Journal of Advances in Biology & Biotechnology

Volume 28, Issue 1, Page 527-535, 2025; Article no.JABB.129771
ISSN: 2394-1081

Reproductive Potential and Ova Diameter in *Schizopyge niger* (Heckel, 1838) from Dal Lake, Kashmir, India

Ifrah Rashid [a*], Tasaduq H. Shah [a*], Farooz A. Bhat [a], Adnan Abubakr [b], Syed Talia Mushtaq [a], Bilal A. Bhat [c], Anayitullah Chesti [d] and Ahali Jahan [a]

[a] Division of Fisheries Resource Management, Faculty of Fisheries, SKUAST-K, India.
[b] Division of Aquatic Environmental Management, Faculty of Fisheries, SKUAST-K, India.
[c] Division of Agricultural Economics and Statistics, Faculty of Agriculture, SKUAST-K, India.
[d] Division of Aquaculture, Faculty of Fisheries, SKUAST-K, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/jabb/2025/v28i11906

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/129771

Original Research Article

Received: 12/11/2024
Accepted: 14/01/2025
Published: 18/01/2025

ABSTRACT

Effective conservation and broodstock management of fish populations rely on the life-history data. Fecundity is a crucial parameter in fisheries, serving as an indicator of the reproductive potential of fish populations. Understanding the fecundity of *Schizopyge niger* is vital for estimating the number

**Corresponding author: E-mail: ifra.rashid0@gmail.com, tasaduqs@gmail.com;*

Cite as: *Rashid, Ifrah, Tasaduq H. Shah, Farooz A. Bhat, Adnan Abubakr, Syed Talia Mushtaq, Bilal A. Bhat, Anayitullah Chesti, and Ahali Jahan. 2025. "Reproductive Potential and Ova Diameter in Schizopyge Niger (Heckel, 1838) from Dal Lake, Kashmir, India". Journal of Advances in Biology & Biotechnology 28 (1):527-35. https://doi.org/10.9734/jabb/2025/v28i11906.*

of offspring produced during the spawning season, a key factor in the stock assessment of species. Evaluating fecundity also plays a significant role in determining the commercial viability of the stock, understanding its life history, supporting aquaculture practices, and ensuring effective fishery management. 30 samples were collected once every month from September, 2022 to August, 2023 and yielded a total of 217 females and 143 males. A total of 20 gravid females were collected during the spawning season (February-March) from Dal lake, Kashmir and fecundity was estimated using gravimetric and actual counting methods. The absolute fecundity ranged from 6,318 to 19,375 eggs, while the relative fecundity ranged from 26.74 to 60.34 eggs per gram of body weight, with a mean of 46.96 eggs/g. A strong positive correlation was observed between fecundity and body size parameters, particularly ovary weight (R^2= 0.6601). The ova diameter during entire study period ranged from 0.21 mm to 2.66 mm, showing a unimodal distribution, which suggests that *S. niger* is an annual spawner with a single spawning event each year. These findings serve as a baseline for the conservation and broodstock management of *S. niger* in the Dal Lake, Kashmir.

Keywords: Schizopyge niger; fecundity; ova diameter; spawning.

1. INTRODUCTION

Fecundity, or reproductive potential, is a critical biological parameter essential for asessing the commercial viability of fish populations (Gomezmarquez, 2003). It is defined as the number of ripe eggs likely to be laid during a spawning season (Bagenal, 1957). Evaluating fecundity is essential for effective management of fisheries and applied aquaculture, as it helps in understanding the renewal potential of fish populations (Lagler, 1956; Tracey et al., 2007; Mohamad et al., 2024). The relationship between fecundity and factors like female size enables estimates of egg production, seasonal offspring numbers, and overall reproductive capacity (Chondar, 1977; Qasim and Qayyum, 1963). Significant variations in fecundity exist across fish species and among conspecifics of uniform size and range (Bagenal, 1957). Variations are further influenced by age, body length, gonadal weight, and genetic diversity, which shape strain-specific maturation and spawning patterns across ecological ranges (Lagler, 1956; Lone and Hussain, 2009). Environmental factors like water temperature, photoperiod, and rainfall also regulate ovarian growth and reproduction cycles (Koger et al.,1999; Huber and Bengtson, 1999; Brule et al., 2022). Fecundity estimation plays a vital role in fisheries conservation and management (Shah et al., 2018), as it forms foundation for predicting the population dynamics and developing strategies for enhancement of fish stocks.

