.00±0.10
Final biomass (kg)	37.64±1.51[a]	41.27±0.35[b]	33.72±0.78[c]
Weight gain (g)	114.47±4.80[a]	125.47±2.43[b]	102.88±0.92[c]
Gross yield (kg m^{-3})	3.14±0.13[a]	3.36±0.09[b]	2.81±0.07[c]
Net yield (kg m^{-3})	2.05±0.13[a]	2.27±0.08[b]	1.73±0.07[c]
Absolute growth rate (g day^{-1})	1.27±0.05[a]	1.39±0.03[b]	1.14±0.01[c]
Specific growth rate (% day^{-1})	0.67±0.05[a]	0.75±0.02[b]	0.62±0.01[c]
Feed intake (kg)	52.62±0.14	59.24±0.14	50.21±0.49
Apparent food conversion rate	1.45±0.03[a]	1.30±0.02[b]	1.87±0.14[c]
Economic food conversion rate (US$/kg gain)*	1.24±0.06[a]	1.00±0.02[b]	2.08±0.30[c]
Condition factor (Fulton's K)	2.45±0.63	1.91±0.01	3.36±0.05
Survival (%)	92.92±1.50	95.42±1.25	89.44±1.88
Feed conversion efficiency	0.69±0.02[a]	0.77±0.01[b]	0.54±0.04[c]
Waste load/kg of feed	0.31±0.02	0.23±0.01	0.46±0.04
Waste load of feed (kg)	16.22±0.90[a]	13.51±0.65[b]	23.28±2.31[c]

Within a row, means followed by different letters are significantly different ($p<0.05$). TL: total length. *USD 1.00 = IDR 14,350.

a larger size distribution than that of the fish reared in the concrete ponds and earthen freshwater ponds throughout the 90 day trial (Figure 2). The mean final body weights of the gurami sago reared in concrete ponds, floating net cages and earthen freshwater ponds were 166.86 g, 179.51 g, and 149.89 g, respectively. The net yield was 2.05 kg m^{-3} for concrete ponds, 2.27 kg m^{-3} for floating net cages and 1.73 kg m^{-3} for earthen freshwater ponds during the 90 days of rearing. The FCE and waste load at 90 days of culture were significantly (p<0.05) affected by the different rearing systems. A summary of the FCR, FCE and waste load feed from the five aquaculture species is presented in Table 2.

The growth rates of gurami sago based on body weight were described according to the following exponential equation: $W = 60.875e^{0.0498t}$ (with $R^2 = 0.83$) for the concrete pond, $W = 48.580e^{0.0613t}$ (with $R^2 = 0.75$) for the floating net cage and $W = 55.7050e^{0.0623t}$ (with $R^2 = 0.75$) for the earthen freshwater pond. The length–weight relationships for the gurami sago reared in concrete ponds were shown by $W = 7.9368L^{1.0146}$ (with $R^2 = 0.83$, Figure 3) and by $W = 3.7760L^{1.2641}$ (with $R^2 = 0.75$, Figure 4) for the floating net cages and by $W = 9.3106L^{1.0056}$ (with $R^2 = 0.75$, Figure 5) for the earthen freshwater ponds. The three *b-values* of each aquaculture system differed from 3.0 ($b<3$, $p<0.05$) indicating negative allometric growth. The Fulton's condition index in the concrete pond, floating net cages and earthen freshwater pond were 2.45, 1.91, and 3.36, respectively.

In this study, the water quality was recorded weekly from each aquaculture system during the experiment period and showed significant differences (p<0.05) in terms of TDS, TSS, DO, COD,

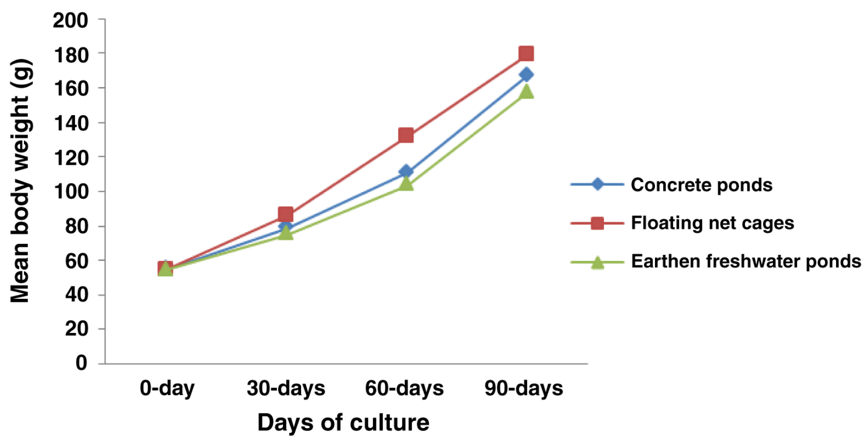

Figure 1. Mean weight gain ± SD (g) of gurami sago in three different aquaculture systems.

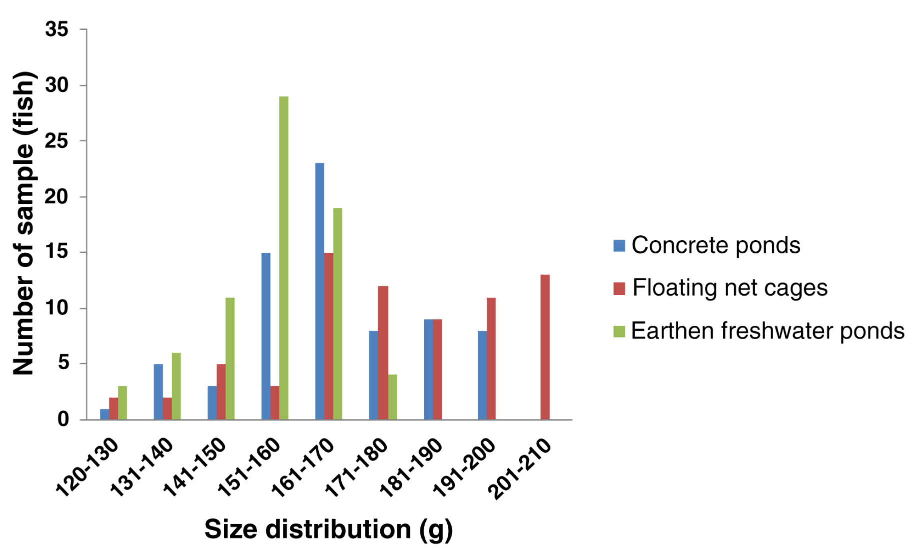

Figure 2. Distribution of gurami sago in the different aquaculture systems (*N*=72).

Table 2. Data on FCR, FCE and waste load from producing 1 kg feed in five aquaculture species.

