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Reproductive biology of sagor catfish (*Hexanematichthys sagor* Hamilton, 1822) in Can Gio water, Vietnam

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Sagor catfish (*Hexanematichthys sagor* Hamilton, 1822) is one of the most popular fish caught in Can Gio reserve biosphere. A study on reproductive biology was conducted to evaluate the reproductive parameters, including male–female distinction, gonadal development stages, sex ratio, spawning season, fecundity, and size at first sexual maturity. The results showed that the number of males and females in the nature was not significantly different. Male and female fish can be distinguished when they reach the mature size. Gonadal of the fish pass through five stages of maturation. The histological screening of gonad, percentage of maturation stage and gonadal somatic index value of the fish showed all year round spawning with a peak of spawning female from March to August. The length at first sexual maturity of the fish is 25.39 cm. Fecundity ranged from 60 to 145 ovaries/individuals strongly related to weight and length. The current findings provide the scientific foundation for the purpose of fishery resource management and artificial breeding of the blue sagor catfish.

[Keywords: Sagor catfish; *Hexanematichthys sagor*; Reproductive biology; Can Gio]

Introduction

In Vietnam, the marine natural resource, especially, the resource of high value species has been rapidly decreasing[1]. One of the main reasons for the decrease of the resource is overexploitation. In addition, there is no reasonable management strategy for sustainable and environment-friendly exploitation of the natural resource. The research on biology of a marine species including reproduction and growth is necessary for management of natural resource. The reproductive cycle of fish is closely tied to the environmental changes, particularly temperature, photoperiod and food supply[2]. Reproductive parameters, such as gonadal development stages, sex ratio, sex at first maturity, spawning season, and fecundity are of great value in fishery resource management and aquaculture practices. The availability of quality seeds and the ability to control fish reproduction are widely recognized as limiting factors in the farming of any commercial species[3].

Sagor catfish (*Hexanematichthys sagor* Hamilton, 1822) belongs to the genus Hexanematichthys, family Ariidae, the main economically valued group[4]. In Vietnam, the genus Arius distributes mostly in the South[5]. Sagor catfish is a high value species. Like other species, the fish is also not sustainably managed in Vietnam and in Can Gio seawater. Thus, there is a great need for a suitable management strategy of the natural resource of the fish as well as the strategy for effective breeding of this fish for supporting the demand. However, information available on the reproductive biology of this fish in Can Gio seawaters is still unknown. Hence, a detailed investigation on reproductive biology of this fish, including male-female distinction, sex ratio, gonadal development stages, spawning season, and fecundity and size at first sexual maturity in Can Gio seawater was conducted and the results discussed in this paper.

Materials and Methods

Sample collection

The study was carried out from September 2016 to August 2017. Fish sample was collected from Can Gio. Around 30 ramdom-size fish were collected each month (Table 1). The fishes were transported to laboratory at the Institute of Oceanography, Vietnam, for analysis. At the laboratory, the fish were killed, weighed and their lenght measured. Reproductive gonad of the fish (testes or ovaries) were then dissected and weighed for further analysis.

Table 1 — Number of fish collected each month during the study period

Month	Jan	Feb	Mar	Apr	May	Ju	Jul	Aug	Sep	Oct	Nov	Dec
No	30	30	30	29	31	30	30	32	28	30	30	31

Sample analysis and data collection

The distinction between male and female was determined based on the appearance of anus and genital papilla, followed by determination of sex ratio. Chi-square test was used to test the difference in the number of males and females in the natural population of the fish.

The maturity stages of females were recognized based on the macroscopic appearance of the ovary in the body cavity and microscopic structure of ova; in males, only the macroscopic appearance of testes were considered. Gonadal development stages of fish were determined by methods of Nikolsky[5] and Xakun & Buskaia[6] using Olympus BX50 microscope at 10X magnification.

Histological analysis of testes and ovary was performed following the method described by Gen et al[7]. Ovaries or testes of each gonadal development stage of fish were dissected and fixed in 4% buffer formalin for 24h. After dehydrating by passing the tissue through a series of alcohol solutions of 70, 85 and 98%, the samples were vacuum-embedded in paraffin. The histological sections (4-5 μm) were stained for general morphological purposes with haematoxylin and eosin. The samples were photographically analyzed and documented using the Olympus BX 50 microscope at 10X and 40X magnification.

