

Sexual dimorphism and reproductive biology of bronze featherback (*Notopterus notopterus*, Pallas 1769) from Kelekar River, Ogan Ilir, South Sumatra, Indonesia

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Abstract

Sexual dimorphism and reproductive biology are fundamental aspects of fish breeding studies. The aim of this research was to analyze the sexual dimorphism and reproductive biology of *Notopterus notopterus*. A total of 74 *N. notopterus* were collected from the Kelekar River in Ogan Ilir Regency, Indonesia, consisting of 38 males (TL: 18–23.6 cm; BW: 35.1–92.1 g) and 36 females (TL: 19.6–26.3 cm; BW: 49.4–133.8 g). Seventeen morphometric characters, three meristic characters, and five reproductive biological parameters were analyzed. The results showed the differences in the morphometric characteristics of male and female *N. notopterus*. However, there was no difference in the meristic characters. The male gonadosomatic index ranged from 0.15 to 0.61%, and the female from 1.12 to 9.10%. The hepatosomatic index of males ranged from 0.19 to 1.38%, and that of females ranged from 0.15 to 1.23%, with a sex ratio of 1.056:1, fecundity of 1.007–3.901 eggs, ova diameters of 1.1–3.9 mm, and maturity levels of developed gonads to mature for males and mature to spawning for females. In conclusion, the differences between male and female *N. notopterus* can be identified morphologically.

Keywords: Broodstock selection; fish reproduction; gonochorism; Indonesian fish; knifefish; notopteridae; secondary sexual characteristics.

Introduction

Bronze featherback (*Notopterus notopterus*, Pallas 1769) is a freshwater fish species native to Indonesia. *N. notopterus* is one of the fish species of the Notopteridae family¹. The Notopteridae consist of approximately ten species in four genera: Chitala, Notopterus, Xenomystus, and Papyrocraus². The only recognized species of Notopterus at present is

*N. notopterus*³. The *N. notopterus* distribution in Asia includes Indonesia, India, Malaysia, Thailand, Bangladesh, Pakistan, and Vietnam^{1,2,4-7}. In Indonesia, this species is distributed in Java, Sumatra, and Kalimantan^{1,8}. *N. notopterus* was found in Kolong-Bendungan Simpung, Bangka Island⁹, Ogan River (tributary of Musi River, South

Sumatra), waters in Bangka Island as well as Kota Bangun and Tanah Ulu (Mahakam River, East Kalimantan)¹⁰, East Pedamaran Floodplain, Ogan Komerling Ilir¹¹, Sei Gesek Reservoir, Bintan, Riau Islands¹², and Kelekar River¹³.

Several studies on *N. notopterus* have been conducted, among others, on aspects of length-weight relationship, relative condition factor and fecundity¹⁴⁻¹⁷, genetic diversity¹⁰, morphometrics and growth patterns¹¹, food and feeding habits¹², reproductive biology⁹, determination of condition factors, somatic condition, hepatosomatic index and gonadosomatic index¹⁸, behavior and reproduction¹⁹, potential biomarkers of oxidative stress²⁰, embryo and larval development²¹, relative condition factors^{22,23}, population dynamics⁵, relationship of ecological factors and commercial²⁴, and its early domestication^{25,26}.

Fishery management mainly depends on knowledge of fish reproductive biology^{27,28}. In adult fish, sexual dimorphism is a frequent and well-known phenomenon²⁹. The majority of fishes are gonochoristic and have various sexually dimorphic

characteristics in their secondary sexual characteristics³⁰. Distinguishing characteristics for the morphological qualities of many teleosts have been documented, including body color, ornamental patterns, breeding tubercles on the snout, pectoral fins and scales, fin hooks, body shape, fin size and shape³¹⁻³⁵.

N. notopterus is one of the most valuable freshwater fish in South Sumatra, Indonesia. This fish is utilized by the community in South Sumatra, especially as a daily side dish and a raw material for the culinary industries of pempek (fish cake) and kerupuk-kemplang (fish crackers). Therefore, this species has the potential for cultivation. There is relatively little known about sexual dimorphism and reproductive biology in *N. notopterus*. Such information is crucial for initial data in the breeding of *N. notopterus*. The study aimed to analyze the sexual dimorphism and reproductive biology of *N. notopterus* from Kelekar River, Ogan Ilir. The results of this study are beneficial in the selection of *N. notopterus* broodstock candidates for breeding programs.

Materials and Methods

The fish collection was conducted in Kelekar River, Tanjung Baru Village, North Indralaya District, Ogan Ilir Regency, South Sumatra, Indonesia (Fig 1). Sampling was conducted in February–May 2023. The temperature, water acidity, and dissolved oxygen at the sampling site ranged from 24.4°C to 28.3°C, 5.5 to 6.4, and 4.9 to 6.4 mg.L⁻¹, respectively. Fishing was conducted by fishermen using fish traps. A total of 74 *N. notopterus* samples

were collected: 38 males (TL: 18–23.6 cm; BW: 35.1–92.1 g) and 36 females (TL: 19.6–26.3 cm; BW: 49.4–133.8 g). The *N. notopterus* samples were transported to the Fisheries Basic Laboratory, Aquaculture Study Program, Department of Fisheries, Faculty of Agriculture, Universitas Sriwijaya, for analysis of morphometric-meristic characters and also aspects of reproductive biology.