Reproductive success is closely related to environmental changes such as temperature, day length, and food availability (Farooq et al., 2018; Bhat et al., 2010). Key demographic traits, including fecundity and gonadosomatic index (GSI), are key parameters for comprehending life history and effective conservation strategies (Shafat et al., 2016). Studies consistently demonstrate linear relationships between fecundity and parameters like fish length, weight, and ovarian metrics (Somdutt and Kumar, 2004; Joshi, 2008; Bahuguna and Khatri, 2009). Ova diameter studies offer further insights into reproductive strategies, indicating uniform ova size within individuals and linking changes in ova diameter to egg development and breeding onset (Bagenal, 1969; Kohinoor et al., 2012). The variation in ova diameter also highlight reproductive strategies and spawning periodicity, influenced by environmental factors like photoperiod, temperature, and food supply (Bromage et al., 2001). Understanding fecundity and ova development is essential for sustainable fisheries management and species conservation.

Snow trouts are believed to have been migrated from Central Asia to inhabit the lakes and streams of Kashmir. These migrations likely originated from watersheds bordered by the Hindukush and Karakoram mountain ranges, as well as the inner regions of the northwestern Himalayas and the Suleiman Ranges (Sehgal, 1999). In India, snow trouts are predominantly found in the cold waters of Jammu and Kashmir, Assam, the Eastern Himalayas, Bhutan, and Sikkim, inhabiting altitudes between 1180 and 3000 meters above sea level (Chandra et al., 2012). Among the species, *Schizopyge niger* (Heckel, 1838), commonly referred to as “Ael Gad” or “Alghad,” is native to the cold rivers and streams of Kashmir, as well as parts of Afghanistan and Pakistan.

2. METHODOLOGY

2.1 Fecundity

During the spawning season (February-March 2023), female brooders were collected from Dal Lake. Fecundity estimation was conducted on 20 gravid females. The specimens were transported to the Fisheries Resource Management (FRM) Laboratory at the Faculty of Fisheries, SKUAST-K, where total length, body weight, ovary length, and ovary weight were recorded. Fecundity was estimated using both the gravimetric and actual counting methods. The fishes were sacrificed, and their ovaries were carefully extracted. Moisture was completely removed from the ovaries using blotting paper. The ovaries were then preserved in 10% NBF (Neutral buffer formalin) for a minimum of 24 hours to harden the eggs, facilitating the accurate counting of sticky eggs. Subsequently, the eggs were dried on blotting paper for 1–2 hours. Subsamples of one gram each were taken from the anterior, middle, and posterior regions of the ovaries, and the eggs were counted using the gravimetric method. The mean egg count from the subsamples was multiplied by the weight of the ovary sections to determine the total number of eggs per gonad.

Absolute fecundity was evaluated using the following equation (Bagenal, 1978).

$$\text{Absolute fecundity} = \frac{\text{No. of ova in a subsample} \times \text{Total ovary weight(g)}}{\text{Weight of sub sample(g)}}$$

The relative fecundity (number of ova per gram of body weight) was calculated by dividing the absolute fecundity with total weight of the fish (g).

$$\text{Relative fecundity} = \frac{\text{Absolute fecundity}}{\text{Weight of fish(g)}} \text{per gram body weight}$$

2.2 Ova Diameter Measurements

Diameters of the intra-ovarian eggs from the preserved ovaries were measured after being soaked overnight in Gilson's fluid to eliminate ovarian muscles, as described by Clark (1934). The distribution of egg patterns was recorded by measuring ova diameter taken from anterior, middle and posterior part of ovary using digital vernier calipers (Trusize). The measured ova were grouped into convenient class intervals and their frequency polygons were drawn graphically. Ovaries at various maturity stages were selected as the representative samples, and 300 ova from each ovary were measured and grouped into modal categories.

2.3 Statistical Analysis

The data obtained in the research was tabulated and analyzed using standard statistical software-Microsoft Excel and SPSS for windows (version 20).

