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Reproductive characteristicszation of the gurami sago sago giant gourami strain (*Osphronemus goramy* Lacepède, 1801): basic knowledge for a future hatchery strategy development strategy for the future

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Netti Aryani (team member)	:	Data Curation, Formal Analysis, Resources, Validation, Writing-Review & Editing

Abstract

Background:

The sSago strain of giant gourami (*Osphronemus gurami* Lacepède) has been released approved on in 2018 as a candidate aquaculture freshwaterfor freshwater aquaculture in Indonesia. -However, information on the reproduction characterizationspecies' reproduction isare minimal. This study analyzed the reproduction characterization characteristics in of the sago strain of the giant gourami broodfish to provide basic knowledge for a hatchery development strategy in the future.

Methods:

A total of 10 female broodfish and 10 males had matured oocytes were measured for body weight and length, and were evaluated for their reproductive charactericharacteristicszation. Broodfish

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Breeding fish ~~are~~ were spawned naturally ~~using~~ in a 1.2 m^3 (2×1×0.6 m) concrete pond with a male-female sex ratio of ~~(~~1:1~~)~~. Egg weight and diameter were measured ~~for~~ in 25 eggs per ~~/~~female using ~~balances (~~ACIS AD- 600i scales with 0.01 g accuracy~~)~~ and a ~~Labo~~ microscope (Labo model L-711) using software camera 3. Semen was collected using plastic syringes in 3 mL aliquots, ~~and~~ then placed in an insulated ice-cooled container, and analyzed within 2 hours of collection.

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Results:

Average weights of female and male broodfish ~~females and males~~ before spawning ~~ed~~ were 2180±159.78 g and 3060±134.99 g, respectively. The relative fecundity, ~~and~~ egg diameter and egg weight were 1029±36 eggs kg^{-1}, 2.42±0.05 mm and 10.33±1.09 mg, respectively. The hatching rate, endogenous feeding period and embryo survival to eyed-egg stage were 76.40±2.27%, 11.2±0.63 day and 94.76±0.42% respectively. Sperm characteristics showed that~~, such as~~ volume ~~(~~was 0.60±0.12 ml kg^{-1}~~)~~ and percentage motile ~~motility~~ was~~(~~ 70.04±2.27%~~) were measured~~. F~~The f~~emale fish weight before spawning~~ed~~ parameters that had strong relationships with the female fish weight after spawned (r^2 = 0.999) and absolute fecundity (r^2= 0.921). While, the parameter of sperm concentration has a strong relationship with the sperm motility (r^2 = 0.556) and duration of sperm motility (r^2 = 0.502).

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Conclusions:

~~Sago~~ The sago strain of the giant gourami broodfish has ~~a good~~ suitable reproductive ~~characterization~~ characteristics for ~~hatchery development for the future~~the development of future hatcheries. ~~The natural spawning that has been success should be followed up with the larval weaning technology and feeding to increase the growth and survival.~~Successful natural spawning should be followed by larval weaning and feeding technology to increase ~~the~~ growth and survival.

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Keywords: Aquaculture, giant gourami, broodfish, egg, sperm, hatchery performance.

Introduction

~~Aquaculture freshwater~~Freshwater aquaculture ~~is a~~ practiced in inland waters such as lakes, rivers, reservoir, floodplains and oxbow lakes, ~~including~~ and freshwater ponds, has expanded during the last decades in Indonesia[1,2,3,4,5]. Approximately 77.57% of fish produced in freshwater aquaculture in ~~production of~~ Indonesia are sourced ~~sources~~ from freshwater ponds and inland waters[6]. However, its development depends upon many factors, such as fish species, aquaculture systems, water depletion, fish diseases, farmers' knowledge and aquaculture practices[7,4,8,9,10].

Freshwater aquaculture is one of the fastest growing aquacultures in Indonesia, with more than 3,378,298.92 metric tons produced in 2018[6,11,12]. Nile tilapia (*Oreochromis niloticus*) ~~has~~ contributed ~~(~~37.93% of the total aquaculture production~~)~~, African catfish (*Clarias galepinus*) ~~(~~33.35%~~)~~, *Pangasius* catfish (*Pangasius ~~hypophtalamus~~hypophthalmus*) ~~(~~12.38%~~)~~, common carp (*Cyprinus carpio*) ~~(~~9.28%~~)~~ and ~~G~~giant gourami (*Osphronemus goramy*) ~~(~~6.96%~~)~~ [13,14,15].

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Indonesian ~~has many strains for~~ giant gourami strains ~~, belonging to~~include the local "tambago", "palapa", "soang", "galunggung" and "blusafir" strains, which ~~has~~ have been ~~produced~~ grown semi-intensively in small-scale farms for decades[8,14,13,16]. ~~But~~ However, ~~it is~~they have not been able to ~~contributed~~ contribute ~~maximally~~ majorly to ~~the production on~~ freshwater aquaculture production ~~of~~ in Indonesia. This ~~a~~ concern to be developing of newly strain of giant gourami, namely gurami sago was living a limited in West Sumatera Province of Indonesia[17,18]. ~~Sago~~ The giant gourami sago strain~~strain of giant gourami~~ is ~~one~~ considered a source for nutritional and food security, including as an ornamental fish among many freshwater fishes' communities in Indonesia.

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~~Sago strain of giant gourami~~The giant gourami sago strain was approved ~~has been released~~ as a candidate for freshwater aquaculture in 2018 (Decree of the Ministry of Marine and Fisheries, Republic of Indonesia No.56/KEPMEN-KP/2018)[19]. However, data on its ~~reproduction~~ reproductive characteristics~~ization in sago strain of giant gourami still a~~ are still limited. T~~On the other hand, t~~he evaluation~~ed to reproduction~~ of reproductive performance in ~~on the~~ other~~s~~ fish species has ~~been~~ had beneficial impacts ~~to~~ in the development~~ed~~ of freshwater aquaculture in ~~the Asia region~~Asia[20,21,22,23,24]. ~~Whereas~~ In contrast, ~~in sago strain of giant gourami broodfish~~ there are still gaps in~~-~~ knowledge of giant gourami sago strain broodfish ~~in terms of~~regarding size at oocyte maturity, ~~time~~ age of sexual maturity, sperm characteristics, egg hatchability, survival after eyed-egg~~s~~ stage, larva weaning and growth rate. These factors were identified as key challenges for successful~~ly a~~ giant gourami sago strain hatchery performance ~~in sago strain of giant gourami for the futures~~in the future. Therefore, the present study was conducted to evaluate the ~~reproduction~~ reproductive ~~characterization~~ characteristics in ~~sago strain of giant gurami broodfish~~giant gourami sago strain ~~as~~ to provide basic knowledge ~~about~~ for hatchery development for the future.