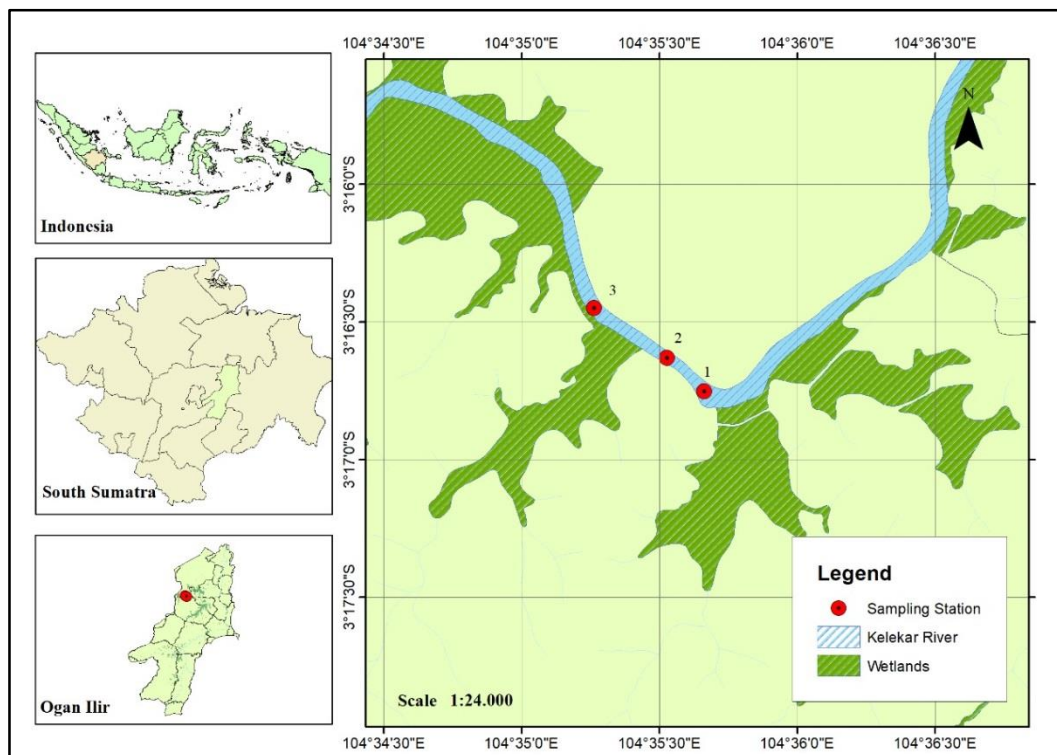


Figure 1. Map of *Notopterus notopterus* (Pallas 1769) sample collection in Kelekar River, Ogan Ilir Regency, South Sumatra, Indonesia

In the laboratory, fish were weighed using a digital scale (accuracy 0.01 g). Then observe the fish morphologically and count the meristic characters (number of rays of the dorsal fin, number of rays of the pectoral fin, and number of rays of the anal fin). Furthermore, the samples were measured for morphometric characters using a caliper (accuracy 0.01 cm) and a ruler (accuracy 0.1 cm). The morphometric characters measured were seventeen characters (Fig 2). Next, the fish were dissected, and the gonads and liver were taken, separated from other organs. Gonads and liver were weighed for the calculation of gonadosomatic index (GSI) = [gonad weight (g) / fish weight (g) x 100] and hepatosomatic index (HSI) = [liver weight (g) / fish weight (g) x 100] ³⁶. The calculation of fecundity

was done gravimetrically, namely, the fish gonads were taken partially, and then the number of eggs in the partial gonads was calculated. Fecundity = [number of sample gonad eggs x (total gonad weight/partial gonad weight)] ³⁷. Oocyte diameter was observed under a digital microscope. The maturity level of fish gonads was categorized based on the morphology and color of the gonads, GSI, and oocyte diameter. The sex ratio was calculated based on the number of male and female fish. The data obtained were grouped into two categories, namely male and female fish. Data tabulation using the Microsoft Excel program was then analyzed descriptively to obtain differences between male and female fish.