3. RESULTS AND DISCUSSION

The range, mean, and standard error of body weight, body length, ovary weight, ovary length, and fecundity are presented in Table 1. The absolute fecundity observed in this study ranged from 6,318 to 19,375 eggs, consistent with findings by Sabha et al. (2017), Hussain et al. (2018), Ali et al. (2020), Saba et al. (2021) and Rashid et al. (2024). Relative fecundity ranged from 26.74 to 60.34 eggs/g body weight, with a mean of 46.96 eggs/g, which is lower than the values reported by Yousuf et al. (1992) (53.23 eggs/g), Shafi et al. (2013) (53 eggs/g), and Shafat et al. (2016) (48.90 eggs/g). The decline in relative fecundity over the years may be attributed to deteriorating water quality in Dal Lake, which significantly impacts fecundity (Krishnani et al., 2003; Mansour et al., 2006). Positive correlations were found between fecundity and total body length, body weight, ovary weight, and ovary length in *S. niger* (Table 2). Among these, ovary weight showed the strongest correlation with fecundity (R^2 = 0.6601), followed by ovary length (R^2 = 0.5512), total body weight (R^2 = 0.5095), and total body length (R^2 = 0.5078), Figs. 1-4. Similar relationships between fecundity and body size parameters have been observed by Kestevan (1942), and others, with weight being a more significant factor than length, as emphasized by Ali and Kadir (1996). The increase in body size allows for greater egg production (Jonsson & Jonsson, 1997), a trend seen across Schizothoracids (Gandotra et al., 2009). In contrast to findings of Varghese (1961) in *Coilia ramcarati*, where egg production decreased with increasing ovary weight, this study found a positive relationship between ovary weight and egg numbers, similar to studies on *Tilapia nilotica* (Soliman et al., 1986) and *Labeo gonius* (Joshi & Khanna, 1980). This highlights ovary weight as a key determinant of fecundity in *S. niger.*

Table 1. Statistical parameters of reproductive traits of female *S. niger*

Parameters	Range	Mean	S.E
Body weight (g)	137.7-345.0	230.3	12.99
Total length (mm)	147.00-395.00	246.13	12.54
Ovary weight (g)	20.0-72.5	39.8	3.79
Ovary length (mm)	60.22-195.11	117.70	6.07
Absolute fecundity (eggs)	6318-19375	10782	841
Relative fecundity (eggs/ g body weight)	26.74-60.34	46.96	2.15

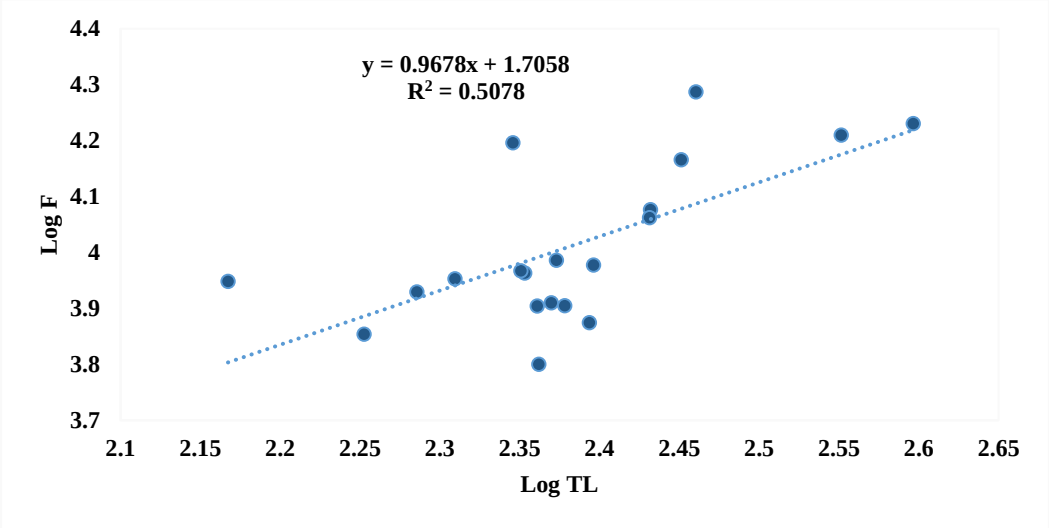

Fig. 1. Logarithmic relationship between absolute fecundity and total length of *S. niger*