Methods

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Ethical considerations

There are no required permits from the government of the Republic of Indonesia to ~~evaluation~~ evaluate ~~reproduction~~ reproductive ~~characterization~~ characteristics in ~~sago strain of giant gourami~~giant gourami sago strain broodfish (*Osphronemus goramy*) ~~for~~ as a candidate for future aquaculture~~ for the future~~. The study was founded by Research and Community Service Universitas Bung Hatta under a competitive grants scheme called the research of Professor in 2021 (~~-~~Contract number: 06.02.1.46.03.2021). This grant included ethical approval and permits to collect~~ed~~ fish ~~samples~~specimens, rear~~ed~~ and spawn~~ed~~ ~~in sago strain of giant gourami~~giant gourami sago strain in the Aquaculture Laboratory Faculty of Fisheries and Marine Science Universitas Bung Hatta facilities. There ~~no suffering animal activity~~was no animal suffering involved in this study and ~~sago strain of giant gourami~~giant gourami sago strain broodfish were still in good condition ~~until~~ when returned to the pond. Ethical approval was granted by the Ethics Commission for Research and Community service at Universitas Bung Hatta (023/LPPM/Hatta/I-2021).

Rearing and selection of breeders

Juvenile fishes were selected about six years ago from a local hatchery in Luhak District, Lima Puluh Kota Regency, West Sumatra Province. The j~~J~~uvenile fish~~es~~ were kept in tanks and transported by truck to the Aquaculture Laboratory, Faculty of Fisheries and Marine Science University of Bung Hatta. ~~-~~A total of 200 individuals ~~in sago strain of giant gourami~~giant gourami sago strain juvenile fishes were reared to sexual maturity ~~adult sex under the~~in a concrete 8.4 m^3 (6×2×0.7 m) freshwater pond~~ 8.4 m^3 (6×2×0.7 m)~~. During ~~were~~ the ~~reared~~ rearing ~~in sago strain of giant gourami juvenile fish until adult sex~~ to sexual maturity, the juvenile fish~~es~~ were given commercial feed pellets which contained 30% crude protein and 4% crude fat.

After that, a total of 30 mature individual~~s~~s~~' adult sex~~ broodfish were separated according ~~by~~ to sex and reared in two concrete 18 m^3 (6×2×1.5 m) freshwater ponds~~ 18 m^3 (6×2×1.5 m)~~. ~~Sago strain of giant gourami broodfish~~The broodfish were feed twice daily (09:00 AM and 16:00 PM), ~~were~~ with extruded ~~pellet~~ feed pellets containing ~~was~~ 39.50% crude protein and 12.21% fat with a predetermined ~~ratio~~ quantity ~~as much as~~of ~~-~~3% of ~~biomass~~ fish weight per ~~/~~day. Besides that, it is also were given sente leaves sufficiently were contained 2.85% protein and 0.47% fat (% wet weight). Each concrete freshwater pond had~~s~~ a 50 mm ~~of middle~~ drain in the middle~~age~~, which ~~is~~ was covered with a net of 0.5 cm mesh size to prevent the fish ~~gurami sago broodfish~~ from escaping and predators from entering. W~~The w~~ater was pumped from ~~the~~ borehole wells at a ~~velocity~~ rate of 5 lit~~er~~res per minute.

A total of 20 broodfish ~~for sago strain of giant gourami has oocyte matured~~ with mature oocytes w~~ere~~as selected, consist~~ing~~ed of 10 females and 10 males. Prior to stocking, ~~of~~ females and males broodfish were weighed using ~~balance~~ scales (OHAUS model CT 6000-USA with 0.1 g accuracy), and ~~their lengths~~body length ~~were~~ was measured using a meter ruler with 1mm accuracy. Average

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Commented [SL14]: Please reword – meaning unclear weight and length of the 10 female broodfish were 2140±159 g and 39.70±1.77 cm, while~~, 10 of~~ those of the male broodfish were 3060±135 g and 43.1±1.79 cm.

Reproducti~~on~~ve ~~characterization~~ parameters in ~~sago strain of giant gourami broodfish~~giant gourami sago strain broodfish were analyzed using the following formula~~es~~:

- Condition factor (CF) = wet weight in gram/length^3 × 100
- ~~; o~~Ovulated egg weight (g) = fish weight before spawning (g) – fish weight after spawning (g)
- ~~; o~~Ova somatic index (%) = egg weight ovulation (g)/ fish weight before spawning (g) x 100

~~;, a~~Absolute fecundity ~~is~~ was the total number of eggs ~~was~~ estimated per nest, and relative fecundity ~~is~~ was the total number of eggs per kg body weight.

Female reproductive performance

Starting in August 2020 onwards, the broodfish were checked ~~each~~ monthly for eggs and semen production. The broodfish were captured with a hand net and anesthetized by oral~~ly~~ ~~with~~ ingestion of 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*[21]. Oocyte maturation was assessed for each individual. The oocyte maturity in ~~sago strain of~~ giant gourami females was assessed from oocytes sampled by intraovarian biopsies using a flexible polyethylene catheter[21]. Egg diameter was measured using Labo microscope model L-711 ~~using~~ and software camera 3.

Natural spawning of broodfish ~~is~~ was carried out ~~using~~ in 1.2- m^3 (2×1×0.6 m) concrete freshwater ponds with a male-female sex ratio of ~~(~~1:1~~)~~. Before the broodfish ~~is~~ spawned, the ponds ~~are~~ were drained, cleaned and all other species ~~are~~ removed. Then, palm fibers ~~are~~ were ~~provided which are~~ placed on top of a bamboo raft in the pond. ~~Furthermore, t~~The pond ~~is~~ was then filled with water and the female and male broodfish ~~are~~ were released into the spawning pond. The male broodfish made a nest for 5 to 7 days, after which spawning ~~takes~~ took place and the female broodfish lai~~y~~ed~~s~~ eggs. Spawning ~~ed~~ occurred in the afternoon (~~ranged from~~between 15.00 to 17.00 PM). Due to the presence of a very large oil globule, ~~sago strain of giant gourami~~ giant gourami sago strain eggs float. After the broodfish had~~s~~ finished laying eggs, the eggs ~~are~~ were kept by the female broodfish in ~~to~~ the nest. ~~Furthermore, A~~After the eggs ~~are were~~ had been kept by the broodfish for four hours in the nest, the eggs ~~are~~ were collected and transferred to an incubation tray, which ~~is~~ was placed in a ventricular hatching system. A total of 100 eggs each incubation trays. Meanwhile, the broodfish were returned to their pond ~~after~~ once spawned, and no mortality occurred.

