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Reproductive Biology and Population Dynamics of the Spadenose Shark, *Scoliodon laticaudus*, from the Veraval Coast, Gujarat: Implications for Fisheries Management

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ABSTRACT

A total of 328 specimens (151 males, 177 females) were collected monthly from commercial landings from April, 2024 to March, 2025 at Veraval Fishing Harbour, Veraval coast, Gujarat, India to study the comprehensive analysis of the length-weight relationship (LWR) and reproductive biology of *S. laticaudus*. The spadenose shark, *Scoliodon laticaudus*, was a key component of elasmobranch landings in India, yet its region-specific biological data remained limited for sustainable management. The LWR revealed a negative allometric growth pattern for both sexes (pooled b=2.84, R^2>0.92), consistent with findings from other Indian populations. The overall sex ratio (1:1.17 M: F) was not significantly different from 1:1, though significant monthly fluctuations were observed. Reproductive analysis indicated a seasonal cycle with peak gonadal activity (GSI) in November and March, suggesting an extended spawning period. The Hepatosomatic Index (HSI) showed a marked pre-spawning rise in females, indicating hepatic energy storage prior to reproduction, followed by a decline during peak GSI, demonstrating a clear energy trade-off. Uterine fecundity ranged from 6 to 9 embryos female^{-1}, with a progressive increase in embryo length indicating continuous gestation. The findings confirmed that *S. laticaudus* **in Gujarat** exhibited distinct regional growth and reproductive patterns. This baseline data was crucial for developing targeted conservation and fisheries management strategies for this prolific yet vulnerable shark species.

KEYWORDS: L and W, GSI, HSI, elasmobranch, bycatch, life history, saurashtra coast

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1. INTRODUCTION

India's fisheries sector has exhibited remarkable growth over recent decades, with total fish production increasing from 0.24 mt in 1980–81 to 1.75 mt in 2022–23. India currently ranks as the world's third-largest fish producer, contributing nearly 8% of global production. Fish and fishery product exports reached 1.78 million tonnes, valued at ₹ 60,523.89 crore (approximately US$ 7.26 billion) during 2023–24, reflecting the sector's expanding role in international markets (Anonymous, 2023a). Within this national framework, Gujarat is a leading contributor to marine fish production and accounts for nearly 23% of total shark landings in India, highlighting the state's prominence in elasmobranch fisheries (Anonymous, 2024a). Elasmobranchs, comprising sharks, rays, and skates, are frequently landed as targeted catch or incidental bycatch in multispecies fisheries along the Indian coast. Despite their often-secondary status in landings, these species possess considerable economic value due to sustained demand for their meat, fins, liver oil, cartilage, and skin (Kizhakudan et al., 2015; Karnad et al., 2020). However, elasmobranchs are widely recognized as one of the most vulnerable groups of marine fishes because of their conservative life history strategies, including slow growth, late maturity, long gestation periods, and low fecundity (Dulvy et al., 2021; Pacoureau et al., 2021). These traits render them particularly susceptible to overfishing and population decline, especially in regions experiencing intense and sustained fishing pressure. Among Indian elasmobranchs, the spadenose shark *Scoliodon laticaudus* is the most abundant shark species, contributing approximately 57% of national shark landings (Anonymous, 2024b). This small, demersal shark inhabits shallow tropical and subtropical waters and is widely distributed along the Indian coastline. The species is characterized by placental viviparity and an extended reproductive cycle, features that allow year-round breeding but also impose energetic constraints on females (Compagno, 1984). Despite its apparent abundance, *S. laticaudus* exhibits biological characteristics typical of elasmobranchs, such as limited fecundity and moderate growth rates, which increase its vulnerability to overexploitation. Consequently, the species is currently listed as Near Threatened on the IUCN Red List (Dulvy et al., 2021). Effective management and conservation of such vulnerable yet economically important species require robust, region-specific biological information. The length-weight relationship (LWR) is a fundamental parameter used to estimate biomass, assess condition, and model growth dynamics in exploited fish populations (Beyer, 1987; Froese, 2006). Reproductive indices such as the Gonadosomatic Index (GSI) and Hepatosomatic Index (HSI) provide valuable insights into reproductive periodicity, maturity cycles, and patterns of energy allocation between somatic maintenance and reproduction (Dadzie and Wangila, 1980; Guy and Brown, 2007). Additionally, studies on feeding ecology and trophic interactions enhance understanding of habitat use and ecological roles within coastal ecosystems (Gerking, 1994; Wootton, 1998). Recent studies have emphasized the importance of localized biological assessments for elasmobranch management, as growth and reproductive parameters often vary significantly across regions (Jabado et al., 2018; Raje et al., 2020; Sen et al., 2021; Akhilesh et al., 2023; Anonymous, 2023b). In this context, the Veraval coast of Gujarat represents a critical area due to its high fishing intensity and substantial contribution to shark landings. However, comprehensive, region-specific data on the growth and reproductive biology of *S. laticaudus* from this area remain limited. Therefore, the present study was undertaken to generate baseline information on the length-weight relationship and reproductive biology of *S. laticaudus* from the Veraval coast, with the aim of supporting science-based, sustainable management and conservation strategies for this species in Gujarat.