Spawning season of the species was determined based on the availability of mature and spent individuals in the commercial landings during different months and the monthly gonado-somatic indices (GSI). The GSI was calculated using the formula: GSI = 100 * (GW/BW), where GW is weight of gonad and BW is weight of fish.

To estimate the length at first maturity (Lm), the females were grouped separately into 8 mm class intervals and fish in stage-III and above were considered mature. Length at first sexual maturity (L_m) were defined as the length at which 50 per cent of all female fish having ovaries at advanced stage of development[7]. The proportion of the female fish with ovaries at advanced stage of development (P) of each size group was adjusted by correction factor, as the biggest size group was 100%. The linear relationship between size group and Ln(1-P/P) was determined and the L_m was calculated at P = 0.5[9].

Table 2 — Distinction between mature male and female of sagor catfish

Male	*Female*
Have the genital papilla	Do not have genital papilla
Belly is slim and rather hard	Belly is larger than male, soft
Genital hole is small and light in color.	Genital hole larger, pink in color.
Mouth cavity is larger	Mouth cavity is small

To estimate fecundity, 30 ovaries in stage–IV were utilised. From formalin-preserved ovary of known weight, a small portion was removed and weighed to the nearest 0.001 g in an electronic balance and then kept in modified Gilson's fluid for two days. All the oocytes in the sample ovary were counted under binocular microscope using a counting chamber. The absolute fecundity was estimated using the formula: Absolute fecundity (F) = (weight of ovary/weight of sample) x number of oocytes in the sample. The relationship between fecundity and total length and weight was determined using the formula: LogF = aLogX + b where F is demoted fecundity, X is total length or weight, a and b are constant. Relative fecundity was calculated using the formula: S=F/W where S is relative fecundity and W is fish weight (g).

Results

Male–female distinction of the sagor catfish: In the sagor catfish that has not matured, it is not possible to distinguish between male and female based on the external characteristics. However, when the fish are mature, male and female can be distinguished by way of several signs (Table 2):

Sex ratio of the sagor catfish

Ratio of male and female was 1:1.07. Number of male and female was not significantly different ($\chi 2 = 0{,}41 < 3{,}845$ (*df = 1, P < 0,05*)).

Gonadal maturity stages of the sagor catfish in Can Gio

The maturity stages of ovary and testes of the sagor catfish in Can Gio is represented in Tables 3 and 4. The histology of ovaries and testes of the blue tang fish in Can Gio is presented as Figures 1 and 2.

Monthly change in the percentage of maturity stage of the sagor catfish in Can Gio

The fishes at mature, stage-III to spent, stage-V of ovaries are presented all year round. However,

Table 3 — Maturity stages of the female sagor catfish in Can Gio

Maturity stages	Particular of the gonads
Stage-I, Immature	Ovary was thin, short and glassy in appearance. It could not be distinguished ovary and testes by snake-eyes. The ovary contain only ovogony at the size about 0,08 ± 0,04 mm. The stages was observed in the fish size under the first maturation size.
Stage-II, Maturing	Ovary developing, ovary and testes can be distinguished by snake-eyes. The egg increase the size to 2.8 ± 1.2 mm diameter.
Stage-III, Mature	Ovary increase the size comparing to stage II. Egg diameter range from 4.4 to 5.8 mm. Histological section show the round nuclear at the center of the egg.
Stage-IV, Ripe/Oozing	End of the maturation process, the ovary filling the entire body cavity, extending in the entire body cavity length. The egg diameter range from 6.7 to 12.3 mm.
Stage-V, Spent	Ovaries are rather flaccid.

Table 4—Maturity stages of the male sagor catfish in Can Gio

Maturity stages	Particular of the gonads
Stage-I, Immature	Testes was thin, short and glassy in appearance. It could not be distinguished ovary and testes by snake-eyes. The stages was observed in the fish size under the first maturation size.
Stage-II, Maturing	Testes start developing, ovary and testes can be distinguished by snake-eyes. Testes are moderately thick, flattened and white.
Stage-III, Mature	Testes increase the size comparing to stage II. Testes are flat, well-developed and creamy white, extending about 2/3 body cavity length
Stage-IV, Ripe/Oozing	Testes are very thick, flat, turgid and creamy, extending in the entire body cavity length
Stage-V, Spent	Testes are sunken