Species	Scientific name	Production system	FCR	FCE	Waste load	Reference
Giant gourami	*Osphronemus goramy*	Floating cage	1.30	0.77	0.23	This study
Tilapia	*Oreochromis niloticus*	Floating cage	1.70	0.59	0.41	Chiu *et al.*,[35]
Spotted rose snapper	*Lutjanus guttatus*	Floating cage	1.44	0.69	0.31	Hernández *et al.*,[36]
Golden pompano	*Trachinotus ovatus*	Floating cage	1.53	0.65	0.35	Qi *et al.*, [29]
Common carp	*Cyprinus carpio*	Floating cage	2.10	0.47	0.53	Mungkung *et al.*,[37]

The FCE for giant gourami culture is 0.77 (1.0 kg feed fish results in 0.77 kg of fish). This value suggests that the waste load is 0.23 kg (1.0 kg feed – 0.77 kg fish). The above calculation can be applied to other species. FCR, feed conversion rate; FCE, feed conversion efficiency.

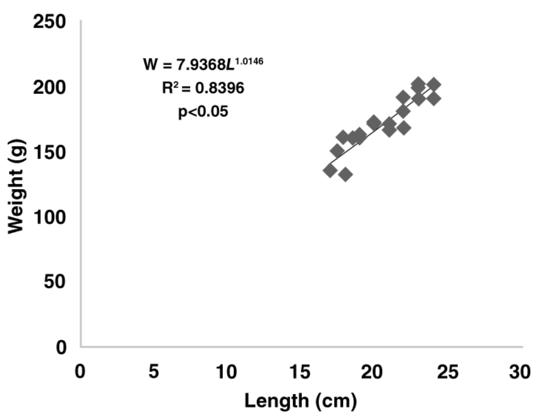

Figure 3. Total length-weight relationship for gurami sago cultured in concrete ponds. Each point represents one sampled fish (*N*=24). The regression equation, coefficient of determination (R^2) and significance (*p*-values) are also provided.

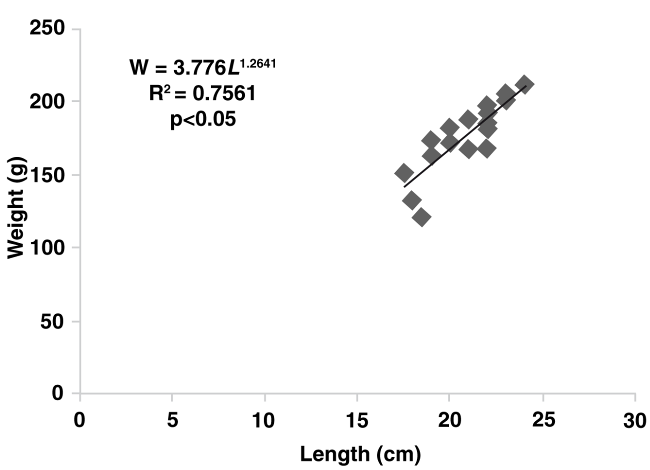

Figure 4. Total length–weight relationship for gurami sago cultured in floating net cages. Each point represents one sampled fish (*N*=24). The regression equation, coefficient of determination (R^2) and significance (*p*-values) are also provided.

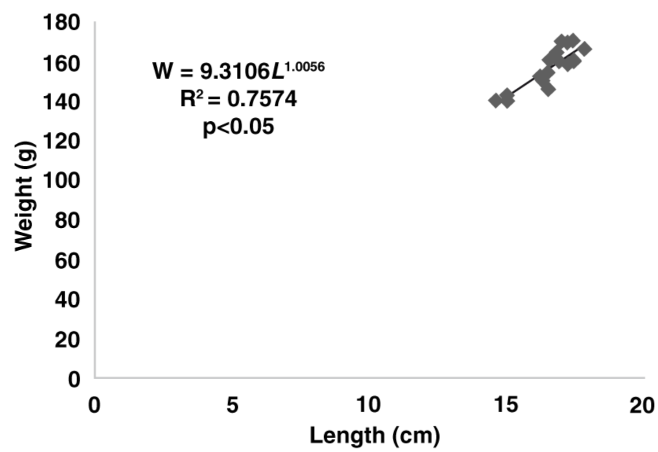

Figure 5. Total length-weight relationship for gurami sago cultured in earthen freshwater ponds. Each point represents one sampled fish (*N*=24). The regression equation, coefficient of determination (R^2) and significance (*p*-values) are also provided.

BOD, ammonia, nitrites, nitrates, pH, alkalinity and hardness, only water temperature did not show a significant difference. Furthermore, in the principal component analysis, PC1 accounted for 66.67% of the 12 parameters of water quality, which had a positive correlation with all water quality parameters. This result shows that value has an effect on the water quality parameters in aquaculture systems. Alkalinity, hardness, pH, and dissolved oxygen make high contributions to the aquaculture system (Table 3). The plot of PC1 and PC2 shows highly isolated water quality parameters between concrete ponds, floating net cages and earthen freshwater ponds (Figure 6).

Discussion

The aquaculture industry needs environmentally friendly aquatic ecosystems. Therefore, aquaculture practices must use aquaculture systems that minimize waste loads and increase added value[1,3,38,39]. In fact, the diversification of aquaculture systems with the efficient use of land resources can increase aquaculture production[28,40]. The comparisons between concrete ponds, floating net cages and earthen freshwater ponds are relevant to determine their relative per unit volume performance of juveniles-rearing of gurami sago. The rearing of gurami sago is an alternative diversity of aquaculture that can contribute to the development of commercial production in the future.

Table 3. Principal component loading and degree of divergence in quantitative traits among samples (Qst) of the water quality parameters.

Water quality parameters	PC1	PC2	Qst
Total dissolved solids	.959	.213	.965
Total suspended solids	.852	-.488	.964
Dissolved oxygen	-.896	-.409	.971
Biological oxygen demand$_5$	.954	.228	.962
Chemical oxygen demand	.972	-.095	.955
Ammonia	.933	.252	.934
Nitrite	.840	-.208	.749
Nitrate	.222	.902	.862
Water temperature	.356	-.477	.354
pH	-.580	.788	.956
Alkalinity	.057	.989	.982
Hardness	.043	.982	.966

Extraction Method: Principal component analysis (PCA).

Gurami sago was successfully reared in concrete ponds, floating net cages and earthen freshwater ponds. However, their growth performance was best in the floating net cages. The high survival rate of gurami sago was found in the floating net cages, which was similar to the gurami tambago strain[8] and gurami sago in the artificial ponds lined with membranes[12]. On the other hand, the survival rates of gurami sago in earthen freshwater ponds (89.44%) were higher than those of carps (65.74%) and stinging catfish (69.00%) in freshwater ponds[27].

The growth rate of gurami sago, with an average initial weight of 54.18 g, was faster in floating net cages than in concrete ponds and earthen freshwater ponds, with specific growth rate (SGR, % day^{-1}) values of 0.67, 0.75 and 0.62, respectively. In contrast, Budi *et al.*[41] stated that giant gourami belonging to the local gurami soang strain in the laboratory with initial weight of 15.83 g had faster growth with an SGR value of 2.13% day^{-1}. The specific growth rate of fish seems to be influenced by the initial weight, strains and aquaculture systems. The economic AFCR value of fish fed in floating net cages was lower than that of fish fed in concrete ponds and earthen ponds. Therefore, it can reduce the cost of feed and increase the economic benefits to producers. This condition indicates that the culture of gurami sago in floating net cages gives fish a chance to consume more feed. However, this AFCR was lower than that of *Nile tilapia*[42,43], and giant gourami[8], and higher than the African catfish AFCR value[44].