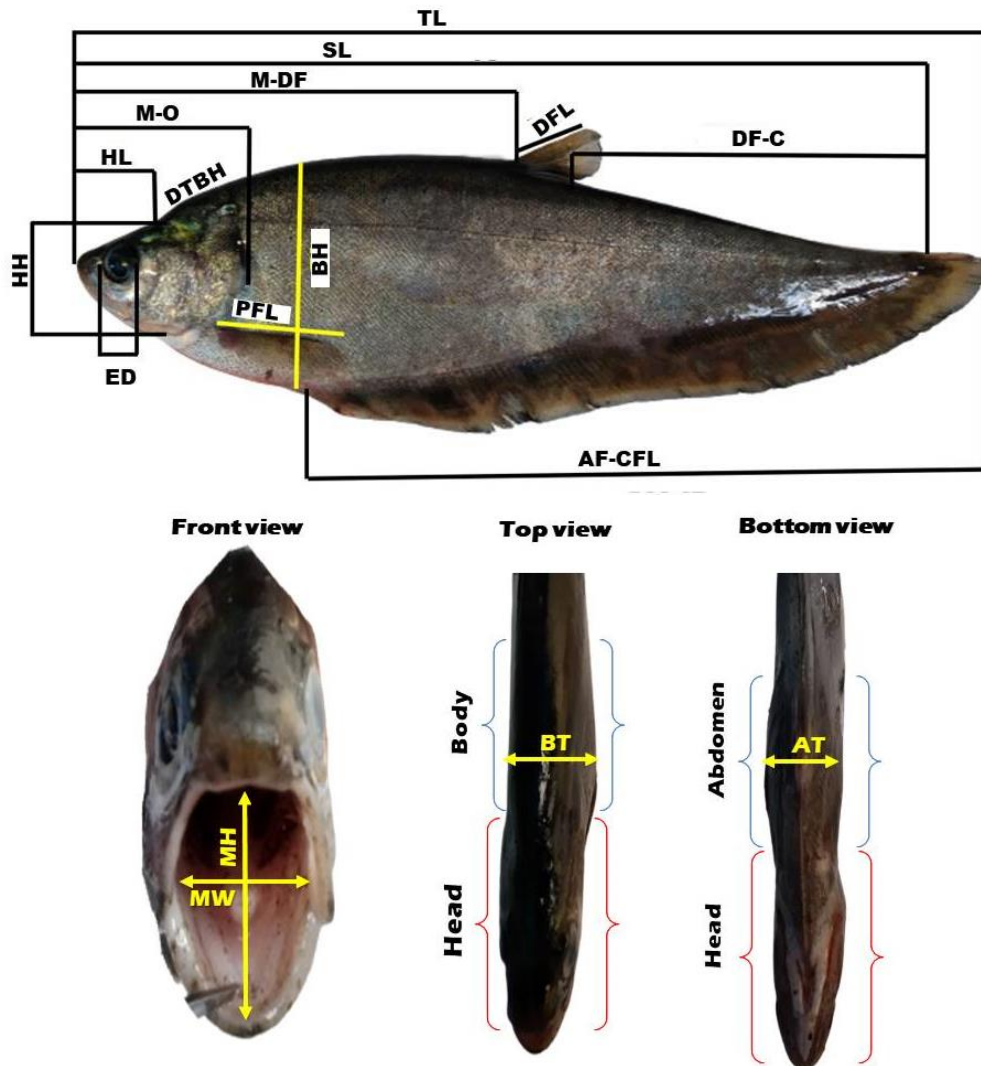


Figure 2. Morphometric character measurements of bronze featherback (*Notopterus notopterus*, Pallas 1769): TL (total length), SL (standard length), M-O (mouth to operculum distance), M-DF (mouth to dorsal fin distance), DF-C (dorsal fin to caudal distance), DFL (dorsal fin length), PFL (pectoral fin length), AF-CFL (anal fin to caudal fin length), BH (body height), HL (head length), HH (head height), ED (eye diameter), DTBH (degree of tilt of the back of the head), BT (body thickness), AT (abdominal thickness), HM (height of mouth), WM (width of mouth)

Results and Discussion

A total of 74 *N. notopterus* samples, consisting of 38 males and 36 females, have been successfully measured for morphometric characters and

calculated for meristic characters. The results of measurements and calculations of *N. notopterus* samples in this study are presented in Table 1.

Table 1. Morphometric and meristic characters of male and female *Notopterus notopterus* (Pallas, 1770) from Kelekar River, Ogan Ilir Regency, South Sumatra, Indonesia

Morphometric character	Male		Proportion (%)	Female		Proportion (%)
	Range (cm)	AVG±SD		Range (cm)	AVG±SD	
TL	18-23.6	20.39±1.39	-	19.6-26.3	22.46±1.56	-
SL	16-21.6	18.60±1.45	91.25 TL	17.3-24.2	20.45±1.59	91.07 TL
HL	1.3-3.5	2.07±0.51	10.18 TL	1.6-3.7	2.16±0.47	9.64 TL
HH	2.1-3.5	2.63±0.38	12.90 TL	2.4-4.3	2.85±0.39	12.70 TL
ED	0.5-0.7	0.64±0.06	30.91 HL	0.8-1.0	0.86±0.06	39.81 HL
BH	3.1-5.1	4.29±0.44	21.07 TL	4.8-6.4	5.62±0.50	25.05 TL
PFL	2.1-3.3	2.53±0.35	12.44 TL	2.2-3.6	2.73±0.37	12.16 TL
DFL	1.7-2.8	2.19±0.27	10.77 TL	1.9-3.2	2.33±0.30	10.38 TL
AF-CFL	13.2-18.4	15.42±1.22	75.62 TL	14.0-19.1	16.44±1.36	73.20 TL
M-O	3.0-4.7	3.65±0.40	17.91 TL	3.0-4.9	3.90±0.44	17.40 TL
M-DF	8.1-11.5	9.75±0.68	47.85 TL	9.5-12.3	10.58±0.80	47.14 TL
DF-C	8.0-11.6	9.85±1.02	48.32 TL	8.5-12.5	10.94±0.98	48.72 TL
BT	1.1-1.3	1.19±0.08	-	1.4-1.9	1.51±0.14	-
AT	0.6-1.0	0.89±0.11	-	1.1-1.6	1.26±0.13	-
MH	0.8-1.2	1.02±0.09	-	0.8-1.2	1.05±0.09	-
MW	0.8-1.1	0.96±0.10	-	0.8-1.2	1.00±0.11	-
DTBH (°)	32.0-50.0	42.36±3.51	-	47.0-63.0	52.6±3.06	-
Meristic character	Number of rays of the male fish		Number of rays of the female fish			
Pectoral (P)	10-14		11-14			
Dorsal (D)	6-9		6-9			
Anal+Caudal (A+C)	107-118		110-118			