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Egg weight and diameter were measured for 25 eggs per female using ~~balances (~~SHIMADZU-model AY 220 scales with 0.1 mg accuracy~~)~~ and a ~~miscrocope~~microscope (Labo ~~microscope~~ model L-711) using software camera 3. A total of 25 eggs were randomly sampled ~~at~~ 16 hours after spawning~~ed~~ to determine the fertility rate (FR). The hatching rate (HR) was determined by counting all hatched fry ~~at~~ 48 hours after spawned. Then, endogenous feeding period counted until the egg yolks run out (day) and embryo survival rate to eyed-egg stage (%)

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Determination of sperm quality

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Hormonal stimulation for spermination efficiency of males of ~~sago strain of giant gourami broodfish~~giant gourami sago strain broodfish used LHRH-a preparations (Ovaprim) with dosage 0.5 ml per kg of brooder. Semen samples were obtained from 10 broodfish in sago ~~strain of~~ giant gourami randomly selected from the farm. The male broodfish were first anesthetized with 50 mg L^{-1} of MS-222[25], ~~and~~ then~~,~~ fish weights (MaW) and total lengths (MaL) were measured. Special care was taken to avoid any contamination of semen with urine, feces, mucus and water. Semen samples were collected using plastic syringes in 3 mL aliquots, and then placed in an insulated ice-cooled container, transported to the laboratory and analyzed within ~~2~~ two hours.

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The sperm ~~evaluate~~ assessment included gross (visual) and microscopic examination as reviewed by Rurangwa *et al.* (2004) and Cabrita *et al.* (2017)[26,27]. The gross examination was based on visual and physical observation of parameters like ~~the~~ semen volume by collecting the semen in a graduated cylinder and determining the level in millimeters. ~~The m~~Microscopic examination was carried out using the Olympus model CX40, with ~~magnification between~~ × 10 and × 25 magnification, to determine ~~other~~ parameters such as motility (MO)~~,~~ percentage and duration, ~~were determined~~ by observing water~~-~~activated semen placed on a glass slide~~e under a microscope~~. Motile sperm were observed and expressed as a percent of non-moving sperm. Motility duration (DMO) was determined as the period between movements of the sperm to cessation of any progress~~ive~~ using Neubauer's hemocytometer and calculated as the number of sperm ml^{-1} [28]. Semen pH was determined with a hand pH meter (HI8424 Hanna Instruments, USA).

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Water q~~Q~~uality

Water samples were collected in the spawning pond and incubation trays ~~were collected~~ to determine ~~the~~ alkalinity, hardness and pH. Alkalinity and hardness were measured according to standard procedure~~presudure~~[29]. pH values were determined with a pH meter (digital mini pH meter ~~),~~, 14pH, IQ Scientific, Chemo-science Thailand Co., Ltd, Thailand). An oxygen meter (YSI model 52, Yellow Spring Instrument Co., Yellow Springs, OH, USA) was used *in situ*, and ~~Water~~ water

Commented [SL23]: Please provide a brief overview of this procedure temperature ~~of~~ in the spawning pond and incubation trays ~~as~~ were measured with a thermometer (Celsius scale).

Statistical analysis

Results were given as the ~~means~~ mean values (± SD). Simple linear regression analyses were performed using SPSS software (version 16.0 for Windows; SPSS Inc., Chicago, IL). The standard deviation of each parameter was determined. For linear regression analyses, ~~significant~~ correlations were considered significant at $p<0.05$, and ~~whereas significant~~ trends or tendencies were considered significant at $p<0.05$.

Results

The ~~reproduction~~ reproductive characteristics~~zation~~ of female broodfish in ~~sago strain of giant~~sago giant gourami is summarized in Table 1. Total number of eggs per nest ~~was estimated per nest~~ (absolute fecundity) varied from 2000 to 2650, while relative fecundity (total number of eggs per kg female brooder) varied ~~were~~ between 977 and 1071. The fertility rate ranged from 76 to 84%, and the hatching ~~rate~~ success rate ranged from 72 to 80%. Endogenous feeding period ranged from 10 to 12 days, and embryo survival rate to eyed-egg stage varied ~~were~~ between 94.73 and 95%.

~~Reproduction~~ Reproductive ~~characterization~~ characteristics for male~~s~~ broodfish and sperm samples are presented in Table 2. The average live weight of the males ~~is~~ was 3340±275.68 g. ~~Sago strain of~~ Sago g~~g~~iant gourami male~~s~~ broodfish ~~is~~ were found to be slightly bigger than female~~s~~ broodfish. Gonad weight ranged from 25 to 30 g, whereas gonad somatic index ranged from 0.83 to 0.93%.

The ~~analyzed of the~~ linear correlation (r^2) between variables of reproduction characterization parameters in sago strain of giant gourami females broodfish results are shown in Table 3. In t~~T~~his study, the ~~reproduction~~ reproductive ~~characterization~~ parameters that ~~had~~ showed strong correlations with the absolute fecundity were female fish weight before spawning (r^2 = 0.921) and female fish weight after spawning (r^2 = 0.864). Similarly, results revealed significant correlations between egg diameter ~~with~~ and ~~the~~ hardened egg diameter (r^2 = 0.833), hardened egg diameter increased (r^2 = 0.699) and fertility rate (r^2 = 0.568). In contrast, the egg diameter was not strongly related to absolute fecundity (r^2 = 0.169) and relative fecundity (r^2= 0.096). On the other hand, the survival rate of larvae~~l~~ (10 days)~~is~~ also had strong correlations with the hatching rate (r^2 = 0.998) and endogenous feeding period (r^2 = 0.757).

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~~The analyzed of the l~~Linear correlation analysis results (r^2) between variables of reproduction characterization parameters in sago ~~strain of~~ giant gourami male~~s~~ broodfish are shown in Table 4.

The reproductive ~~characterization~~ parameters that had a strong correlation with gonad weight were somatic index of gonads (r^2 = 0.836), while semen volume (r^2 = 0.521), semen pH (r^2 = 0.521) and sperm concentration (r^2 = 0.506) were moderately correlated with gonad weight. ~~Whereas~~In contrast, the gonadal weight negatively ~~related~~ correlated ~~to~~ with sperm motility (r^2 = 0.017) and duration of motility (r^2 = 0.275). ~~Besides that~~In addition, the sperm concentration ~~is~~ was also ~~had~~ moderately correlat~~ions~~ed with the sperm motility (r^2= 0.556) and duration of motility (r^2= 0.502).