In this study, the growth performance of different gurami sago individuals in each aquaculture system was caused by differences in water quality. The PCA shows that there are differences in water quality among concrete ponds, floating net cages and

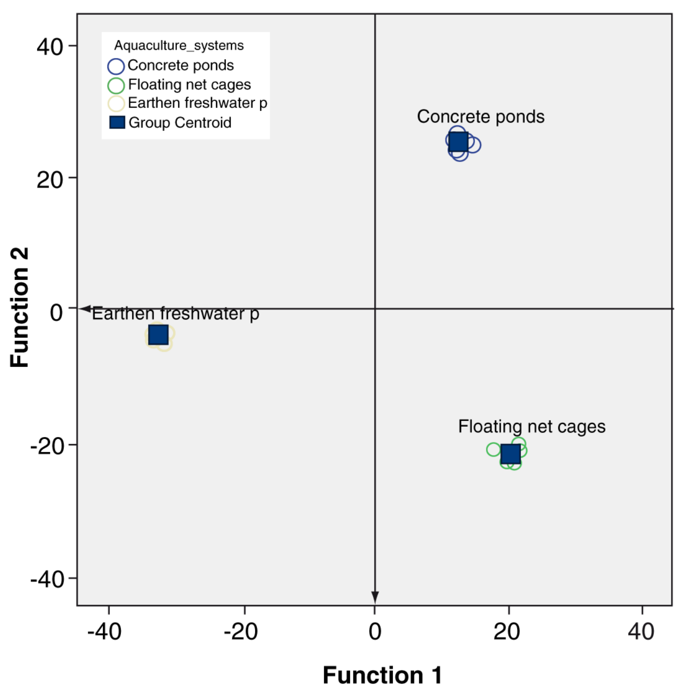

Figure 6. Sample centroids of discriminant function scores based on water quality parameters.

earthen freshwater ponds. The alkalinity, hardness, and pH might affect the growth performance of gurami sago in aquaculture systems. Pouil *et al.*[7] state that nutrient input in the cultured of giant gourami in the earthen freshwater ponds strong correlation with sediment nutrient accumulation, of which 61% total nitrogen and 77% phosphorus inputs were trapped in the accumulated sediments, which directly impacts to aquatic environment. Furthermore, Boyd *et al.*[45] stated that the productivity of aquatic ecosystems and aquaculture production can be influenced by water quality, such as alkalinity, hardness and pH. Many studies have found that growth performance can be affected by water temperature[46,47], DO level[48] and nitrite-nitrogen[27].

The aquaculture system influences the production of gurami sago. The highest production was found in the floating net cages, with a value of 3.36 kg m^{-3}. However, its production was lower than that of other freshwater cages, for example 4.19 to 10.70 kg m^{-3} for the strain gurami tambago (*O. goramy*)[8], 25.4 to 26.3 kg m^{-3} for pirarucu (*Arapaima gigas*)[49], 88.5 kg m^{-3} for silver perch, (*Bidyanus bidyanus*)[50] and 11.60 to 16.03 kg m^{-3} for spotted rose snapper (*Lutjanus guttatus*)[36]. It seems that different levels of aquaculture production can be influenced by species diversity, stocking density and duration of aquaculture. Giant gourami can produce a maximum profit after 324 days of aquaculture[51].

Herein, we recommend gurami sago strain aquaculture in concrete ponds, floating net cages and earthen freshwater ponds for 324 days. According to De Oliveira Continho *et al*,[52] fish reared in cages can increase the variation in weight production. In contrast, the freshwater cages have been marred by increasing the frequencies of fish mortality, causing negative implications to finances and the environment[23,24,53]. Bosma and Verdegem[54] reported that the direct risks related to aquaculture in ponds were habitat destruction, suboptimal freshwater consumption, organic pollution, eutrophication, and water contamination with pesticides. These factors can cause production to decline and cause low economic value.

In this study, after the analysis of growth performance and production, we also analyzed the length–weight relationship and condition factor (K) from aquaculture systems. The exponent of the length–weight relationship - or per Froese[55], the allometric coefficient (b) - calculated was 1.0146 for concrete ponds, 1.2641 for floating net cages and 1.0056 for earthen freshwater ponds. Gurami sago grown in different aquaculture systems showed negative allometric growth. These values were smaller than 2.94 for the culture of *Tilapia zillii*[56] and 2.99 and 2.93 for *Pangasianodon hypophthalmus* and *Clarias gariepinus,* respectively[57]. The K-values were not different among concrete ponds, floating net cages and earthen freshwater ponds. The finding explains that no different morphological factors were found in gurami sago cultures in concrete ponds, floating net cages and earthen freshwater ponds. However, cultures of gurami sago in floating net cages had a smaller condition factor or had values close to 1.00. The variation in the condition factor (K) of gurami sago may be influenced by different factors, such as environmental conditions, feed intake and increased of body weight. The condition factor (K) of fish depends on many factors, including species diversity, growth, physiological performance, age, and gonadal maturity[14,56,58–60].

Conclusion

In conclusion, our study showed that gurami sago strain can be efficiently reared in concrete ponds, earthen freshwater ponds and floating net cages. For all tested parameters, the best aquaculture system was found in the floating net cages. Nevertheless, further investigations on fish farming in the floating net cages which a technically feasible and economics at a larger scale are needed to determine commercial interest and environment impacts, especially on water quality, in an effort to develop of gurami sago fish farming in Indonesia.

Data availability

Underlying data

Figshare: Row data growth performance of gurami sago in different aquaculture systems.doc, https://doi.org/10.6084/m9.figshare.11719542.v1[61].

This project contains the following underlying data:

- Table 1. Sample size of weight and length of the gurami sago strain (0 days, 30 days, 60 days and 90 days) in the concrete pond culture (*N*=24)
- Table 2. Sample size of weight and length of the gurami sago strain (0 days, 30 days, 60 days and 90 days) in the floating net cage culture (*N*=24)
- Table 3. Sample size of weight and length of the gurami sago strain (0 days, 30 days, 60 days and 90 days) in the earthen freshwater pond culture (*N*=24)
- Table 4. Sample size means of initial weight, final body weight and weight gain of gurami sago (*N*=24)
- Table 5. Sample size means of initial length, final total length and length increase of gurami sago (*N*=24)
- Table 6. Data on mean initial biomass, final biomass and gross yield of gurami sago (*N*=24)
- Table 7. Data on mean SGR, feed intake and apparent feed conversion rate of gurami sago (*N*=24)
- Table 8. Data on mean economic food conversion, feed conversion efficiency and waste load of feed (*N*=24)
- Table 9. Data on mean growth (g) of gurami sago at 0 days, 30 days, 60 days, and 90 days (*N*=24)
- Table 10. Data on mean size distribution (g) of gurami sago in the different aquaculture systems in the 90-day trial (*N*=72).
- Table 11. Row data for water quality parameters of reared gurami sago in different aquaculture systems for each month.