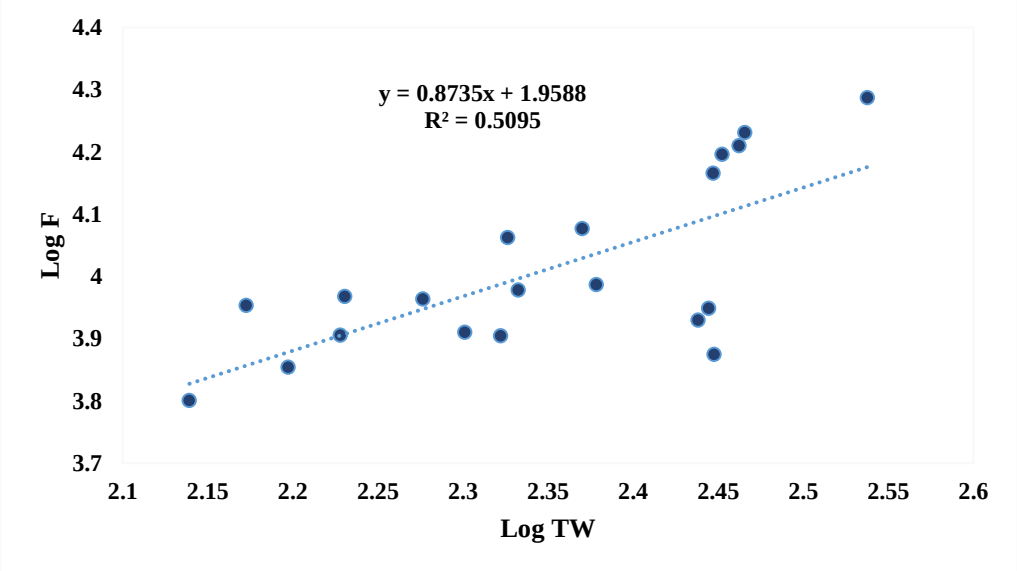

Fig. 2. Logarithmic relationship between absolute fecundity and total weight of *S. niger*

The study also identified multiple maturity stages in *S. niger,* including immature, early maturing, advanced maturing, mature, late mature, and spent stages (Table 2). Qasim (1973) proposed five maturity stages for Indian teleosts, which aligns with the observations of present study. Ova diameter in *S. niger* ranged from 0.21 mm to 2.66 mm, similar to the findings of CIFRI (1977) (0.23 mm to 2.07 mm) and Sabha et al. (2017) (0.2 mm to 2.5 mm). The unimodal distribution of

ova diameter further supports the cyclic nature of spawning in *S. niger* (Fig. 5). In this study, the smallest ova size was recorded in June (0.21 mm), and the largest in March (2.66 mm), which are consistent with findings of Sabha et al. (2017) and Jan & Ahmed (2018) for *S. niger* and *S. plagiostomus* respectively. These observations suggest that *S. niger* is an annual spawner, with a single spawning event each year, in line with findings by Sunder (1986).

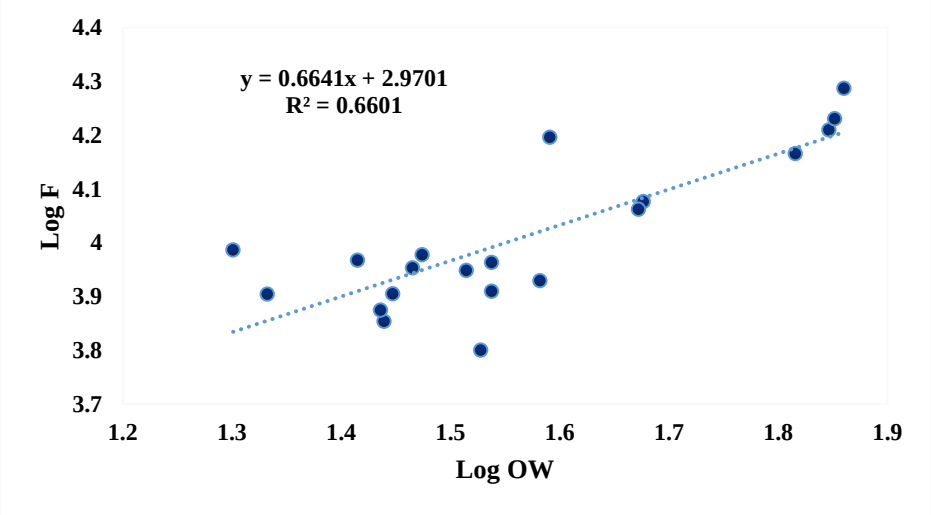

Fig. 3. Logarithmic relationship between absolute fecundity and ovary weight of *S. niger*