The physic~~o~~-chemical water quality parameters in the spawning ponds and incubation trays for embryo development ~~in sago strain of giant gourami~~ were as follows: water alkalinity ranged from 50.5 mg L^{-1} to 52.5 mg L^{-1}, hardness varied from 65.5 mg L^{-1} to 67.5 mg L^{-1}, pH ranged from 6.4 to 6.6, oxygen ranged from 6.1 mg L^{-1} to 6.7 mg L^{-1}, and temperature varied from 28 °C to 30 °C.

Table 1. Reproduction characterization in sago strain of giant gourami females broodfish (Mean ± SD)

	Variables	Range (Min-Max)
Fish length (cm)	39.70±1.77	38-43
Fish weight before spawning (g)	2140±159.78	1958-2500
Fish weight after spawning (g)	2108±157.64	1930-2465
Condition factor	3.30±0.42	2.54-3.86
Egg weight ovulated (g)	32.80±2.86	28-38
Ova somatic index (%)	1.55±0.07	1.43-1.65
Absolute fecundity (egg/fish)	2205±201	2000-2650
Relative fecundity (egg/kg body weight)	1029±36	977-1071
Egg diameter (mm)	2.42±0.05	2.32-2.46
Hardened egg diameter (mm)	3.42±0.02	3.40-3.45
Egg diameter increase (%)	29.63±1.43	27.8-32.14
Egg weight (mg)	10.33±1.09	9.02-12.20
Hardened egg weight (mg)	13.36±1.27	11.74-15.20
Hardened egg weight increase (%)	22.69±2.24	19.74-24.81
Fertility rate (%)	81.60±3.37	76-84

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Hatching rate (%)	76.40±2.27	72-80
Endogenous feeding period (day)	11.2±0.63	10-12
Embryo survival rate to eyed-egg stage (%)	94.76±0.42	94.73-95

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Table 2. Reproduction characterization in sago strain of giant gourami males broodfish (Mean ± SD)

	Variables	Range (Min-Max)
Fish weight (g)	3060±134.99	2800-3200
Fish length (cm)	43.1±1.79	40- 5
Condition factor	3.74±0.43	3.08-4.38
Gonads weight (g)	27.5±1.72	25-30
Gonadosomatic index (%)	0.90±0.03	0.83-0.94
Semen volume (mL per kg body weight)	0.60±0.12	0.4-0.7
Semen pH	8.18±0.15	7.9-8.4
Sperm concentration (10^9/mL)	1.44±0.14	1.2-1.6
Motility (%)	70.04±2.27	68-75
Duration of motility (sec)	50.2±7.25	43-61

Table 3. Correlations of variables (r^2) in sago strain of giant gourami females broodfish

	FEL	FWBS	FWAS	CF	OEW	OVI	AF	RF	EW	HEW	EWI	ED	HED	HDI	FR	HR	EFP
FEL																	
FWBS	**0.720**																
FWAS	**0.717**	**0.999**															
CF	**0.757**	**0.575**	**0.574**														
OEW	**0.539**	**0.565**	**0.553**	0.365													
OVI	0.281	0.191	0.012	0.000	**0.774**												
AF	0.255	**0.921**	**0.864**	**0.637**	0.387	0.072											
RF	0.012	0.207	0.063	0.011	0.065	0.321	**0.524**										
EW	**0.894**	**0.659**	**0.655**	**0.677**	0.552	0.246	**0.567**	0.041									
HEW	**0.841**	**0.631**	**0.626**	**0.514**	**0.582**	0.295	0.468	0.004	**0.924**								
EWI	0.165	0.109	0.109	0.354	0.033	0.000	0.010	0.002	**0.924**	0.041							
ED	0.164	0.132	0.338	0.131	0.378	**0.688**	0.169	0.096	0.030	0.263	0.000						
HED	0.064	0.029	0.237	0.126	0.025	0.207	0.022	0.064	0.468	0.184	0.030	**0.833**					
HDI	0.266	0.293	0.342	0.209	0.103	0.085	0.373	0.195	0.318	0.298	0.006	**0.699**	0.294				
FR	0.026	0.229	0.020	0.000	0.135	0.264	0.000	0.004	0.067	0.004	0.160	**0.568**	0.064	0.054			

HR	0.035	0.020	0.060	0.046	0.000	0.009	0.003	0.009	0.226	0.108	0.364	0.018	0.001	0.143	**0.703**		
EFP	0.113	0.186	0.190	0.094	0.006	0.098	0.231	0.103	**0.747**	**0.806**	0.147	0.317	0.001	0.116	0.015	0.013	
SR	0.070	0.032	0.034	0.027	0.007	0.003	0.112	0.024	0.194	0.019	0.005	0.033	0.000	0.324	0.063	**0.998**	**0.757**

Statistically important at $r^2 > 0.500$ (underlined)

FeL: female fish length (cm); FWBS: female fish weight before spawning (g); FWAS: female fish weight after spawning (g); CF: condition factor; OEW: egg weight ovulation (g), OVI: Ova somatic index (%), AF: absolute fecundity (eggs), RF: relative fecundity (eggs), EW: egg weight (mg), HEW: Hardened egg weight (mg), EWI: eggs weight increase (%), ED: egg diameter (mm), HED: hardened egg diameter (mm), HDI: hardened egg diameter increase (%), FR: fertility rate (%), HR: hatching rate (%), EFP: endogenous feeding period (days), SR: survival rate (10 days).

Table 4. Correlations of variables (r^2) in sago strain of giant gourami males broodfish

	MaL	MaW	CF	GW	GI	SV	pH	SC	MO
MaL	-								
MaW	**0.714**								
CF	**0.807**	0.347							
GW	0.399	**0.550**	0.187						
GI	0.003	0.042	0.071	**0.836**					
SV	0.025	**0.576**	0.042	**0.521**	0.000				
pH	**0.516**	**0.772**	0.353	**0.521**	0.127	0.296			
SC	0.186	**0.661**	0.131	**0.506**	0.068	0.425	**0.645**		
MO	0.068	0.453	0.061	0.017	0.130	0.393	0.280	**0.556**	
DMO	0.159	0.322	0.083	0.275	0.012	0.082	0.430	**0.502**	**0.519**

Statistically important at $r^2 > 0.500$ (underlined)

MaW: male fish weight (g), MaL: male fish length (g), CF: condition factor; GW: gonadal weight (g); GI: gonad somatic index (%), SV: semen volume (ml), SC: sperm concentration (10^9/mL), MO: motility (%), DMO: duration of motility (sec).

Table 5. Summary of the fecundity, gonadal somatic index, egg diameter and hatching rate of giant gourami.