The total length of *N. notopterus* used in this study ranges from 18 cm to 23.6 cm; body weight ranges from 35.1 g to 92.1 g for male fish; The length ranges from 19.6 cm to 26.3 cm; and body weight ranges from 49.4 g to 33.8 g for female fish. According to the study results of ⁹, the total length of female fish ranged from 130 mm to 249 mm, males from 120 mm to 232 mm, and the body weight of males was 22.17–97.17 g and females 38.98–120.47 g. The total length of *N. notopterus* ranges from 401 mm to 950 mm ¹⁰. The male *N. notopterus* measured between 19.1 cm and 24.1 cm in length and weighed between 48.7 g and 133.4 g, while the female measured between 17.2 cm and 25.6 cm in length and weighed between 69.7 g and 151.2 g ¹⁶.

The dorsal fin of *N. notopterus* fused with the caudal fin and anal fin. Each fin contains only rays

and no spine. Meristic characters have been successfully counted. The results showed that P.10-14, D.6-9, and A+C.107-118. The results of the study by ³⁸ showed that P.11-14, D.5-7, and A.98-111. According to ³⁹, the number of rays on the P.13-14, D.7-9, and A.97-111. However, ⁴⁰ stated that D.7-9, and A.97-111. According to ⁸, P.13-14, and A. 99-111.

One of the vital physiological processes that is essential to the life cycle of any organism, including fish, is reproduction ⁴¹. Planning improved conservation and management strategies for fishery resources requires a fundamental understanding of the reproductive cycle of fish ^{28,42}. Some aspects of *N. notopterus* reproductive biology observed in this study are presented in Table 2.

Table 2. Reproductive aspects of male and female *Notopterus notopterus* (Pallas, 1770) from Kelekar River, Ogan Ilir Regency, South Sumatra, Indonesia

Parameters	Sampling Period							
	February		March		April		May	
	Male	Female	Male	Female	Male	Female	Male	Female
GSI (%)	0.31±0.05	5.18±1.04	0.39±0.11	4.50±1.16	0.30±0.14	3.22±1.69	0.28±0.06	3.59±2.57
HSI (%)	0.65±0.22	0.53±0.10	0.52±0.19	0.51±0.22	0.79±0.23	0.80±0.36	0.79±0.27	0.73±0.19
Ova diameter (mm)	-	1.2-3.6	-	1.1-3.9	-	1.2-3.9	-	1.2-3.8
Fecundity	-	1361-3543	-	1455-3121	-	1060-1471	-	1007-3901
Sex ratio	1:1		1.14:1		1.5:1		0.86:1	

The GSI utilized to ascertain the fish's reproductive periodicity⁴³. Table 2 shows that the GSI value of female fish was highest in February, and the male fish was highest in March. The GSI of female fish is higher than that of male fish. The GSI value is also related to the stage of gonad maturity. The GSI value increases with increasing gonad maturity. The increase in GSI indicates a developmental process in the gonads. The GSI value will reach a maximum value before spawning occurs. In addition, the GSI value is influenced by environmental factors related to the food availability as an energy source for somatic development and fish reproduction⁴⁴.

HSI values for female fish were highest in April and for males in May. HSI is the percentage value of the ratio between liver weight and total body weight. One of the organs that plays a role in fish reproduction is the liver. The liver plays an important role in the vitellogenesis process. This process is triggered by the increasing concentration of estradiol in the blood. Estradiol is an important hormone produced by the ovaries in female fish that is beneficial in the process of vitellogenesis. The higher the level of estradiol concentration in the blood, the earlier the liver will carry out the vitellogenesis process, and gonad maturation will be faster^{45,46}. The HSI indicated an energy reserve in the liver⁴⁷ and a bio-indicator of contaminant exposure^{48,49}. The fecundity of *N. notopterus* in this

study ranged from 1.007 to 3.901 eggs per individual.⁵⁰ showed that fecundity values ranged from 53 to 748 and from 175 to 4.494⁵¹. The value of fecundity is influenced by several factors, one of which is environmental. Variations in the number of fish fecundities are also caused by variations in the length and weight of fish.