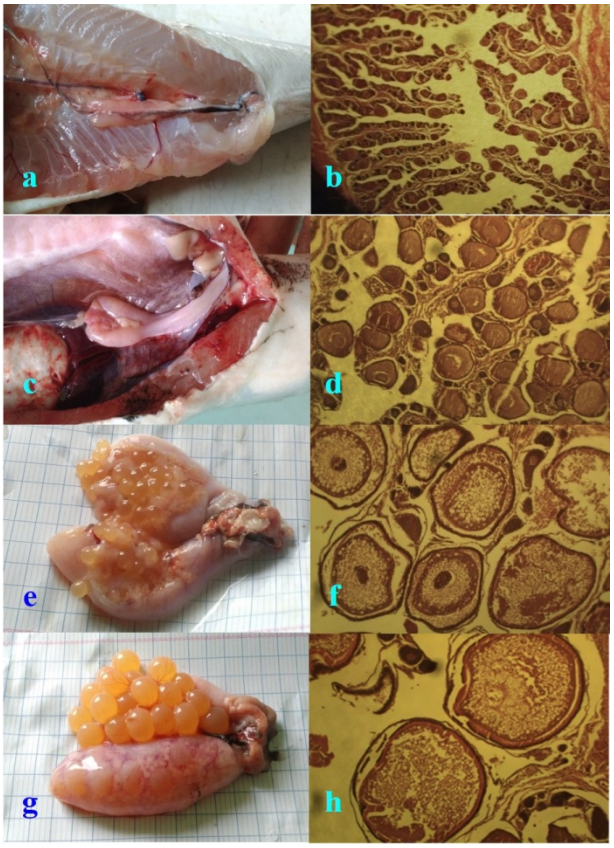

Fig. 1 — Ovary and histological section of the ovaries of the sagor catfish in Can Gio*(a, b: stage-I; c,d: stage-II; e, f: stage-III; g, h: stage-IV)*

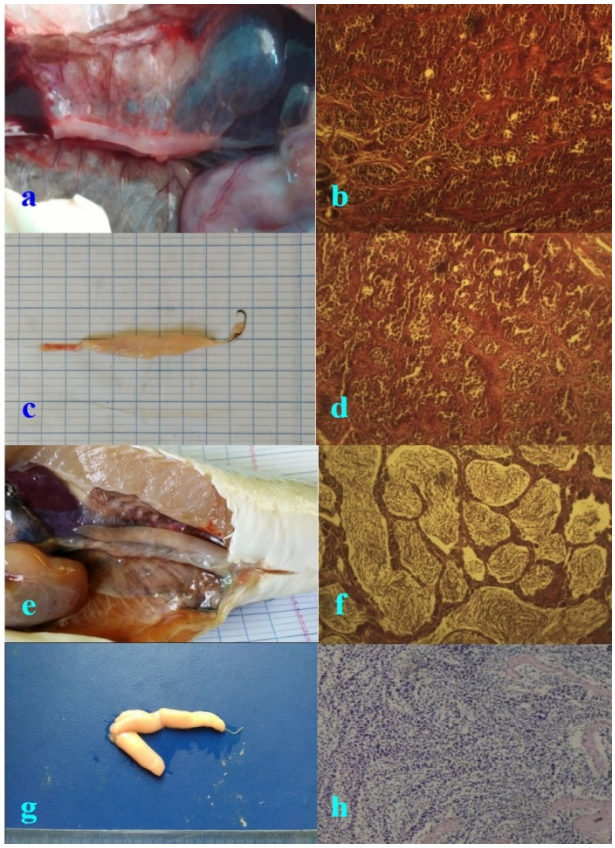

Fig. 2 — Testes and histological sections of the testes of the sagor catfish in Can Gio*(a, b: stage-I; c,d: stage-II; e, f: stage-III; g, h: stage-IV;)*

percentage of fish at maturation stages-III, IV and V was higher during the period from March to August than that during the period from September to February. The percentage of advance stage of ovaries (III, IV and V) in July was the highest (82%) and the lowest was in January 41 (%) (Fig. 3).

Monthly change in GSI of the sagor catfish in Can Gio

GSI of the females was the highest in July (5.15 ± 2.85) and the lowest in November (0.85 ± 0.42). For males, the highest GSI was in July (1.12 ± 0.95) and the lowest GSI was observed in December (0.30 ± 0.25) (Fig. 4).