Species	Strain	Relative fecundity (egg/kg fish)	GSI (%)	Eggs diameter (mm)	Hatching rate (%)	Reference
Osphronemus goramy	Sago	1037±90	1.91±0.35	2.42±0.05	76.40±6.33	This study
Osphronemus goramy	Bastar	2423±348	2.78±1.16	2.2 ± 0.2	96.36± 2.30	[16]
Osphronemus goramy	Galunggung	4011±287	4.15±0.63	2.5±0.05	89.3±1.30	[8]

Osphronemus goramy	-	5508±1547	2.32±0.50	2.18±0.19	61.60±0.0	[30]
Osphronemus goramy	Tambago	2.896±185	3.16±0.11	2.47±0.03	91.06±4.06	[31]

Discussion

In our study, body weight in female sago ~~strain of~~ giant gourami ~~female~~ broodfish before spawning ranged from 1958 to 2500 g per fish and ova somatic index ranged from 1.43 to 1.65%. Body weight in female sago ~~strain of~~ giant gourami ~~female~~ broodfish was ~~is the~~ smaller than ~~as~~ that of giant gourami belonging to the galunggung strain, which ranged~~d~~ from 2500 to 3500 g. Conversely, ova somatic index of galunggung strain are found to be slightly bigger than ~~with~~ that of sago ~~strain of~~ giant gourami, which -ranged from 3.7 to 4.6%[8]. The differences ~~of~~ in reproductive~~on~~ ~~characterization~~ characteristics in broodfish can be ~~affected~~ explained by strains, brood size, age used, previous spawning history and the production setting[23].

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Absolute fecundity ~~(AFs)~~ in sago ~~strain of~~ giant gourami ranged ~~between~~ from 2000 to 2650 eggs fish^{-1} and relative fecundity (RF)~~s were~~ ranged from 977 to 1071 eggs kg^{-1}. Egg produced in kg fish^{-1} (RF) is thought to be more informative than absolute fecundity. ~~Relative fecundity (~~RF~~)~~ in sago strain of giant gourami were smaller compared to those in galunggung strain, palapah strain and blusafir strain[8,31,16]. On the other hand, the difference of relative fecundity can also be related to differences in broodfish size and age used[23]. Environmental factors such as rainfall ~~is~~ also influenced the number of eggs per spawn in giant gourami brood, while the water temperature negatively related to number of eggs per spawn[15]. Furthermore, egg diameter in sago strain of giant gourami is found to be almost the same than others strain of giant gourami (Table 5). In this study, ~~EDs~~ egg diameters ~~obtained~~ average was 2.42±0.05 mm, consistent with those reported by ~~an~~other researchers~~,;~~ ~~for example~~ 2.18±0.19 mm for the giant gourami[30], 2.40±0.05 mm for blusafir strain[16] and 2.5±0.05 mm for galunggung strain[8]. ~~Apparently, t~~The differences the ~~relative fecundity~~RF, ova somatic index, egg diameter and hatching rate of giant gourami can be influenced by differences in the strains. Furthermore, ~~the~~ egg diameter has been influenced by ~~the~~ dietary protein level[32,33,34,35], age of broodfish[36], and spawning season[37,38]. In our study, egg diameter was shown to be positively correlated with egg weight, hardened egg weight, and egg~~s~~ weight increase~~d~~. Egg weight of rainbow trout also increased after the hardening process and is a positively correlated with the viability of eggs[39]. Other egg quality metrics, such as hatching rate, and survival to first feeding, has been correlated with good egg quality.

In this study, the hatching rate of embryo ~~(HRs)~~ in sago strain of giant gourami were smaller than those of other strains of giant gouramy[8,31,16]. This condition might be affected by the egg and sperm quality in ~~sago strain of giant gourami broodfish~~giant gourami sago strain broodfish. In the present study, whether eggs and sperm quality of sago giant gourami breeders are affected by feed ~~nutrition~~ type ~~for sago strain of giant gourami brooder~~ was~~is~~ poorly understood. ~~Meanwhile, the b~~Broodfish sex ratio ~~has not~~had no influence ~~d~~ on egg quality[8]. The ~~reproduction~~ reproductive ~~characterization~~ parameters that ~~had strong correlations~~ were strongly correlated with the hatching rate were fertility rate (r^2=0.703) and survival rate (10 days) (r^2= 0.998). According to Sink et al. (2010)[40] that indicator of egg quality the strong correlation with biochemical composition of eggs. In this study, we did not evaluate the biochemical composition of egg, because ~~due to~~ the relationship~~ed~~ between egg quality and biochemical composition is difficult to interpret[41].

The keys ~~of~~ regulator hormones~~s~~ of fish reproduction~~ed~~ ~~were~~ are gonadotropins ~~(GTHs)~~, follicle-stimulating hormone ~~(FSH)~~, luteinizing hormone ~~(LH)~~, and sex steroids[42,43]. ~~Besides that~~In addition, oocyte development~~ed~~ and maturation~~ed~~ are also regulated by locally acting paracrine and autocrine signalling[44,45]. However, there is no~~t~~ information about the effects of such ~~kinds of~~ factors on ~~the~~ oocyte development in sago ~~strain of~~ giant gourami. Nevertheless, extrusion feed enriched with ~~the~~ vitamin E (d-α-tocopherol) as much as 137.8, 238.05, 338.72 and 439.39 mg per kg feed ingredients affected ~~to~~ markers of reproductive functions of giant gourami brooder (e.g., time sexual maturity, ova somatic index, relative fecundity and egg diameter)[31].

Various efforts have been made by scientists to increase~~d~~ reproductive performance of female broodfish, such as ~~to~~ increasing ~~e about~~ dietary protein level for *Xiphophorus helleri*[33], *Channa marulius*[46] and *Ictalurus punctatus*[40]. Additionally, implantation of 17ß-estradiol has also ~~managed to~~ improved the reproductive performance in *Hemibagrus nemurus*[47]. Currently ~~In this context~~, whether the increase in protein level of feed and use of hormones~~al~~ can increase the reproductive~~ed~~ potential in sago ~~strain of~~ giant gourami ~~are~~ is poorly understood. Therefore, the experiment use of feed protein levels and hormonal dosage it is very important to applied for ~~sago strain of giant gourami broodfish~~giant gourami sago strain broodfish in the future.