The diameter of the ova of *N. notopterus* in this study ranged from 1.1 mm to 3.9 mm. Previous studies ranged from 1.05 to 2.2 mm⁹. The oocyte diameter is categorized as a mature ovary. The higher the oocyte diameter value, the higher the ovary's maturity. The results showed that the diameter of the oocyte in the ovary varied. This indicates that the development of oocytes in the ovary is not uniform. It is suspected that *N. notopterus* spawns gradually. This is by the opinion of⁹ that *N. notopterus* releases mature oocytes gradually. *N. notopterus* spawns more than once during a spawning season. The sex ratio is an important component in the study of fish reproduction^{42,52}. The balance of the number of male and female fish in a body of water affects the continued existence of a species. The results of this study show that the number of male fish is higher than the number of female fish, except in the May sampling period. This result indicates that the population of male fish is greater than that of female fish.

Conclusion

There are differences in the morphometric characteristics of male and female *N. notopterus*. However, there are no differences in meristic characters. The gonadosomatic index of male fish ranged from 0.15% to 0.61%, and that of females ranged from 1.12% to 9.10%. The hepatosomatic index of male fish ranged from 0.19% to 1.38%, and females ranged from 0.15 to 1.23%; the sex

ratio of the sample fish obtained was 1.06:1. The fecundity value of the sampled fish ranged from 1.007 to 3.901. The oocyte diameter of the sample fish ranged from 1.1 to 3.9 mm. The gonadal maturity stage of the sample fish was at the developing to mature stage for males and mature to spawning for females.

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Authors' Declaration

- Conflicts of Interest: None.
- We hereby confirm that all the Figures and Tables in the manuscript are ours. Furthermore, any Figures and images, that are not ours, have been included with the necessary permission for re-publication, which is attached to the manuscript.
- The author has signed an animal welfare statement
- Ethical Clearance: The project was approved by the local ethical committee at Universitas Sriwijaya, Indralaya, Indonesia

Authors' Contribution Statement

MM in conception, design, acquisition of data, analysis, interpretation, drafting the manuscript, revision and proofreading, MS in acquisition of data, analysis interpretation, drafting the

manuscript, revision and proofreading, FHT in conception, design, acquisition of data, drafting the manuscript, revision, MIS in acquisition of data.

References

1. Kottelat M. The fishes of the inland waters of Southeast Asia: a catalogue and core bibliography of the fishes known to occur in freshwaters, mangroves and estuaries. *Raffles Bull Zool.* 2013; (27): 1–663.
2. Barby F, Ráb P, Lavoué S, Ezaz T, Bertollo L, Kilian A, et al. From chromosomes to genome: Insights into the evolutionary relationships and biogeography of old. *Genes.* 2018; 9(6): 306. <https://doi.org/10.3390/genes9060306>.
3. Lavoué S, Ghazali SZ, Jamaluddin JA, Nor SA, Zain KM. Genetic evidence for the recognition of two allopatric species of Asian bronze featherback *Notopterus notopterus* (Teleostei, Osteoglossomorpha, Notopteridae). *Zoosyst Evol.* 2020 Jan 7; 96(2): 449-54. <https://doi.org/10.3897/zse.96.51350>.
4. Hilton EJ, Lavoué S. A review of the systematic biology of fossil and living bony-tongue fishes, Osteoglossomorpha (Actinopterygii: Teleostei). *Neotrop Ichthyol.* 2018 Oct 11; 16(3): e180031. <https://doi.org/10.1590/1982-0224-20180031>.
5. Mustafa MG, Singha S, Islam MR, Mallick N. Population dynamics of *Notopterus notopterus* (Pallas, 1769) from the Kaptai reservoir of Bangladesh. *SAARC J Agricult.* 2014; 12(2): 112-22. <https://doi.org/10.3329/sja.v12i2.21920>.
6. Naeem M, Salam A, Gillani Q, Ishtiaq A. Length-weight relationships of *Notopterus notopterus* and introduced *Oreochromis niloticus* from the Indus River, southern Punjab, Pakistan. *J Appl Ichthyol.* 2010 Aug; 26(4): 620-. <https://doi.org/10.1111/j.1439-0426.2010.01480.x>.
7. Srivastava SM, Singh SP, Pandey AK. Food and feeding habits of threatened *Notopterus notopterus* in Gomti river, Lucknow (India). *J Exp Zool India.* 2012; 15(2): 395–402.
8. Kottelat M, Whitten T. Freshwater fishes of Western Indonesia and Sulawesi: additions and corrections. Hong Kong: Periplus editions; 1996. 8 pp..
9. Gustomi A, Sulistiono S, Yonvitner Y. Reproductive biology featherback (*Notopterus notopterus* Pallas, 1769) in Simpung Reservoir, Bangka Island. *Indones. J Agric Sci.* 2016; 21(1): 56-62. <https://doi.org/10.18343/jipi.21.1.56>
10. Ahmad W, Naeem M. Genetic diversity in natural population of *Notopterus notopterus* evaluated through mitochondrial DNA marker ATPase 6/8 regions and cytochrome b gene. *Mol Biol Rep.* 2022 May; 49(5): 3903-3910. <https://doi.org/10.1007/s11033-022-07240-4>.
11. Muslim M. Length-weight relationship and condition factor of *Notopterus notopterus* (Pallas, 1769) from East Pedamaran Floodplain, Ogan Komering Ilir, South Sumatra, Indonesia. *Int. J. Adv. Multidisc. Res.*