Length at first sexual maturity of the sagor catfish in Can Gio

The length of the first sexual maturity of the sagor catfish in Can Gio was counted at 25.38 cm (Fig. 5).

Fecundity of the sagor catfish in Can Gio

The absolute fecundity of the sagor catfish in Can Gio was 120.50±25.48 ovaries/individual (ranged from 60 to 145 ovaries/individual). The relative fecundity of the fish was 0.165±0.043 ova/g of female fish (ranged from 0.125 to 0.225 ova/g of female fish). The relationship between fecundity and the length and weight of the fish is presented in Figures 6 and 7.

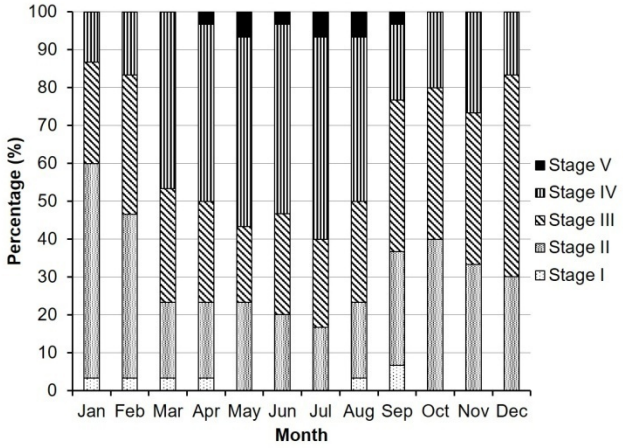

Fig. 3 — Monthly percentages of maturation stages of the sagor catfish in Can Gio

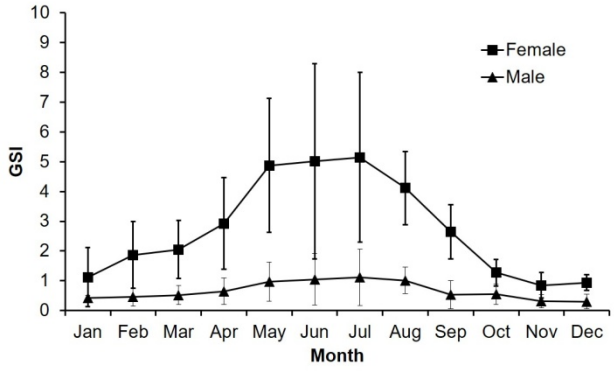

Fig. 4 — Monthly change of the GSI of the sagor catfish in Can Gio

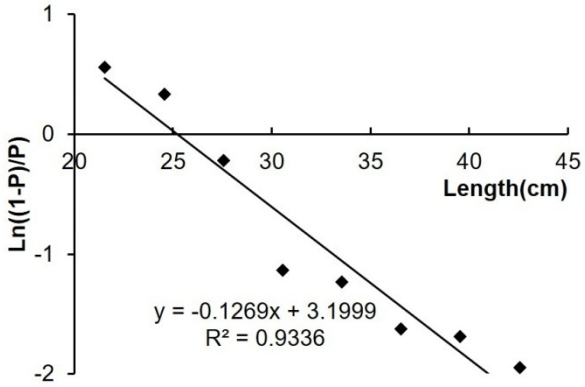

Fig. 5 — Groups of size relationship and Ln ((1-P) / P) of the sagor catfish in Can Gio

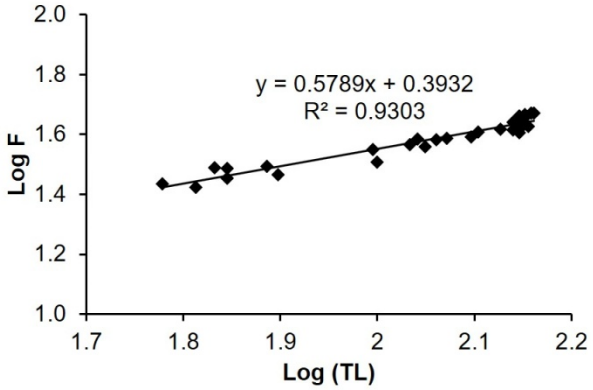

Fig. 6 — Fecundity - total length relationship of the the sagor catfish in Can Gio