Figshare: Row Data_survival (fish) of gurami sago_12 Feb 2020.doc, https://doi.org/10.6084/m9.figshare.11845560.v1[62]

Acknowledgements

The authors thank the Director of Indonesia Endowment Fund for Education, and the Ministry of Finance, Republic of Indonesia for supporting this study through the competitive grants scheme Productive Innovative Research (Policy/Governance) 2019. We appreciate all of the students, fish farmers and partners who helped the author during data collection in the field.

References

1. Ahmad N, Thompson S: **The blue dimensions of aquaculture: A global synthesis.** *Sci Total Environ.* 2019; **652**: 851–861.
PubMed Abstract | Publisher Full Text
2. Zhe Z, Di W, Wenxia T, *et al.*: **Extracting aquaculture ponds from natural water surfaces around inland lakes on medium resolution multispectral images.** *Int J Appl Earth Obs Geoinformation.* 2019; **80**: 13–25.
Publisher Full Text
3. Dauda AB, Ajadi A, Tola-Fabunmi AS, *et al*.: **Waste production in aquaculture: Sources, components and managements in different culture systems.** *Aquaculture and Fisheries.* 2019; **4**(3): 81–88.
Publisher Full Text
4. Jia B, St-Hilaire S, Singh K, *et al*.: **Farm-level returns and costs of yellow catfish (*Pelteobagrus fulvidrago*) aquaculture in Guangdong and Zhejiang provinces China.** *Aquac Rep.* 2016; **4**: 48–56.
Publisher Full Text
5. Iliyasu A, Mohamed ZA, Terano R: **Comparative analysis of technical efficiency for different production culture systems and species freshwater aquaculture in Peninsular Malaysia.** *Aquaculture Reports.* 2016; **3**: 51–57.
Publisher Full Text
6. Arifin OZ, Prakoso VA, Subagja J, *et al.*: **Effects of stocking density on survival, food intake and growth of giant gourami (*Osphronemus goramy*) larvae reared in a recirculating aquaculture system.** *Aquaculture.* 2019; **509**(2): 159–166.
Publisher Full Text
7. Pouil S, Samsudin R, Slembrouck J, *et al.*: **Nutrient budgets in a small-scale freshwater fish pond system in Indonesia.** *Aquaculture.* 2019; **504**: 267–274.
Publisher Full Text
8. Aryani N, Azrita, Mardiah A, *et al.*: **Influence of feeding rate on the growth, feed efficiency and carcass composition of the Giant gourami (*Osphronemus goramy*).** *Pak J Zool.* 2017; **49**(5): 1775–1781.
Publisher Full Text
9. CDSI (Central Data System Information): **Ministry of Marine and Fisheries Republic of Indonesia.** (In Indonesian). 2018.
Reference Source
10. The Ministry of Marine and Fisheries the Republic of Indonesia: **Decision of the Ministry of Marine and Fisheries the Republic of Indonesia Number 56 / KEPMEN-KP/ 2018 on Release of Gurami Sago**. (In Indonesian). 2018.
Reference Source
11. Azrita, Syandri H: **Effects of salinity on survival and growth of Gurami Sago (*Osphronemus goramy*) juveniles.** *Pak J Biol Sci.* 2018; **21**(4): 171–178.
PubMed Abstract | Publisher Full Text
12. Syandri H, Mardiah A, Azrita, *et al*.: **Effect of stocking density on the performance of juvenile Gurami sago (*Osphronemus goramy*) in the synthetic sheet pond.** *Pak J Zool.* 2020; **52**(2): 717–726.
Publisher Full Text
13. Liu W, Tan H, Chen W, *et al.*: **Pilot study on water quality regulation in a recirculating aquaculture system with suspended growth bioreactors.** *Aquaculture.* 2019; **504**: 396–403.
Publisher Full Text
14. Yu ZL, Hun N, Yang MJ, *et al.*: **Environmental water flow can boost foraging success of the juvenile rapa whelk *Rapana venosa* (Muricidae) in aquaculture tanks with still or flowing water: Indication of chemosensory foraging.** *Aquaculture.* 2019; **513**: 734392.
Publisher Full Text
15. Pedrosa RU, de Mattos BO, Coasta DSP, *et al.*: **Effects of feeding strategies on growth, biochemical parameters and waste excretion of juvenile arapaima (*Arapaima gigas*) raised in recirculating aquaculture systems (RAS).** *Aquaculture.* 2019; **500**: 562–568.
Publisher Full Text
16. Wik TEI, Lindén BT, Wramner PI: **Integrated dynamic aquaculture and wastewater treatment modelling for recirculating aquaculture systems.** *Aquaculture.* 2009; **287**(3–4): 361–370.
Publisher Full Text
17. Ballester-Molto M, Sanchez-Jerez P, Cerezo-Valverde J, *et al.*: **Particulate waste outflow from fish-farming cages. How much is uneaten feed?** *Mar Pollut Bull.* 2017; **119**(1): 23–30.
PubMed Abstract | Publisher Full Text
18. Syandri H, Azrita, Mardiah A: **Nitrogen and phosphorus waste production from different fish species cultured at floating net cages in Lake Maninjau, Indonesia.** *Asian J Sci Res.* 2018; **11**(2): 287–294.
Publisher Full Text
19. Musinguzi L, Lugya J, Rwezarula P, *et al.*: **The extent of cage aquaculture, adherence to best practices and reflections for sustainable aquaculture on African inland waters.** *J Great Lakes Res.* 2019; **45**(6): 1340–1347.
Publisher Full Text
20. Halide H, Stigebrandt A, Rehbein M, *et al.*: **Developing a decision support system for sustainable cage aquaculture.** *Environ Model Softw.* 2009; **24**(6): 694–702.
Publisher Full Text
21. Lindim C, Becker A, Grüneberg B, *et al.*: **Modelling the effects of nutrient loads reduction and testing the N and P control paradigm in a German shallow lake.** *Ecol Eng.* 2015; **82**: 415–427.
Publisher Full Text
22. Gondwe MJ, Guildford SJ, Hecky RE: **Carbon, nitrogen and phosphorus loadings from tilapia fish cages in Lake Malawi and factors influencing their magnitude.** *J Great Lakes Res.* 2011; **37**: 93–101.
Publisher Full Text
23. Syandri H, Azrita, Junaidi, *et al.*: **Levels of available nitrogen-phosphorus before and after fish mass mortality in Maninjau Lake of Indonesia.** *J Fish Aquat Sci.* 2017; **12**(4): 191–196.
Publisher Full Text
24. Opiyo MA, Marijani E, Muendo P, *et al.*: **A review of aquaculture production and health management practices of farmed fish in Kenya.** *Int J Vet Sci Med.* 2018; **6**(2): 141–148.
PubMed Abstract | Publisher Full Text | Free Full Text
25. Ni Z, Wu X, Li L, *et al.*: **Pollution control and *in situ* bioremediation for lake aquaculture using an ecological dam.** *J Clean Prod.* 2017; **172**: 2256–2265.
Publisher Full Text
26. Varol M: **Impacts of cage fish farms in a large reservoir on water and sediment chemistry.** *Environ Pollut.* 2019; **252**(Pt B): 1448–1454.
PubMed Abstract | Publisher Full Text
27. Kibria AS, Haque MM: **Potentials of integrated multi-trophic aquaculture (IMTA) in freshwater ponds in Bangladesh.** *Aquacult Rep.* 2018; **11**: 8–16.
Publisher Full Text
28. Henriksson PJ, Tran N, Mohan C, *et al.*: **Indonesian aquaculture futures-evaluating environmental and socioeconomic potentials and limitations.** *J Cleaner Prod.* 2017; **162**: 1482–1490.
Publisher Full Text
29. Qi Z, Shi R, Yu Z, *et al.*: **Nutrient release from fish cage aquaculture and mitigation strategies in Daya Bay, southern China.** *Mar Pollut Bull.* 2019; **146**: 399–407.
PubMed Abstract | Publisher Full Text
30. Aryani N, Suharman I, Syandri H: **Reproductive performance of asian catfish (*Hemibagrus wyckii* Bleeker, 1858), a candidate species for aquaculture [version 2; peer review: 2 approved].** *F1000Res.* 2018; **7**: 683.
PubMed Abstract | Publisher Full Text | Free Full Text
31. APHA: **Standard Methods for Examination of Water and Wastewater.** 19th Edn. American Public Health Association, Washington DC, USA, 1995.
Publisher Full Text
32. Mokoro A, Oyoo-Okoth E, Nguji CC, *et al.*: **Effects of stocking density and feeding duration in cage-cum-pond-integrated system on growth performance, water quality and economic benefits of *Labeo victorianus* (Boulenger 1901) culture.** *Aquac Res.* 2014; **45**(10): 1672–1684.
Publisher Full Text
33. Ricker WE: **Computation and interpretation of biological statistics of fish population.** *Fisheries Research Board of Canada Bulletin.* 1975; 191.
Reference Source
34. Duncan DB: **Multiple range and multiple F tests.** *Biometrics.* 1955; **11**(1): 1–42.
Publisher Full Text
35. Chiu A, Li L, Gou S, *et al.*: **Feed and fish meal use in the production of carp and tilapia in China.** *Aquaculture.* 2013; **414–415**: 127–134.
Publisher Full Text
36. Hernández C, Ibarra-Castro L, Hernández CH, *et al.*: **Growth performance of**