- Stud. 2023; 3(5):1227-1231.
12. Rapita R, Susiana S, Kurniawan D, Lestari F, Sabriaty D, Rianti U. Food habits of belida fish (*Notopterus notopterus*, Pallas 1769) in Sei Gesek Reservoir, Bintan Regency, Riau Island, Indonesia. IOP Conf Seri: Earth Environ Sci. 2021 Nov 1; 919: 012003. <https://doi.org/10.1088/1755-1315/919/1/012003>
 13. Muslim M, Syaifudin M. Biodiversity of freshwater fish in Kelekar Floodplain Ogan Ilir Regency in Indonesia. J Trop Biodivers Biotechnol. 2022; 7(1): 67494. <https://doi.org/10.22146/jtbb.67494> .
 14. Kaur V, Rawal YK. Length-weight relationship (LWR) in *Notopterus notopterus* (Pallas) from Sukhna Lake, Chandigarh. IOSR J Pharm Biol Sci. 2017; 12(4): 63–65. <https://doi.org/10.9790/3008-1204046365>
 15. Kaushik KK, Sahu P, Nath R. Length-weight relationship of *Notopterus notopterus* (Pallas, 1769), *Anabas testudineus* (Bloch,1792) and *Clarias batrachus* (Linnaeus, 1758) from Pokoriya River, Morigaon, Assam, India. Int J Sci Technol Res. 2019; 8(10): 3087–3088. <https://doi.org/10.2307/1540>
 16. Paul MG, Nath P, Dutta A. Length-weight relationship, relative condition factor and fecundity of *Notopterus notopterus* (Pallas, 1769) from river Brahmaputra in Dhubri, Assam, India J Fish. 2022; 10(3): 103201. <https://doi.org/10.17017/j.fish.398>
 17. Winn NA, Sandi P, Khaing T, Thi K. Length weight relationship of twelve freshwater fish species from Sunny Lake, Mandalay Region, Myanmar. Greener J Biol Sci. 2021; 11(2): 74-80.
 18. Sudarshan S, Kulkarni RS. Determination of condition factor (K) somatic condition factor (Ks) hepatic and gonado somatic indices in the fresh water fish *Notopterus Notopterus*. Int J Sci Res. 2013; 2(11): 524-6.
 19. Sukendi S, Thamrin T, Putra RM, Yulindra A. Cultivation technology of bronze featherback (*Notopterus notopterus*, Pallas 1769) at different stocking densities and types of feed. IOP Conf Seri: Earth Environ Sci.. 2020; 430(1): 012027. <https://doi.org/10.1088/1755-1315/430/1/012027>
 20. Mohanty D, Samanta L. Multivariate analysis of potential biomarkers of oxidative stress in *Notopterus notopterus* tissues from Mahanadi River as a function of concentration of heavy metals. Chemosphere. 2016 Jul 1; 155: 28-38. <https://doi.org/10.1016/j.chemosphere.2016.04.035>
 21. Srivastava SM, Gopalakrishnan A, Singh SP, Pandey AK. Embryonic and larval development of threatened bronze featherback, *Notopterus notopterus* (Pallas). J Exp Zool India. 2012; 15(2): 425–30.
 22. Achakzai WM, Saddozai S, Baloch WA, Soomro AN, Memon N. Length-weight relationship and condition factor of *Notopterus notopterus* (Pallas, 1769) from Manchar Lake Sindh, Pakistan. Sindh Univ Res Jour. 2015 Sep 15; 47(3): 515–18.
 23. Kumar KH, Kiran BR. Relative condition factor of feather back, *Notopterus Notopterus* (Pallas) from Jannapura Pond, Bhadravathi Taluk, Karnataka. Int J Sci Res Sci Eng Technol. 2016; 2(1): 36-9.
 24. Kyaw MM, Kyaw MM, Lum MR, Naing SS. Relationship of ecological factors and commercial bronze featherback fish, *Notopterus notopterus* (Pallas, 1769); Irrawaddy River, Myitkyina Segment, Kachin State, Myanmar. Mandalay University, Research Journal. 2020; 11: 98–111.
 25. Muslim M, Simanjuntak WJ. Growth and survival of bronze featherback (*Notopterus notopterus*, Pallas 1769) reared on bucket. Magna Scientia Adv Res Rev. 2023; 9(1): 101–05. <https://doi.org/10.30574/msarr.2023.9.1.0133> .
 26. Muslim M, Pitriani E, Agustina H. Growth and survival of bronze featherback (*Notopterus notopterus*) adapted on box container and aquarium. GSC adv Res Rev. 2023; 16(3): 133-37. <https://doi.org/10.30574/gscarr.2023.16.3.0368>
 27. Dinh QM, Tran NTT. Reproductive biological traits of the goby *Stigmatogobius pleurostigma* (Bleeker, 1849) from the Mekong Delta, Vietnam. J Indian Fish. 2018; 65(1): 20–25. <https://doi.org/10.21077/ijf.2018.65.1.68188-04>
 28. Parmaksız A, Oymak SA, Dogan N, Naim DM, Unlu E. Reproductive characteristics of an invasive species *Carassius gibelio* (Bloch, 1782) in Ataturk Dam Lake, Turkey. J Indian Fish. 2017 Jan 1; 64(4): 28-33. <https://doi.org/10.21077/ijf.2017.64.4.67478-04>
 29. Capasso LU, Del Re MC, Bravi SE, Taverne LP. Sexual dimorphism in a population of Pycnodontiformes of the Aptian (Lower Cretaceous) from Profeti (province of Caserta, Southern Apennines, Italy). Boll Mus Civ Stor Nat. Verona. 2021; 45: 31-41.
 30. Chacko JJ, Sekharan NM. Sexual dimorphism in structures, size and shape of the cyprinid Nilgiri melon barb. Fish Aquat Life. 2022 Sep 30; 30(3): 138-48. <https://doi.org/10.2478/aopf-2022-0013> .
 31. Ambus N, Moody EK. Size-based sexual dimorphism of nitrogen excretion in livebearing fishes. Ecol Freshw Fish. 2019 Apr; 28(2): 222-8. <https://doi.org/10.1111/eff.12445>
 32. Garcia EQ, Zuanon J. Sexual dimorphism in the electric knifefish, *Gymnorhamphichthys rondoni* (Rhamphichthyidae: Gymnotiformes). Acta Amazonica. 2019 Aug 12; 49: 213-20. <https://doi.org/10.1590/1809-4392201804392>
 33. Mainero AH, Al-Jufaili SM, Jawad L, Reichenbacher B. Sex dimorphism and evidence of sexually selected traits: A case study on the killifish *Aphaniops stoliczkanus* (Day, 1872). Acta Zoologica. 2022 Aug 21; 104: 473–87. <https://doi.org/10.1111/azo.12436>
 34. Uba KI. Sexual shape dimorphism in the monomorphic fish *Decapterus macrosoma* (Teleostei: Carangidae). Comput Ecol Softw. 2019 Dec 1; 9(4): 134-42.