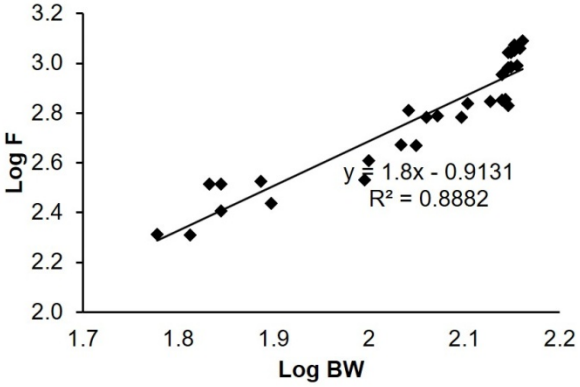

Fig. 7 — Fecundity - total weight relationship of the the sagor catfish in Can Gio

Discussion

Reproductive characteristic of fish is necessary for fishery resource management and aquaculture practices. The current study is the first attempt to investigate some reproductive parameters of the sagor catfish in Can Gio, one of the important reserve biospheres in Vietnam. Results show that the gonad of the sagor catfish was divided into five stages of maturity. This is normally observed in the tropical fish having the year-round reproduction cycles. At mature or ripe stages, beside the main component oocytes (oocyte at early vitellogenic and advanced vitellogenic stages), the primary growth oocytesalso exist in considerate number. This is the signal that the sagor catfish spawns continuously during the spawning season. In addition, the data on the changes in percentage of maturity stages and GSI in the current study suggests that the sagor catfish spawns all year round with a peak season from March to August. The results are consistent with other studies on tropical marine fish, such as *Galeichthys felis, and Arius sciurus* [9]. The fishes in estuary and coastal seawater almost spawn year round and have one peak spawning season[11; 12]. The data on changes in GSI and the monthly change in the percentage of maturity stage of the sagor catfish in Can Gio also shows that the fishes have peak spawn in the month of July. The results are consistent with other studies on the fishes belonging to family Ariidae, such as *Arius thalassinus* from February to July[13]; *Arius felis* from May to August; *Galeichthys felis* from April to July[14]; *and Barge marinus* from April to June[15].

The fecundity of fishes is usually determined from the number of ova of the mature group in the ovary. In the present study, the fecundity of the sagor catfish was determined from the examination of 30 specimens. The fecundity showed high correlation coefficient with the total length of the fish. The regression of fecundity and total length can be expressed as LogF = 0.578 *Log(TL) + 0.393 with R^2 value as 0.930. The regression of fecundity and body weight can be expressed as LogF = 1.8*Log(BW) - 0.913 with R^2 value as 0.888. The absolute fecundity of the sagor catfish in Can Gio is higher than that of other fishes belonging to the family Ariidae: *Arius felis* (20–64 ova/fish)[16], *Galeichths felis* (40–62 ova/fish)[14], and *Tachysurus thalassinus* (25-42 ova/fish[17]. In contrast, the fecundity of sagor catfish is lower than that of *Arius sciurus* (Absolute fecundity range from 461–1,047 ova/fish and relatively fecundity range from 11.813–16.362 egg/kg)[9]. The fecundity of sagor catfish is similar to that of *Arius thalassinus* having absolute fecundity from 85–153 ova/fish and relatively fecundity from 11.5–21.5 egg/kg)[13].

The current study also showed that the sagor catfish longer than 44 cm has the mature percentage of 100%, the fish shorter than 20 cm is not mature, and the fish longer than 26 cm has mature percentage of more than 50%. The calculated result show that the length at first sexual maturity of the sagor catfish in Can Gio is 25.39 cm with a very strong correlation between the length and percentage of maturation (R = 0.9662). The length at first sexual maturity of the sagor fish in Can Gio is similar to *Arius felis* (23.6 cm), larger than *Arius melanopus* (16.3 cm) and *Galeichths felis* (19 cm), but smaller than *Tachysurus thalassinus* (36 cm)[17].

Conclusion

The present study reveals that the sagor catfish in Can Gio seawater spawns year round with peak season from March to August; The length at first sexual maturity of the fish is 25.39 cm. The fecundity ranged from 60 to 145 ovaries/individual and is strongly related to weight and length. The currently findings provide the scientific foundation for the purpose of fishery resource management and artificial breeding of the sagor catfish.

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