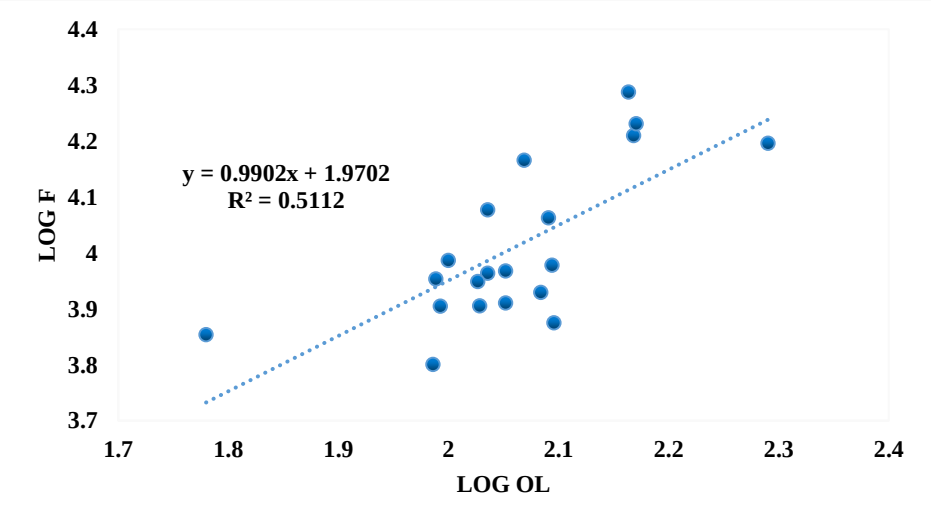

Fig. 4. Logarithmic relationship between absolute fecundity and ovary length of *S. niger*

Table 2. Statistical estimates of ova diameter of *S. niger*

Maturity stages of ovary	Number of observations	Ova diameter (mm) Mean ± S.E
Immature (I)	300	0.41± 0.00
Maturing (II)	300	0.69± 0.01
Mature (III)	300	1.23± 0.01
Ripe (IV)	300	2.01± 0.02
Spent (V)	300	1.24± 0.02