35. Ueng YT, Lin FJ, Chan YS, Tsao CW, Chen MJ. Sexual dimorphism, length-weight relationships, fecundity, and diet of the striped eel catfish *Plotosus lineatus* (Plotosidae) on Taiwan's southwest coast. *Nat Resour.* 2022 Mar 22; 13(3): 77-90. <https://doi.org/10.4236/nr.2022.133006>
36. Jan M, Jan N. Studies on the fecundity (F), gonadosomatic index (GSI) and hepatosomatic index (HSI) of *Salmo trutta fario* (Brown trout) at Kokernag trout fish farm, Anantnag, Jammu and Kashmir. *Int J Fish Aquat Stud.* 2017; 5(6): 170-3.
37. Bishai HM, Ishak MM, Labib W. Fecundity of the mirror carp *Cyprinus carpio* L. at the Serow Fish Farm (Egypt). *Aquaculture.* 1974 Jan 1; 4: 257-65. [https://doi.org/10.1016/0044-8486\(74\)90038-6](https://doi.org/10.1016/0044-8486(74)90038-6)
38. Rianti U, Susiana S, Kurniawan D. Morphometric and meristic characteristics of bronze featherback (*Notopterus notopterus*, pallas 1769) in Sei Gesek Reservoir Bintan Regency. *Bawal: Widya Riset Perikanan Tangkap.* 2021 Dec 6; 13(3): 123-32. <https://dx.doi.org/10.15578/bawal.13.3.2021.123-132>
39. Mulyani I, Budijono B. Morphometric and meristic analysis of Asian knifefish (*Notopterus notopterus*) in Sail River, Pekanbaru Riau Province. *J-BEKH.* 2020 Dec 1; 7(2): 59-64. <https://doi.org/10.23960/jbekh.v7i2.156>
40. Sudarto S. Flatfish that have potential for ornamental fish. *Media Akuakultur.* 2011 Jun 30; 6(1): 59-62.
41. Muchlisin ZA. A general overview on some aspects of fish reproduction. *Aceh Int J Sci Technol.* 2014 Jan 1; 3(1):43-52. <https://doi.org/10.13170/AIJST.0301.05>
42. Chelapurath RR, Kuttanelloor R, Balakrishna MK. Reproductive biology of the endemic cyprinid fish *Hypselobarbus thomassi* (Day, 1874) from Kallada River in the Western Ghats, India. *J Appl Ichthyol.* 2020 Oct; 36(5): 604-12. <https://doi.org/10.1111/jai.14064>
43. Jewel MA, Haque MA, Ferdous MS, Khatun MS, Hasan J. Gonadosomatic index and fecundity of threatened reba carp, (Hamilton), in the Ganges River (northwest Bangladesh). *Fish Aquat Life.* 2019; 27(2): 80-5. <https://doi.org/10.2478/aopf-2019-0009>
44. Kasmi M, Hadi S, Kantun W. Reproductive biology of Indian mackerel, *Rastreliger kanagurta* (Cuvier, 1816) in Takalar coastal waters, South Sulawesi. *J Iktiologi Indones.* 2017 Oct 23; 17(3): 259-71. <https://doi.org/10.32491/jii.v17i3.364>
45. Garnayak SK, Mohanty J, Rao TV, Sahoo SK, Sahoo PK. Vitellogenin in Asian catfish, *Clarias batrachus*: Purification, partial characterization and quantification during the reproductive cycle by ELISA. *Aquaculture.* 2013 May 10; 392: 148-55. <https://doi.org/10.1016/J.aquaculture.2013.02.020>
46. Sullivan CV, Yilmaz O. Vitellogenesis and yolk proteins, fish. *Encyclopedia of reproduction.* 2018 Jan 1; 6: 266-77. <https://doi.org/10.1016/B978-0-12-809633-8.20567-0>
47. Pandit DN, Gupta ML. Hepato-somatic index, gonado-somatic index and condition factor of *Anabas testudineus* as bio-monitoring tools of nickel and chromium toxicity. *Int J Innov Eng Technol.* 2019; 12(3): 25-8. <http://dx.doi.org/10.21172/ijiet.123.05>
48. Araújo FG, Morado CN, Parente TT, Paumgarten FJ, Gomes ID. Biomarkers and bioindicators of the environmental condition using a fish species (*Pimelodus maculatus* Lacepède, 1803) in a tropical reservoir in Southeastern Brazil. *Braz J Biol.* 2017 Aug 17; 78: 351-9. <https://doi.org/10.1590/1519-6984.167209>
49. Singh S, Srivastava AK. Variations in hepatosomatic index (HSI) and gonadosomatic index (GSI) in fish *Heteropneustes fossilis* exposed to higher sub-lethal concentration to arsenic and copper. *J Ecophysiol Occup Health.* 2015 Dec 1; 15(3/4): 89-93. <https://doi.org/10.15512/joeoh/2015/v15i3-4/121589>
50. Azadi MA, Islam MA, Nasiruddin M, Quader MF. Reproductive biology of *Notopterus notopterus* (Pallas) in Kaptai reservoir, Bangladesh. *Bangladesh J Zool.* 1995; 23: 215-20.
51. Gupta S, Ray A. Review on biology and culture potential of *Notopterus notopterus* (Pallas, 1769). *Int J Aquat Biol.* 2022 Apr 1; 10(2):78-91.
52. Purushottama GB, Ramasubramanian V, Dash G, Akhilesh KV, Ramkumar S, Kizhakudan SJ, et al. Reproductive biology and diet of the grey sharpnose shark *Rhizoprionodon oligolinx* Springer, 1964 (Chondrichthyes: Carcharhinidae) from the north-eastern Arabian Sea. *J Indian Fish.* 2017; 64(4): 9-20. <https://doi.org/10.21077/ijf.2017.64.4.63379-02>