Average ~~SVs~~ semen volume ~~was found~~ in sago ~~strain of~~ giant gourami ~~are~~ were lower (0.4 to 0.6 ml) than those of *Hemibagrus wyckii* (0.60 to 1.20 ml)[21], but higher than those of *Pterygoplichthys gibbiceps*[48]. It appears that the semen volume depend on fish species[21,49,50]. ~~So m~~Many factors influenced ~~on~~sperm quality and quantity ~~of sperm~~ such as genetic, physiological, spawning season

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Commented [SL35]: Please rephrase, meaning is unclear and environmental factors.[26,49,51,52]. On the other hand, improvements nutrition feed of broodfish and proofer feeding greatly improve gamete quality and larval production[46,53]. While, synthetic hormones such as salmon gonadotropin releasing hormone analogue and domperidone (GnRH + Domperidone) effective on sperm quality[54,55]. Nevertheless, ~~for~~ sperm fertility competition occurs in the aquatic environment, and ~~that had strong correlation~~and was strongly with the water quality in ponds. In this study, the water quality parameters in spawning ponds in terms of alkalinity (50.5 to 52.5 mg L^{-1}) and hardness (65.5 to 67.5 mg L^{-1}), pH (6.4 to 6.6) and water temperature (28 to 30 °C). The all water quality parameters can be supported the ability for sperm to fertilized an egg.

The sperm motility in sago ~~strain of~~ giant gourami ranged from 68 to 75%, and duration of motility ranged from 43 to 61 sec. Th~~is~~ese results ~~that~~ are consistent with *Genypterus blacodes* and *Esox lucius*[56,50]. ~~The S~~Sperm motility include~~d~~s the percentage of motile sperm, straight line velocity, curvilinear velocity, average path velocity and linearity[50]. In this study, we did not investigate ~~of~~ those parameters. ~~Meanwhile~~In addition, the percentage of motil~~ity~~e sperm is influenced by addition of extenders and cryoprotectants[57,58,59]. However, sperm motility ~~on~~ from fresh semen was slightly ~~better~~ greater compared to cryopreser~~vation~~ved semen ~~on~~ from~~the~~ *Esox lucius*[50]. The fertility rate of eggs ranged from 76 and 84%~~,~~; ~~nevertheless~~however, ~~it is does not detected any~~ no significan~~tly~~t correlation was detected~~s~~ between fertility rate and sperm parameters. Conversely, the sperm concentration ~~had~~ was moderately correlat~~ion~~ed with ~~the~~ sperm motility and duration of motility. The parameters commonly measured to assess sperm quality in brood were volume, density and motility (such as the percentage of motile sperm, straight line velocity curvilinear velocity, average path velocity, linearity and amplitude of lateral head displacement), includ~~ed~~ing fertilizing capacity [49,50,52,60]. In ~~T~~this study, we did not investigate the ionic composition of the semen, but this phenomenon could be related to the ionic composition of semen which might has a significant influence on sperm motility and duration of motility.

Conclusions

This research analyzed the ~~reproduction~~ reproductive ~~characterization~~characteristics in ~~the sago strain of giant gourami broodfish~~giant gourami sago strain broodfish reared in concrete freshwater ponds, in the Aquaculture Laboratory Faculty of Fisheries and Marine Science, Universitas Bung Hatta. Relative fecundities of the ~~Sago strain of giant gourami broodfish~~giant gourami sago strain broodfish ~~had the relative fecundities~~ ranged from 977 to 1071 eggs, and egg diameter ~~between~~ ranged from 2.32 to 2.46 mm. ~~The semen~~ Semen volume ranged from 0.4 to 0.7 ml per kg body weight and sperm motility ~~were~~ was comprised between 68 to 75%. ~~There was a~~A strong linear

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Data availability

Underlying data

~~Repository~~Figshare: ~~Title.~~ Reproduction characterization of the gurami sago (*Osphronemus goramy* Lacepède, 1801): basic knowledge for a hatchery development strategy for the future. https://doi.org/10.6084/m9.figshare.14661189.v1 [61].

~~**DOI: 10.6084/m9.figshare.14661189**~~

This project contains the following underlying data:

- Table 1. Raw data of fish length, weight, absolute fecundity and relative fecundity of gurami sago broodfish
- Table 2. Raw data of egg diameter (mm) in sago strain of giant gourami broodfish
- Table 3. Raw data of hardened egg diameter (mm) in sago strain of giant gourami broodfish
- Table 4. Raw data of egg diameter increase (%) in sago strain of giant gourami broodfish
- Table 5. Raw data of egg weight (mg) in sago strain of giant gourami broodfish
- Table 6. Raw data of hardened egg weight (mg) in sago strain of giant gourami broodfish
- Table 7. The data of egg weight increase (%) in sago strain of giant gourami broodfish
- Table 8. The data of fertilization rate (%) in sago strain of giant gourami broodfish
- Table 9. The data of hatching rate (%) in sago strain of giant gourami broodfish

- Table 10. Male size, gonadal weight and semen in sago strain of giant gourami broodfish
- Table 11. Sperm concentration (10^9/mL) in sago strain of giant gourami broodfish
- Table 12. Sperm Motility (%) in sago strain of giant gourami broodfish
- Table 13. Duration motility (sec) in sago strain of giant gourami broodfish

Competing interests

No competing interests were disclosed.

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References

1. 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. ~~Reference Source~~
2. Aryani N, Suharman I, Azrita, *et al*.: Diversity and distribution of fish fauna of upstream and downstream areas at Koto Panjang Reservoir, Riau Province, Indonesia. F1000Research, 2020; 8:1435. Publisher Full Text
3. Mungkung R, Aubin J, Prihadi TH, *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

4. 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

5. FAO, The State of World Fisheries and Aquaculture: Meeting the Sustainable Development Goals. *Food and Agriculture Organization of the United Nations*, Rome.2018.

6. CDSI (Central Data System Information). Ministry of Marine and Fisheries Republic of Indonesia, 2018 (In Indonesian). Reference Source

7. Azrita, Aryani N, Mardiah A, *et al.*: Growth, production and feed conversion performance of the gurami sago (*Osphronemus goramy* Lacepède, 1801) strain in different aquaculture systems. *F1000Research* 2020, 9:161. Publisher Full Text

8. Arifin OZ, Slembrouck J, Subagja J, *et al.*: New insights into giant gourami (*Osphronemus goramy*) reproductive biology and egg production control. *Aquaculture*, 2019; 519:734743

9. Ahmad N, Thompson S.: The blue dimensions of aquaculture: A global synthesis. *Sci. Total Environ*. 2019; 652: 851–861. Publisher Full Text

10. Ranjan R, Megarajan S, Xavier B, *et al.*: Broodstock development, induced breeding and larval rearing of Indian pompano, *Trachinotus mookalee* (Cuvier, 1832) – A new candidate species for aquaculture. *Aquaculture*, 2018; 495: 550–557. Publisher Full Text

11. Henriksson, PJG, Nhuong T, Chadag VM, *et al.*: Indonesian aquaculture futures-evaluating environmental and socioeconomic potentials and limitations.2017; J. Cleaner Prod., 162: 1482-1490. Publisher Full Text