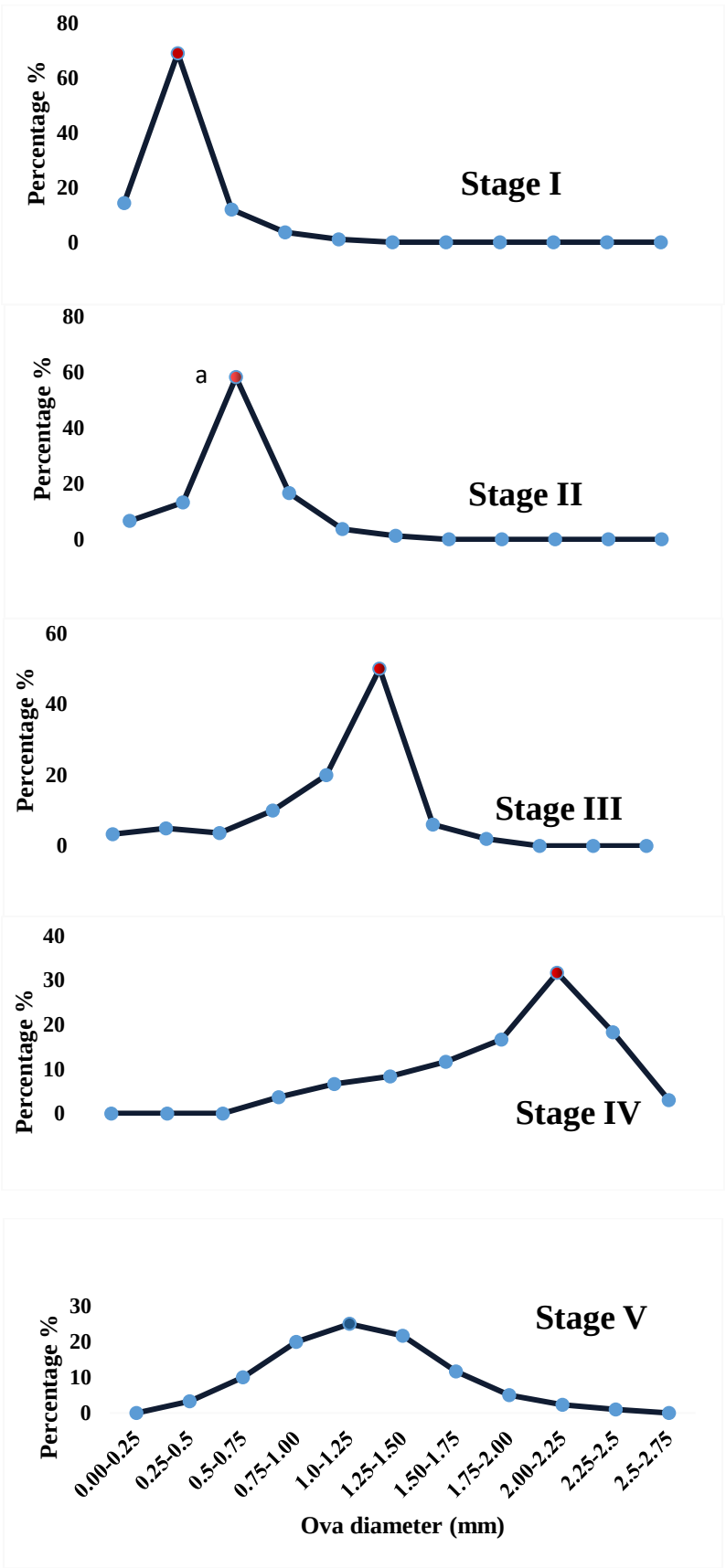

Fig. 5. Ova diameter frequency in different maturity stages of *S. niger*

4. CONCLUSION

Fecundity and ova diameter are the biological factors related to reproductive potential of fish species. Fecundity plays a vital role in aquaculture as it directly impacts the recruitment of fish into fisheries.The present study highlights the reproductive characteristics of *Schizopyge niger* from Dal Lake, Kashmir. The observed fecundity ranges and correlations with body size parameters emphasize the role of ovary weight as a primary determinant of fecundity. The decline in relative fecundity over time suggests that environmental factors, particularly deteriorating water quality, may have negatively impacted reproductive success in *S. niger*. The unimodal distribution of egg diameters confirms that *S. niger* is an annual spawner, with a single spawning event per year. These findings are crucial for developing effective conservation strategies and managing fish populations in Dal Lake, ensuring the long term sustainability of this species.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

Ali, A.B. and Kadir, B.K.A. (1996). The reproductive biology of the cyprinid, *Thynnichthys thynnoides* (Bleeker), in the Chenderoh Reservoir—a small tropical reservoir in Malaysia. *Hydrobiologia, 318:* 139-151.

Ali, S., Shah, T. H., Bhat, A., & Rashid, I. (2020). Studies on the reproductive potential of *Schizopyge niger* (Heckel, 1838) from Kashmir. *Journal of Pharmacognosy and Phytochemistry*, *9(4):*613-616.

Bagenal, T. (1978). Methods of assessment of fish production in fresh waters. IBP Handbook No. 3. Black Well Science Co. p. 365.

Bagenal, T.B. (1957). Annual variations in fish fecundity. *Journal of Marine Biological Association United Kingdom. 36:* 377-382.

Bagenal, T.B. (1969). The relationship between food supply and fecundity in brown tout *Salmo trutta* L. *Journal of Fish Biology 1:* 167–182.

Bahuguna, S.N. and Khatri, S. (2009). Studies on fecundity of hill stream Loach *Noemacheilus montanus* (McClelland) in relation to total length, total weight, ovary length and ovary weight. *Our Nature*. *7:* 116-12

Bhat, F.A., Yousuf, A.R., Balkhi, M.H., Mahdi, D. and Shah, F.A. (2010). Length-weight relationship and morphometric characteristics of Schizothorax spp. in the River Lidder of Kashmir. *Indian J. Fish. 57(2):* 73-76.

Bromage, N., Porter, M. and Randall, C. (2001). The environmental regulation of maturation in farmed finfish with special reference to the role of photoperiod and melatonin. *Aquaculture, 197(1-4),* pp.63-98.

Brulé T, Renán X, Colás-Marrufo T. (2022). Potential impact of climate change on fsh reproductive phenology: a case study in gonochoric and hermaphrodite commercially important species from the southern Gulf of Mexico. *Fishes*, *7(4):*156.

Chandra, S., Barat, A., Singh, M., Singh, B. K., & Matura, R. (2012). DNA bar-coding of Indian coldwater fishes of genus Schizothorax (family: Cyprinidae) from Western Himalaya. World. *Journal of Fish Marine Sciences, 4(4),* 430–435.

Chondar, S.L. (1977). Fecundity and its role in racial studies of *Gadusia chapra* (Pisces: Clupeidae). *The Proceedings of the Indian Academy of Sciences*. *86:* 245-254.