Spotted Rose Snapper in floating cages and continuous water-flow tank Systems. *N Am J Aquac.* 2015; **77**(4): 423–428.
Publisher Full Text

37. Mungkung R, Joël A, Tri HP, *et al.*: **Life Cycle Assessment for environmentally sustainable aquaculture management: a case study of combined aquaculture systems for carp and tilapia.** *J Clean Prod.* 2013; **47**: 249–256.
Publisher Full Text

38. Samuel-Fitwi B, Wuertz S, Schroeder JP, *et al.*: **Sustainability assessment tools to support aquaculture development.** *J Clean Prod.* 2012; **32**: 183–192.
Publisher Full Text

39. Valenti WC, Kimpara JM, Preto B de L, *et al.*: **Indicators of sustainability to assess aquaculture systems.** *Ecol Indic.* 2018; **88**: 402–413.
Publisher Full Text

40. Jayanthi M, Thirumurthy S, Muralidhar M, *et al.*: **Impact of shrimp aquaculture development on important ecosystems in India.** *Glob Environ Change.* 2018; **52**: 10–21.
Publisher Full Text

41. Budi DS, Alimuddin, Suprayudi MA: **Growth response and feed utilization of giant gourami (*Osphronemus goramy*) juvenile feeding different protein levels of the diets supplemented with recombinant growth hormone.** *HAYATI Journal of Biosciences.* 2015; **22**(1): 12–19.
Publisher Full Text

42. Shrestha MK, Bhandari MP, Diana JS, *et al.*: **Positive impacts of Nile tilapia and predatory sahar on carp polyculture production and profits.** *Aquaculture and Fisheries.* 2018; **3**(5): 204–208.
Publisher Full Text

43. Moniruzzaman M, Uddin KB, Basak S, *et al.*: **Effects of stocking density on growth body composition, yield and economic return of monosex tilapia (*Oreochromis niloticus* L.) under cage culture system in Kaptai Lake in Bangladesh.** *Journal Aquaculture Research & Development.* 2015; **6**: 357.
Publisher Full Text

44. Oké V, JurgensGoosen N: **The effect of stocking density on profitability of African catfish (*Clarias gariepinus*) culture in extensive pond systems.** *Aquaculture.* 2019; **507**: 385–392.
Publisher Full Text

45. Boyd CE, Turker CS, Somridhivej B: **Alkalinity and hardness: Critical but Elusive concepts in aquaculture.** *J World Aquac Soc.* 2016; **47**(1): 6–41.
Publisher Full Text

46. Desai AS, Singh RK: **The effects of water temperature and ration size on growth and body composition of fry of Common carp, *Cyprinus carpio*.** *J Therm Biol.* 2009; **34**(6): 276–280.
Publisher Full Text

47. Yuen JW, Dempster T, Oppedal F, *et al.*: **Physiological performance of ballan wrasse (*Labrus bergylta*) at different temperatures and its implication for cleaner fish usage in salmon aquaculture.** *Biol Control.* 2019; **135**: 117–123.
Publisher Full Text

48. Sun M, Hassan SG, Li D: **Models for estimating feed intake in aquaculture: A review.** *Comput Electron Agric.* 2016; **127**: 425–438.
Publisher Full Text

49. De Oliveira EG, Pinheiro AB, de Olivera VQ, *et al.*: **Effects of stocking density on the performance of juvenile pirarucu (*Arapaima gigas*) in cages.** *Aquaculture.* 2012; **370–371**: 96–101.
Publisher Full Text

50. Rowland SJ, Mifsud C, Nixon M, *et al.*: **Effects of stocking density on the performance of the Australian freshwater silver perch (*Bidyanus bidyanus*) in cages.** *Aquaculture.* 2006; **253**(1–4): 301–308.
Publisher Full Text

51. Wijayanto D, Faik K, Ristiawan AN: **Model of profit maximization of the giant gourami (*Osphronemus goramy*) culture.** *Omni-Akuatika.* 2017; **13**(1): 54–59.
Publisher Full Text

52. De Oliveira Continho JJ, Neira LM, de Sandre LCG, *et al.*: **Carbohydrate-to-lipid ratio in extruded diets for NILE tilapia farmed in net cages.** *Aquaculture.* 2018; **497**: 520–525.
Publisher Full Text