إزدواج الشكل الجنسي و بيولوجيا الإنجاب للـ *Notopterus Bronze featherback* (Pallas 1769، *notopterus*) من نهر كيليكار، أوغان إير، جنوب سومطرة، إندونيسيا

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الخلاصة

يعد ازدواج الشكل الجنسي وعلم الأحياء الإنجابي من الجوانب الأساسية لدراسات تربية الأسماك. كان الهدف من هذا البحث هو تحليل ازدواج الشكل الجنسي والبيولوجيا الإنجابية لـ *N. notopterus*. تم جمع ما مجموعه 74 *N. notopterus* من نهر كيليكار في منطقة أوغان إير، إندونيسيا، وتتكون من 38 ذكرًا (طول الجسم: 18-23.6 سم؛ وزن الجسم: 35.1-92.1 جم) و36 أنثى (طول الجسم: 19.6-26.3 سم؛ وزن الجسم: 35.1-92.1 جم) و36 أنثى (طول الجسم: 19.6-26.3 سم؛ وزن الجسم: 49.4-133.8 جم). تم تحليل سبعة عشر شخصية مورفومترية وثلاثة صفات مرسية وخمسة معايير بيولوجية إنجابية. أظهرت النتائج وجود اختلافات في الخصائص المورفومترية للذكور والإناث *N. notopterus*. ومع ذلك، لم يكن هناك اختلاف في الشخصيات المرسية. ويتراوح مؤشر الغدد التناسلية عند الذكور من 0.15 إلى 0.61%، وعند الإناث من 1.12 إلى 9.10%. تراوح المؤشر الكبدى عند الذكور من 0.19 إلى 1.38%، وتراوح عند الإناث من 0.15 إلى 1.23%، مع نسبة جنس 1:1.056، وخصوبة 1.007-3.901 بيضة، وأقطار البويضات 1.1-3.9 ملم، ومستويات النضج. من الغدد التناسلية المتطورة لتتضح عند الذكور وتتضح لوضع البيض عند الإناث. في الختام، يمكن تحديد الاختلافات بين الذكور والإناث *N. notopterus* شكليا.

الكلمات المفتاحية: اختيار الأمهات؛ تكاثر الأسماك داء البنية. الخصائص الجنسية الثانوية.