CIFRI. (1977). Report on Dal Lake, Srinagar, Kashmir with suggestions for development of its fishery. CIFRI, West Bengal.

Clark, F. N. (1934). Maturity of the California sardine, (*Sardinella caerulea*) determined by ova diameter measurements*. California Department of Fish and Game, 42,* 1-49.

Farooq, I., Bhat, F.A., Balkhi, M.H., Shah, T.H., Qadri, S., Aalia, S. and Talia, S. (2018). Study on gonadal maturation of *Schizothorax labiatus* McClelland inhabiting river Jhelum, kashmir. *Journal Of Coldwater Fisheries*. *1(1):* 97-102.

Gandotra, R., Shanker, R., & Singh, D. (2009). Studies on fecundity of snow trout *Shizothorax richardsonii* (Gray) from lotic bodies of Rajouri district (J&K). *Current World Environment, 4(1),* 127-131.

Gomezmarquez, J.L., Pena-Mendoza, B., Salgado-ugarte, I.H. and Guzman-arroyo,

M. (2003). Reproductive aspects of *Oreochromis niloticus* (Perciformes: Cichlidae) at Coatetelco lake, Morelos, Mexico. *International Journal of Tropical Biology. 51(1):* 221-228.

Heckel, J. J. (1838). Fische aus Caschmir Gesammelt und Herausgegeben von Carl Freiherrn v. Hügel, Beschrieben von Joh. Jacob Heckel. P. P. Mechitaristen, Wien.

Huber M and Bengtson D. (1999). Efects of photoperiod and temperature on the regulation of the onset of maturation in the estuarine fsh *Menidia beryllina* (Cope). *J Exp Mar Biol Ecol., 240(2):*285–302.

Hussain, S., Bhat, F. A., Maqsood, H. M., Baklhi, M. U.H., Majid, I., & Najar, A. M. (2018). Present status ofbreeding biology of *Schizothorax niger* in Dal LakeKashmir. *Journal of Entomology and Zoology studies*, *6(6),*930-935.

Jan, M. and Ahmed, I. (2016). Assessment of fecundity, gonadosomatic index and hepatosomatic index of snow trout, *Schizothorax plagiostomus* in river Lidder, from Kashmir Himalaya, India. *International Journal of Fisheries and Aquatic Studies*, *4(2),* pp.370-375.

Jonsson, N. & Jonsson, B. (1997). Energy allocation in polymorphic brown trout. *Functional Ecology 11:* 310–317.

Joshi, S.K. (2008). Fecundity of freshwater teleost, *Botia almorhae* (Day). *Journal of Environmental Biological Science.* 22(2): 67-171.

Kesteven, A . L. (1942). Studies on the biology of Australian mullets. Parti. Account of the fishery and preliminary statement of biology of *M. dobula* Gunther. *Coun. Sci. Industr. Res. Bull.,* No. 157, Melbourne.

Koger CS, Teh SJ, Hinton DE. (1999). Variations of light and temperature regimes and resulting efects on reproductive parameters in medaka (*Oryzias latipes*). *Biol Reprod., 61(5):*1287–93.

Kohinoor A H M, Jahan D A, Khan M M, Islam M S and Hussain M G (2012) Reproductive Biology of Feather Back, Chital (*Notopterus chita*la, Ham.) Cultured in a pond of Bangladesh. *Int. J. Agri. Res. Innov. Tech. 2,* 26-31.

Krishnani, K. K., Azad, I. S., Kailasam, M.,Thirunavukkarasu, A. R., Gupta, B. P., Joseph, K. O.,Muralidhar, M., & Abraham, M. (2003). Acute toxicity of some heavy metals to *Lates calcarifer* fry with a noteon its histopathological manifestations. *Journal of Environmental Science and Health*, *38(4),* 645–655.

Lagler, K.F. (1956). Enumeration of fish eggs. In: Freshwater Fishery Biology (Ed. W.M.C. Brown Co.) Dubque pp. 106-110.

Lone, K.P. and Hussain, A. (2009). Seasonal and age related variations in the ovaries of *Labeo rohita* (Hamilton, 1822): A detailed gross and histological study of gametogenesis, maturation and fecundity. *Pakistan Journal of Zoology. 41(3):* 217-239.