53. Azevedo PA, Podemski CL, Hesslein RH, *et al.*: **Estimation of waste outputs by a rainbow trout cage farm using a nutritional approach and monitoring of lake water quality.** *Aquaculture.* 2011; **311**(1–4): 175–186.
Publisher Full Text

54. Bosma RH, Verdegen MCJ: **Sustainable aquaculture in ponds: Principles, practices and limits.** *Livest Sci.* 2011; **139**(1–2): 58–68.
Publisher Full Text

55. Froese R: **Cube law, condition factor and weight-length relationships: history, meta-analysis and recommendations.** *J Appl Ichthyol.* 2006; **22**(4): 241–253.
Publisher Full Text

56. Nehemia AD, Maganira JD, Rumisha C: **Length-Weight relationship and condition factor of tilapia species grown in marine and fresh water ponds.** *Agri Biol J N Am.* 2012; **3**(3): 117–124.
Publisher Full Text

57. Okomoda VT, Koh ICC, Hassan A, *et al.*: **Length-weight relationship and condition factor of the progenies of pure and reciprocal crosses of *Pangasianodon hypophthalmus* and *Clarias gariepinus*.** *AACL Bioflux.* 2018; **11**(4): 980–987.
Reference Source

58. Gebremedhim S, Mingist M: **Length-weight relationship, gonado somatic index and Fulton condition factor of the dominant fishes at Aveya river, Blue Nile Basin Ethiopia.** *J Fish Aquat Sci.* 2014; **9**(1): 1–13.
Publisher Full Text

59. Mortuza MG, Al-Misned FA: **Length-weight relationships, condition factor and sex-ratio of Nile Tilapia, *Oreochromis niloticus* in Wadi Hanifah, Riyadh, Saudi Arabia.** *World J Zool.* 2013; **8**(1): 106–109.
Reference Source

60. Aryani N, Suharman I, Sabrina H: **Length-weight relationship and condition factor of the critically endangered fish of Geso, *Hemibagrus wyckii* (Bleeker, 1858) Bagridae from Kampar Kanan River, Indonesia.** *J Entomol Zool Stud.* 2016; **4**(2): 119–122.
Reference Source

61. Syandri H, Azrita A, Aryani N, *et al.*: **Row Data of Growth performance of Gurami Sago.doc.** *figshare.* Dataset. 2020.
http://www.doi.org/10.6084/m9.figshare.11719542.v1

62. Syandri H, Azrita A, Aryani N, *et al.*: **Row Data_survival(fish) of gurami sago_ 12 Feb 2020.doc.** *figshare.* Dataset. 2020.
http://www.doi.org/10.6084/m9.figshare.11845560.v1

Open Peer Review

Current Peer Review Status: ? ✓ ✓

Version 3

Reviewer Report 03 February 2021

https://doi.org/10.5256/f1000research.53869.r78325

?

Simon Pouil
INRAE, Jouy-en-Josas, France

General comment:

I carefully read this revised version of the manuscript and, unless I am mistaken, none of my previous comments have still be considered. No rebuttal and/or answer has been provided as well. So, for these reasons, I still have some reservations about the publication of this, moreover very interesting, study.

I hope my previous comments would help the Authors to revise their manuscript.

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: aquaculture, aquatic ecotoxicology

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Version 2

Reviewer Report 07 January 2021

https://doi.org/10.5256/f1000research.25835.r74355

Rudy Agung Nugroho
Animal Physiology, Development, and Molecular Laboratory, Department of Biology, Faculty of Mathematics and Natural Sciences, Mulawarman University, Samarinda, Indonesia

I have read and compared between version 1 and version 2, the article has some improvement. There are some points that should be taking into attention for the authors for the next research and I can conclude that this article can be indexed after an amendment.

ABSTRACT

- **Methods:** A mean of 240 juveniles were stocked (mean, 54.53 g and 13.88 cm), please add the word (initial weight mean, 54.53 g and 13.88 cm).

- **Conclusion:** Please mentioned which production is better among different aquaculture systems.

INTRODUCTION

- Sufficient.

MATERIALS AND METHODS

- Sufficient.

RESULTS AND DISCUSSION

- Well written and organized.

CONCLUSION

- As mentioned in the summary: "our study showed that gurami sago strain can be efficiently reared in floating net cage", in which term gurami can be efficient rear in floating net cage for all parameters or some? Please add information more briefly.

Is the work clearly and accurately presented and does it cite the current literature?
Yes

Is the study design appropriate and is the work technically sound?
Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Yes

If applicable, is the statistical analysis and its interpretation appropriate?
Yes

Are all the source data underlying the results available to ensure full reproducibility?
Yes

Are the conclusions drawn adequately supported by the results?
Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Fish nutrition, Animal Physiology, Biology Molecular

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Author Response 09 Jan 2021

Hafrijal Syandri, Bung Hatta University, Padang, Indonesia

We have been added some information to complete our article :

Response for Rudy Agung Nugroho Comments:

ABSTRACT :
methods: We have been added the word initial weight means, 54.53 g and initial length 13.88 cm in the sentence
Conclusion : The best aquaculture system was found in the floating net cages.

CONCLUSION :
In conclusion, our study showed that gurami sago strain can be efficiently reared in concrete ponds, earthen freshwater ponds and floating net cages. For all tested parameters, the best aquaculture system was found in the floating net cages.

Competing Interests: No competing interests were disclosed.

Reviewer Report 11 September 2020

https://doi.org/10.5256/f1000research.25835.r62660

Peter Vilhelm Skov
DTU Aqua, Section for Aquaculture, The North Sea Research Centre, Technical University of Denmark, Hirtshals, Denmark

The desired corrections have been addressed. There are still some grammatical issues in the text, but I presume the editorial staff will handle this.

Is the work clearly and accurately presented and does it cite the current literature?
Yes

Is the study design appropriate and is the work technically sound?

Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Yes

If applicable, is the statistical analysis and its interpretation appropriate?
Yes

Are all the source data underlying the results available to ensure full reproducibility?
Yes

Are the conclusions drawn adequately supported by the results?
Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Aquaculture nutrition and bioenergetics

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Reviewer Report 12 May 2020

https://doi.org/10.5256/f1000research.25835.r62661

?

Simon Pouil
INRAE, Jouy-en-Josas, France

I acknowledge the Authors did revise their manuscript. Nevertheless, most of my previous comments remained not addressed in the revised version. The Authors should argue why they did not consider these comments. Please find below the comments, listed by sections, that should be addressed before submission of a new revised version.

General comment:
I believe it is really important at this point that the Authors deeply revise Introduction and Materials and Methods taking into account all the comments of the reviewers to ensure that the objectives of the study are clear, that the experience is scientifically valid and that the data analysis has been performed correctly. This is why I am waiting for a thoroughly revised version before providing additional comments on the Results and Discussion.