12. Tran N, Rodriguez UP, Chan CY, *et al.*: Indonesian aquaculture futures: An analysis of fish supply and demand in Indonesia to 2030 and role of aquaculture using the AsiaFish model. Marine Policy, 2017; 79, 25–32. Publisher Full Text

13. 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*). *Pakistan J. Zool*. 2017; 49(5): 1775-1781. Reference Source

14. Nugroho E, Azrita, Syandri H, *et al.*: DNA barcoding of giant gourami (*Osphronemus goramy*) from West Sumatra, Indonesia. *AACL Bioflux*, 2019, 12, (4): 1074-1079. Reference Source

15. Slembrouck J, Arifin OZ, Pouil S, *et al.*: Seasonal variation of giant gourami (*Osphronemus goramy*) spawning activity and egg production in aquaculture ponds. *Aquaculture*,2020; 735450. PubMed Abstract Publisher Full Text

16. Radona D, Nafiqoh N.: Reproductive Characteristics and Heterosis value of Bastar and Bluesafir population of giant gourami crosses. *Berita Biologi*, 2014: 13(2):153-159 (in Indonesian). Reference Source

17. Azrita, Syandri H.: Effects of salinity on survival and growth of gurami sago (*Osphronemus goramy*, Lacepède, 1801) Juveniles. *Pak. J. Biol. Sci*., 2018; 21 (4): 171-178. Reference Source

18. Nugroho E, Azrita, Syandri H, *et al*.: Evaluation of genetic divergence of kalui fish (*Osphronemus goramy*) strains from West Sumatra revealed by random amplified polymorphism DNA (RAPD) marker. *Jurnal Riset Akuakultur*, 2016; 11 (4), 313-319 (in Indonesian). Reference Source

19. CDSI (Central Data System Information). Ministry of Marine and Fisheries, Republic of Indonesia, 2018 (In Indonesian). Reference Source.

20. Kanyilaz M.: Reproductive performance of a newly described Salmonid fish, Alakir Trout (*Salmo Kottelati*), a candidate species for aquaculture. *Pak. J. Zool*. 2016; 48(1): 83–89. Reference Source

21. Aryani A, Suharman I, Syandri H.: Reproductive performance of asian catfish (*Hemibagrus wyckii* Bleeker, 1858), a candidate species for aquaculture. *F1000Research* 2018, 7:683 Publisher Full Text

22. Aruho C, Walakira JK, Rutaisire J.: An overview of domestication potential of *Barbus altianalis* (Boulenger, 1900) in Uganda. *Aquac. Rep*., 2018; 11, 31–37. Publisher Full Text

23. Osure GO, Phelps RP.: Evaluation of reproductive performance and early growth of four strains of Nile tilapia (*Oreochromis niloticus*, L) with different histories of domestication. *Aquaculture*, 2006; 253(1-4): 485–494. Publisher Full Text

24. Krejszeff S, Katarzyna T, Daniel Z, *et al.*: Domestication affect spawning of the ide (*Leuciscus idus*)-preliminary study. *Aquaculture*. 2009; 295(1–2): 145–147. Publisher Full Text

25. Weber RA, Peleteiro JB, García Martín LO, *et al*.: The efficacy of 2-phenoxyethanol, metomidate, clove oil and MS-222 as anaesthetic agents in the Senegalese sole (*Solea senegalensis* Kaup 1858). *Aquaculture*. 2009; 288(1–2): 147–150. Publisher Full Text

26. Rurangwa E, Kime D, Ollevier F, *et al*.: The measurement of sperm motility and factors affecting sperm quality in cultured fish. *Aquaculture*, 2004; 234(1-4): 1-28. Publisher Full Text

27. Cabrita E, Martínez-Páramo S, Gavaia PJ, *et al*.: Factors enhancing fish sperm quality and emerging tools for sperm analysis. *Aquaculture*, 2014; 432, 389–401. Publisher Full Text.

28. Mylonas CC, Duncan NJ, Asturiano JF.: Hormonal manipulations for the enhancement of sperm production in cultured fish and evaluation of sperm quality. *Aquaculture*, 2017: 472, 21–44. Publisher Full Text.

29. Rice EW, Baird RB, Eaton AD, *et al.*: Standard methods for the examination of water and wastewater, 22nd ed**.** American Public Health Association, American Water Works Association, Water Environment Federation. 2012. Reference Source

30. Amornsakun T, Kullai S, Hassan A.: Some aspects in early life stage of giant gourami, *Osphronemus goramy* (Lacepede) larvae. *Songklanakarin J. Sci. Technol*, 2014; 36 (5): 493 – 498. Reference Source

31. Bari Y.: Addition of vitamin E to artificial feed in an effort to increase the reproductive potential of giant gourami (*Osphronemus goramy* Lacepede) broodstock. Thesis of Postgraduate, Bogor Agricultural University (unpublish, in Indonesian), 1997. Reference Source

32. Izquierdo M, Fernández-Palacios H, Tacon AG.: Effect of broodstock nutrition on reproductive performance of fish. *Aquaculture*, 2001; 197(1-4): 25–42. Publisher Full Text

33. Chong ASC, Ishak SD, Osman Z, *et al*.: Effect of dietary protein level on the reproductive performance of female swordtails *Xiphophorus helleri* (Poeciliidae). *Aquaculture*, 2004; 234: 381–392. Publisher Full Text.

34. Hafeez-ur-Rehman M, Abbas F, Ashraf M, *et al*.: Effect of different dietary protein levels on egg development and its response to inducing agents during induced spawning of *Channa marulius*. *Pakistan J. Zool*., 2017: 49 (1):337 – 343. Reference Source

35. Sarih S, Djellata A, Roo J, *et al*.: Effects of increased protein, histidine and taurine dietary levels on egg quality of greater amberjack (*Seriola dumerili*, Risso, 1810). *Aquaculture*, 2018; 499:72-79. Publisher Full Text

36. Jeuthe H, Brännäs E, Nilsson J.: Effects of egg size, maternal age and temperature on egg, viability of farmed Arctic charr. *Aquaculture*, 2013; 408-409, 70–77. Publisher Full Text

37. Stuart KR, Armbruster L, Johnson R, *et al*.: Egg diameter as a predictor for egg quality of California yellowtail (*Seriola dorsalis*). *Aquaculture*, 2020; 522: 735154*.* PubMed Abstract | Publisher Full Text.

38. Grant B, Davie A, Taggart JB, *et al*.: Seasonal changes in broodstock spawning performance and egg quality in ballan wrasse (*Labrus bergylta*). *Aquaculture*, 2016; 464: 505–514. Publisher Full Text.