Mansour, N., McNiven, M., & Richardson, G. F. (2006). The effect of dietary supplementation with blueberry,á-tocopherol or astaxanthin on oxidative stability of Arctic char (*Salvelinus alpinus*) semen. *Theriogenology*,*66(2),* 373–82.

Mohamad, I., Bhat, F. A., Balkhi, M. H., Shahq, T. H., Bhatq, B. A., & Wali, A. (2024). Assessment of Fecundity and Its Relation with Body Parameters of Common Carp,[Cyprinus carpio (var.) communis] in Dal Lake, Kashmir. *Agricultural Science Digest*, *4(1).*

Qasim S.Z (1973) An appraisal of the studies on maturation and spawning in marine teleosts from the Indian waters. *Ind. J. Fish. 20(1 and 2),* 166-181.

Qasim, S.Z. and Qayyum, A. (1963). Fecundities of some freshwater fish. *Proceedings of the National Institute of Sciences of India,* 29: 373-382.

Rashid, I., Shah, T.H., Bhat, F.A., Abubakr, A., Bhat, B.A. and Jahan, A. (2024). Age-Dependent Enhancement in Fecundity and Ova Diameter of *Schizopyge niger* (Heckel, 1838) in Dal Lake, Kashmir: Reproductive Potential in Schizothoracids. *Fishery Technology, 61(4):*326-334.

Saba, K., Rashid, F., Amin, A., Bhat, F., Hussain, T. and Asimi, O.A. (2021). Reproductive and Breeding Biology of Snowtrout *Schizothorax niger*. Recent updates in molecular Endocrinology and Reproductive Physiology of Fish: An Imperative step in Aquaculture, pp.77-92.

Sabha, K. K., Najar, A. M., Bhat, F. A., Shah, T. H, Balkhi, M. H., & Faisal, R. (2017). Reproductive biology of (*Schizothorax niger*) snow trout in Nigeen lake Kashmir. *Journal of Experimental Zoology*, *20(1):* 623-626.

Sehgal, K. L. (1999). Coldwater fish and fisheries in the Indian Himalayas: rivers and streams. In T. Petr (Eds.), Fish and

fisheries at higher altitudes: Asia (pp. 41-63). Food and agricultural organization of the United Nations, Rome.

Shafat, S., Bhat, F.A., Balkhi, M.H., Najar, A.M., Mudasir. H. (2016). Reproductive Traits of *Schizothorax niger* Heckel, 1838 in Dal Lake, Kashmir. *SKUAST Journal of Research*. *18(2):* 138-145.

Shafi, S., Yousuf, A. R., & Parveen, M. (2013). Breeding biology and fecundity estimation of *Schizothorax niger* (Heckel, 1838) from Dal Lake, Kashmir. *International Journal of Innovative Research and Studies*, *2:* 111-123.

Shah, T. H., Chakraborty, S. K., Kumar, T., & Sadawarte, R. K. (2018). Observations on the fecundity of *Sardinella longiceps* from Ratnagiri waters off west coast of India. *Journal of Experimental Zoology India*, *21(1):*237-240.

Soliman, A.K., Jauncey, K. and Roberts, R.J. (1986). The effect of dietary ascorbic acid supplementation on hatchability, survival rate and fry performance in *Oreochromis mossambicus* (Peters). *Aquaculture*, *59(3-4):*197-208.

Somdutt, P. and Kumar, S. (2004). Studies on fecundity of *Puntius sarana* (Ham.) in relation to total length, total weight and ovary weight. *Journal of Indian Fisheries Association. 31:* 81-85.

Sunder, S. 1986. On the breeding biology of Snow trout *Schizothorax longipinnis* from river Jhelum Kashmir India. *Indian Journal of Fisheries*, *33:* 201-210.

Tracey, S.R., Lyle, J. and Haddon, M. (2007). Reproductive biology and per-recruit analyses of striped trumpeter *(Latris lineata)* from Tasmania, Australia: Implications for management. *Fisheries Research*. *84:* 358-368.

Varghese, T.J. (1961). Observation of the biology of *Raconda russeliana*. *Indian Journal of Fisheries*. *8:* 96-106.

Yousuf, A. R., & Pandit, A. K. (1992). Breeding biology of *Schizothorax niger* (Heckel). *Current Trends in Fish and Fishery Biology and Aquatic Ecology*, 55-62.

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of the publisher and/or the editor(s). This publisher and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.

© Copyright (2025): Author(s). The licensee is the journal publisher. This is an Open Access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/129771