Introduction:
The flow of the Introduction may be improved. Thus, the first paragraph is not informative enough and too general. I suggest providing relevant figures about freshwater finfish production in

Indonesia showing that this country is among the main producing country in the world. Some sentences could be added regarding the important role of freshwater aquaculture in the country by providing food and economic resources as well as employment in rural communities…
Then the second paragraph should be focused on giant gourami as Authors did but maybe in a awkward way because the sentences said that giant gourami is important but this species accounts for only 7% of the national production. Even if it is true, giant gourami production represents now more than 100,000 tonnes/year of production and this production is growing (latest available production volumes and increasing rate per year should be provided). This species has high patrimonial and economic values (among the most expensive freshwater fish species in Indonesia). Instead of having the comparison of production volumes with other freshwater fish species, I suggest to the Authors to provide data and relevant arguments to highlight the importance of giant gourami in Indonesia. Most of the information should be available in the following references:

FAO (2019) Cultured Aquatic Species Information Programme. Osphronemus goramy. Cultured AquaticSpecies Information Programme. Text by Caruso, D., Arifin, Z.O., Subagja, J., Jacques Slembrouck, J.and New, M. In: FAO Fisheries and Aquaculture Department [online]. Rome. Updated 26 September 2019

FAO (2020). FishStatJ: software for fishery statistical time series. FAO, Roma.

Thus, the structure of the Introduction could be, with appropriate transition sentences:
1/ Importance of freshwater finfish aquaculture in Indonesia
2/ Giant gourami among the main freshwater commodities in the country
3/ Gaps of knowledge in gourami aquaculture
4/ Rearing structures for giant gourami aquaculture
5/ Objectives of the study

In my previous report I highlighted the confusion between “strain” and “species” with those terms used interchangeably throughout the manuscript. Again, gurami sago is not a new species as the Authors said, it is a strain of giant gourami *Osphronemy goramy.* Here again, as I said on my previous report, I do not see the point to be focused on this strain in the Introduction because the findings from this study may be interesting for giant gourami in general. The strain used should be only mentioned in the Materials and Methods section.

Materials and Methods:
In the subsection “Ethical considerations”, I think the sentence “The animals used in this study did not suffer during the experiment” should be deleted because it is always difficult to assess suffering in fish. The most important information regarding ethical considerations was already provided.

As said in the previous review performed by Reviewer 2, water parameter values should be included in a Table within the manuscript, not as additional data.

Change “Sampling design” by “Experimental procedures”

In this subsection, when the origin of the fish is provided I suggest saying that the fish belonged to the “Gurame sago” strain, moving the information regarding this strain from the Introduction.

I suggest rephrasing the following sentence “Twenty-four fish samples were obtained from each concrete pond, floating net cage and earthen freshwater pond. 10% of the fish were sampled every month for each aquaculture system, due to giant gourami is sensitive to handling.” to “Twenty-four fish were sampled monthly from each concrete pond, floating net cage and earthen freshwater pond. The sample size and sampling frequency were selected in order to sample 10% of the total number of fish for each rearing structure while limited stress for the fish caused by handling.”

I am not sure to understand how the “Waste load of feed” and “FCE” were evaluated since they require to be able to quantify the feed ingestion, right? I do not know how such an estimation can be performed in the tested rearing systems. The Authors should clarify this point already highlighted in the previous report.

For the data analysis, assumptions of ANOVA (normality and variance homoscedasticity) should be tested and met on residuals, it should be clearly indicated in the manuscript.
“Levine’s test” should be corrected by “Levene’s test”.
“One-way ANOVA was used to analyze the effect of each treatment”, effects on what?
The Authors should be precise regarding the data analyzed through ANOVA. I guess all of them did not meet the assumptions for using parametric ANOVA.

In the same section, the Authors said they used discriminant analysis to examine grouping of the rearing systems using water quality parameters but the terms “Principal Component Analysis (PCA)” were used in their response to the reviewer comments that are not referring to the same statistical approach. The actual analysis performed should be clarified and better described in the data analysis section by explaining potential data transformation prior to the analysis, how the principal components have been selected...

Figures and Tables
As I said in my previous report, the Authors should provide visible standard deviations values and statistical differences in the Figures when it is appropriate and better axis scale in order to improve data readability. For allometric relationships, p-values for model estimates should be provided. Overall, the Authors should pay special attention to provide revised Figures allowing them to clearly visualize each data.

Again, water quality parameter values should be provided in a Table within the manuscript.

Is the work clearly and accurately presented and does it cite the current literature?
Yes

Is the study design appropriate and is the work technically sound?
Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Yes

If applicable, is the statistical analysis and its interpretation appropriate?
Yes

Are all the source data underlying the results available to ensure full reproducibility?
Yes

Are the conclusions drawn adequately supported by the results?
Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: aquaculture, aquatic ecotoxicology

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Version 1

Reviewer Report 01 April 2020

https://doi.org/10.5256/f1000research.24486.r60878

?

Peter Vilhelm Skov
DTU Aqua, Section for Aquaculture, The North Sea Research Centre, Technical University of Denmark, Hirtshals, Denmark

Introduction:

- “Aquaculture activities are responsible for the supply of fish for human consumption. To meet the demand for food from aquaculture production, competition uses natural resources, such as land and water[1–3]. Many studies state that aquaculture production depends on many factors, including its species, aquaculture system, technical efficiency, production inputs, and infrastructure” - This is a rather convoluted paragraph. Please rephrase to improve coherence.

- “In 2018, the total aquaculture production in Indonesia was 16,032,122 metric tons” - That is probably correct, but then you go on to state that it all comes from fish culture. I think (supported by FAO 2018 yearbook) that around 12 million tons is seaweed. Please check and correct.

- ”synthetic sheet ponds..” - I would prefer “artificial ponds lined with membranes” or something similar

- It is not clear to me what is meant by ”middle-scale commercial culture”. Is this in relation to intensity? Please clarify.

M&M:

- “Feed conversion efficiency (FCE) = [fish weight gain (g)/total feed ingested (g)] Apparent feed conversion rate (AFCR) = supplied feed/increase fish weight” - It is interesting that you have two indicators of feed performance where one is listed as apparent. I presume that feed waste was not collected in any of your rearing systems, and therefore all of your feed intake are apparent and based on “supplied feed”, also the FCE.

- “Waste load of feed = [feed intake (kg)] – [final biomass (kg)]” - I am not familiar with this variable, nor do I completely understand what it signifies, but presumably, it should be biomass gain, and not just final biomass?

Results:

- One of the things that can explain the observed differences in growth performance is likely to be your water quality parameters. While it is fine with the PCA plot, I would really like to see the water quality measurements in a table. Once these are available, perhaps it would be possible to discuss which water quality parameters would be essential to control to successfully produce gourami in land-based systems.

Is the work clearly and accurately presented and does it cite the current literature?

Yes

Is the study design appropriate and is the work technically sound?

Yes

Are sufficient details of methods and analysis provided to allow replication by others?

Partly

If applicable, is the statistical analysis and its interpretation appropriate?

Partly

Are all the source data underlying the results available to ensure full reproducibility?

Partly

Are the conclusions drawn adequately supported by the results?

Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Aquaculture nutrition and bioenergetics

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 12 Apr 2020

Hafrijal Syandri, Bung Hatta University, Padang, Indonesia

Introduction:

- Introduction in first paragraph have been rephrase to improve coherences in the paragraph.
- We have omitted the data of Indonesian fisheries production in the introduction.
- “Synthetic sheet ponds” have been change to “artificial ponds lined with membranes”.
- “middle-scale commercial culture” meant “middle-scale farms”

M & M

- We used the “Feed Conversion Efficiency (FCE)” Formula based on Chatvijitkul *et al*. 2017.

Reference: Chatvijitkul, S., Boyd C.E., Davis, D.A., McNevin, A.A. (2017). Pollution potential indicators for feed-based fish and shrimp culture. Aquaculture 477: 43-49.

- We have been revised the formula of “Waste load of feed”. Please see in sub-bab “Measurement Parameters”.

Results:

In Table 1, the parameters of waste load /kg of feed were added

The water quality parameters have been revised. We have data of water quality parameter in Table form, and it is has been state in raw data which have uploaded in Figshare (see Table 11 revised).

Competing Interests: No competing interests were disclosed.

Reviewer Report 19 March 2020

https://doi.org/10.5256/f1000research.24486.r60880

?

Simon Pouil

INRAE, Jouy-en-Josas, France

The present manuscript entitled "Growth, production and feed conversion performance of the gurami sago (*Osphronemus goramy* Lacepède, 1801) strain in different aquaculture systems" examines the zootechnical performances of a giant gourami Osphronemus goramy strain called

“gurami sago” in three different rearing structures: concrete ponds, floating net cages and earthen freshwater ponds.
Overall, the study presented is quite simple but nevertheless interesting especially because some important gaps of knowledge remain in giant gourami aquaculture. Thus, results presented, showing better growth performance and feed conversion efficiency when giant gourami is reared in floating net cages, are relevant to the field. Having said that, I think that the present version of the manuscript may be improved in some ways.

My main concerns are related to some methodological aspects as well as the presentation of the data.

I addressed below some general comments regarding on the different sections of the manuscript. I hope the following comments help the authors in revising the manuscript.

Introduction:
The description of the rationale of the study could be improved. I suggest to go straight to the point with a first paragraph explaining why giant gourami is important in Indonesian aquaculture and avoiding too general information. Authors may provide some production figures and explain, based on relevant references, that giant gourami is an emblematic local species with high practical and market value, omnivorous with a strong vegetarian component as thus, a candidate species for improving sustainability in aquaculture.

Authors should clearly state that, although giant gourami has been reared for decades in Indonesia, there are still important gaps of knowledge in its aquaculture.

Another point that is true throughout the manuscript: be careful in the use of “strain” and “species”. These two terms seem to be used as synonyms in the manuscript although they refer to different concepts. I am not sure that the focus done on the strain used is so important in the Introduction. I think that the results provided here are useful for the species itself and not only this specific strain.

Methods:
Overall, I found the Methods well-presented and informative enough. Nevertheless, I have one important concern regarding the statistics. Indeed, water parameters were recorded monthly, meaning that only 3 values per rearing structures are available to perform the canonical discriminant functions (CDF). Considering the variations of most of the measured parameters that can be occur in rearing structures such as shallow earthen ponds sometimes on the same day, I think such analysis is not appropriate.

Furthermore, Authors should state why only 10% of the fish were sampled every month. I guess is because giant gourami is sensitive to handling but this information may be interesting to add.

Results:
As I already mentioned, I have some doubts regarding the validity of the CDF using water quality data.

I believe that the presentation of the results can be improved. Authors should provide visible standard deviations values and statistical differences in the Figures when it is appropriate and better axis scale in order to improve data readability. For allometric relationships, p-values for model estimates should be provided.

Table 1: “Final food conversion rate (Fulton’s K)”, I guess it should be changed by “Condition factor (Fulton’s K)”

Discussion:
Although water quality is likely a key parameter to explain some of the observed differences in zootechnical performances among the rearing structures, unfortunately, since water parameter values were recorded only once a month, I think that there is not enough information provided to use these results.

Conclusion:
In the concluding paragraph, I expected clear recommendations for giant gourami aquaculture based on the findings from this study.

References:
I believe that some references relating to the aquaculture of the giant gourami are missing. I suggest to consider the following references which can be useful in the Introduction and Discussion:

FAO (2019) Cultured Aquatic Species Information Programme. Osphronemus goramy. Cultured Aquatic Species Information Programme. Text by Caruso, D., Arifin, Z.O., Subagja, J., Jacques Slembrouck, J. and New, M. In: FAO Fisheries and Aquaculture Department [online]. Rome. Updated 26 September 2019.

Arifin O.Z., Slembrouck J., Subagja J., Pouil S., Yani A., Asependi A., Kristanto A.H., Legendre M. (2020). New insights into giant gourami (Osphronemus goramy) reproductive biology and egg production control. Aquaculture 519: 734743.[1]

Kristanto A.H., Slembrouck J., Subagja J.,Pouil S., Arifin O.Z., Prakoso V.A., Legendre M. (2020). Egg and fry production of giant gourami (Osphronemus goramy): Rearing practices and recommendations for future research. Journal of the World Aquaculture Society 51: 119-138.[2]

References
1. Arifin O, Slembrouck J, Subagja J, Pouil S, et al.: New insights into giant gourami (Osphronemus goramy) reproductive biology and egg production control. *Aquaculture*. 2020; **519**. Publisher Full Text
2. Kristanto A, Slembrouck J, Subagja J, Pouil S, et al.: Survey on egg and fry production of giant gourami (Osphronemus goramy): Current rearing practices and recommendations for future research. *Journal of the World Aquaculture Society*. 2020; **51** (1): 119-138 Publisher Full Text

Is the work clearly and accurately presented and does it cite the current literature?
Partly

Is the study design appropriate and is the work technically sound?

Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Partly

If applicable, is the statistical analysis and its interpretation appropriate?
Partly

Are all the source data underlying the results available to ensure full reproducibility?
Yes

Are the conclusions drawn adequately supported by the results?
Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: aquaculture, aquatic ecotoxicology

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 12 Apr 2020
Hafrijal Syandri, Bung Hatta University, Padang, Indonesia

Introduction:
The introduction has been improving. The paragraph go straight to the point of why giant gourami important in Indonesian Aquaculture.

Methods:
Overall, the method has been revised based on your comment. We also add water quality data which come from our daily logbook. Actually water quality parameters were recorded weekly, but at the first we show in the Table 3 only per month for results Principal Component Analysis (PCA). Now we have changed it into weekly recorded (Table 3).

Results:
The results have been revised based on your comment. The allometric relationships (p-values) have been added in Figures 3, 4 and 5. Furthermore, Table 1 has been revised.

Discussion:
The water quality parameters have been revised based on your comment. We have changed it into weekly recorded. We have data from our daily logbook which already recorded during the research period. The complete raw data shows in Figshare (Table 11 revised).

Conclusion
We have been revised the conclusion.

References:
We have been added some references based on your suggestion.

Competing Interests: No competing interests were disclosed.