39. Lahnsteiner F, Patzner RA.: Rainbow trout egg quality determination by the relative weight increase during hardening: a practical standardization. *J. Appl. Ichthyol*. 2002; 8(1):24-26. Reference Source

40. Sink TD, Lochmann RT, Pohlenz C, *et al*.: Effects of dietary protein source and protein–lipid source interaction on channel catfish (*Ictalurus punctatus*) egg biochemical composition, egg production and quality, and fry hatching percentage and performance. *Aquaculture*, 2010; 298(3-4): 251– 259. Publisher Full Text.

41. Morehead D, Hart P, Dunstan G, *et al*.: Differences in egg quality between wild striped trumpeter (*Latris lineata*) and captive striped trumpeter that were fed different diets. *Aquaculture*, 2001; 192 (1): 39–53. Publisher Full Text.

42. Mateos J, Mañanos E, Carrillo M, *et al*.: Regulation of follicle-stimulating hormone (FSH) and luteinizing hormone (LH) gene expression by gonadotropin-releasing hormone (GnRH) and sexual steroids in the Mediterranean Sea bass. Comparative Biochemistry and Physiology Part B: Biochemistry and Molecular Biology, 2002; 132(1): 75–86. Publisher Full Text

43. Paullada-Salmerón JA, Cowan ME, Loentgen GH, *et al*.: The gonadotropin-inhibitory hormone system of fish: The case of sea bass (*Dicentrarchus labrax*). *Gen. Comp. Endocrinol.,* 2019; 279: 184-195. Publisher Full Text.

44. Lubzens E, Young G, Bobe J, *et al*.: Oogenesis in teleosts: How fish eggs are formed. *Gen. Comp. Endocrinol.*, 2010; 165 (3): 367–389. Publisher Full Text.

45. Lubzens E, Bobe J, Young G, *et al*.: Maternal investment in fish oocytes and eggs: The molecular cargo and its contributions to fertility and early development. *Aquaculture*, 2017; 472: 107–143. Publisher Full Text.

46. Hafeez-ur-Rehman M, Abbas F, Ashraf M *et al*.: Effect of Different Dietary Protein Levels on Egg Development and its Response to Inducing Agents during Induced Spawning of *Channa marulis*, *Pakistan J. Zool.*, 2017; 49 (1):337-343. Reference Source.

47. Aryani N, Suharman I.: Effect of dietary protein level on the reproductive performance of female of green catfish (*Hemibagrus nemurus* Bagridae). *J Aquac Res Dev*., 2015; 6:11. Reference Source

48. Collazos-Lasso LF, Mariana CGE, Elisabeth AB.: Induced reproduction of the sailfin pleco, *Pterygoplichthys gibbiceps* (Kner, 1854) (Pisces: Loricariidae). *AACL Bioflux*, 2018, 11 (3): 724-729. Reference Source

49. Caldas JS, Godoy L.: Sperm characterization of the endangered Amazonian fish *Hypancistrus zebra*: basic knowledge for reproduction and conservation strategies. *Anim. Reprod. Sci.*, 2019; 204: 117-124. Publisher Full Text.

50. Dietrich GJ, Nynca J, Szczepkowski M, *et al*.: The effect of cryopreservation of semen from whitefish (*Coregonus lavaretus*) and northern pike (*Esox lucius*) using a glucose-methanol extender on sperm motility parameters and fertilizing ability. *Aquaculture*, 2016; 464: 60–64. Publisher Full Text.

51. Butt IAE, Litvak MK, Trippel EA.: Seasonal variations in seminal plasma and sperm characteristics of wild-caught and cultivated Atlantic cod, *Gadus morhua*. *Theriogenology*, 2010; 73(7): 873–885. Publisher Full Text.

52. Abinawanto, Intan AP, Retno L.: Sperm motility of giant gourami (*Osphronemus goramy*, Lacepede, 1801) at several concentrations of honey combined with DMSO after short-term storage. *AACL Bioflux*, 2017, 10 (2): 156-163. Reference Source

53. Valdebenito II, Gallegos PC, Effer BR.: Gamete quality in fish: evaluation parameters and determining factors. *Zygote*, 2013; 23(02): 177–197. Publisher Full Text.

54. Cejko BI, Krejszeff S, Żarski D, *et al*.: Effect of carp pituitary homogenate (CPH) and sGnRHa (Ovaprim) on northern pike (*Esox lucius*) spermiation stimulation and its effect on quantity and quality of sperm. *Anim. Reprod. Sci.*, 2018; 193: 217–225. Publisher Full Text.

55. Zadmajid V.: Comparative effects of human chorionic gonadotropin (hCG) and Ovaprim™ (sGnRHa+domperidone) on the reproductive characteristics of wild-caught male Longspine scraper, *Capoeta trutta* (Heckel, 1843). *Aquaculture*,2016; 463: 7–15. Publisher Full Text

56. Dumorné K, Valdebenito I, Contreras P, *et al*.: Effect of pH, osmolality and temperature on sperm motility of pink cusk-eel (*Genypterus blacodes*, (Forster, 1801)). *Aquac. Rep.*, 2018; 11: 42-46. Publisher Full Text.

57. Golshahi K, Aramli MS, Nazari RM, *et al*.: Disaccharide supplementation of extenders is an effective means of improving the cryopreservation of semen in sturgeon. *Aquaculture*, 2018; 486: 261–265. Publisher Full Text.

58. Yusoff M, Hassan BN, Ikhwanuddin M, *et al*.: Successful sperm cryopreservation of the brown-marbled grouper, Epinephelus fuscoguttatus using propylene glycol as cryoprotectant. *Cryobiology*, 2018; 81: 168–173. Publisher Full Text

59. Kommisrud E, Myromslien FD, Stenseth EB, *et al*.: Viability, motility, ATP content and fertilizing potential of sperm from Atlantic salmon (*Salmo salar* L.) in milt stored before cryopreservation. *Theriogenology*. 2020; 151: 58-65. Publisher Full Text

60. Cejko BI, Żarski D, Palińska-Żarska K, *et al*.: Artificial seminal plasma improves motility and fertilization capacity of common carp *Cyprinus carpio* L. sperm during one hour of storage. *Aquaculture*, 2019; 506: 224-228. Publisher Full Text.

~~60.~~61. Syandri, Hafrijal; Azrita, Azrita; Aryani, Netti (2021): Untitled ItemReproduction characterization of the gurami sago (Osphronemus goramy Lacepède, 1801): basic knowledge for a hatchery development strategy for the future. figshare. Journal contribution. https://doi.org/10.6084/m9.figshare.14661189.v1