2. MATERIALS AND METHODS

2.1. Study area and specimen collection

Specimens of the spadenose shark, *Scoliodon laticaudus* (n=328), were collected monthly over twelve consecutive months from April 2024 to March 2025. Sampling was conducted at Veraval Fishing Harbour (20°54'55.1"N, 70°21'21.4"E), a major fish landing centre on the Saurashtra coast in Gujarat, northwestern India. Samples were procured directly from the commercial landings of mechanized trawlers and gillnetters, the primary fishing gears responsible for shark catches in this region. Immediately upon landing, a representative, randomly selected subsample of the catch was obtained for subsequent biological analysis.

2.2. Biological measurements and laboratory processing

Following collection, each specimen was transported on ice to the laboratory to preserve tissue integrity. For every individual, the Total Length (TL) was measured from the tip of the snout to the posterior edge of the caudal fin to the nearest 1.0 mm, and the Total Body Weight (W) was recorded to the nearest 0.1 g. A ventral incision was made to expose the visceral cavity. Sex was determined macroscopically based on the presence or absence of claspers. The gonads, liver, and uterus were then carefully excised for further examination to determine sex, assess reproductive status.

2.3. Length-weight relationship analysis

The total length (TL) of each specimen was measured to the nearest 0.1 mm, and the body weight (BW) was recorded to the nearest gram. The length-weight relationship (LWR) was determined using the allometric equation established by Le Cren (1951):

$W = aL^b$

This equation was linearized for parameter estimation as:

$\log W = \log a + b \log L$

where W was the total body weight (g), L was the total length (mm), a was the intercept (condition factor), and b was the slope (allometric coefficient).

A one-way Analysis of Variance (ANOVA) was employed to test for significant differences in the LWR between male and female specimens. Furthermore, a Student's t-test was conducted to determine if the estimated growth coefficient (b) deviated significantly from the theoretical isometric growth value of 3.

2.4. Reproductive biology

*2.4.1. Gonadosomatic index (GSI)*The reproductive cycle was assessed monthly using the Gonadosomatic Index (GSI), a standard metric for evaluating gonad maturation and identifying spawning periods (Le Cren, 1951). The GSI was calculated for each specimen using the formula:

GSI=(Gonad Weight/Total Body Weight)×100

Temporal trends in reproductive activity were analyzed by plotting mean monthly GSI values to identify peak periods, indicative of the spawning season.

2.4.2. Sex ratio

Statistical differences in GSI across months were tested using the Chi-square method (Narasimham, 1994).

2.4.3. Hepatosomatic index (HSI)

The Hepatosomatic Index (HSI) was calculated to assess the relative liver size as a proxy for energy storage and mobilization related to reproductive cycles (Wingfield and Grimm, 1977). The index was determined using the formula:

HSI = (Liver weight/Total body weight)×100

2.4.4. Fecundity analysis

Uterine fecundity was determined by directly counting the number of embryos present in the uterus of gravid females. Embryo length was also measured to assess developmental stages, following the methodology of Sen et al. (2018).

2.5. Statistical analysis

All morphometric and biological data were systematically recorded and processed using Microsoft Excel. Subsequent statistical analyses followed standard procedures as outlined by Snedecor and Cochran (2014). The key parameters analyzed included total length (TL), total body weight (BW), sex, gonad weight, liver weight, and the number of embryos for fecundity assessment.

3. RESULTS AND DISCUSSION

3.1. Length-weight relationship (LWR)

A total of 328 *Scoliodon laticaudus* specimens (151 males, 177 females) ranging from 330.0–650.0 mm in total length and 153–882 g in body weight were analyzed. The length-weight relationship was described by the following equations, Pooled: $W=aL^b$, with a regression coefficient (b) of 2.84 (R^2=0.94); Males: b=2.79 (R^2=0.93); Females: b=2.87 (R^2=0.92) as in (Figure 1). A t-test confirmed that

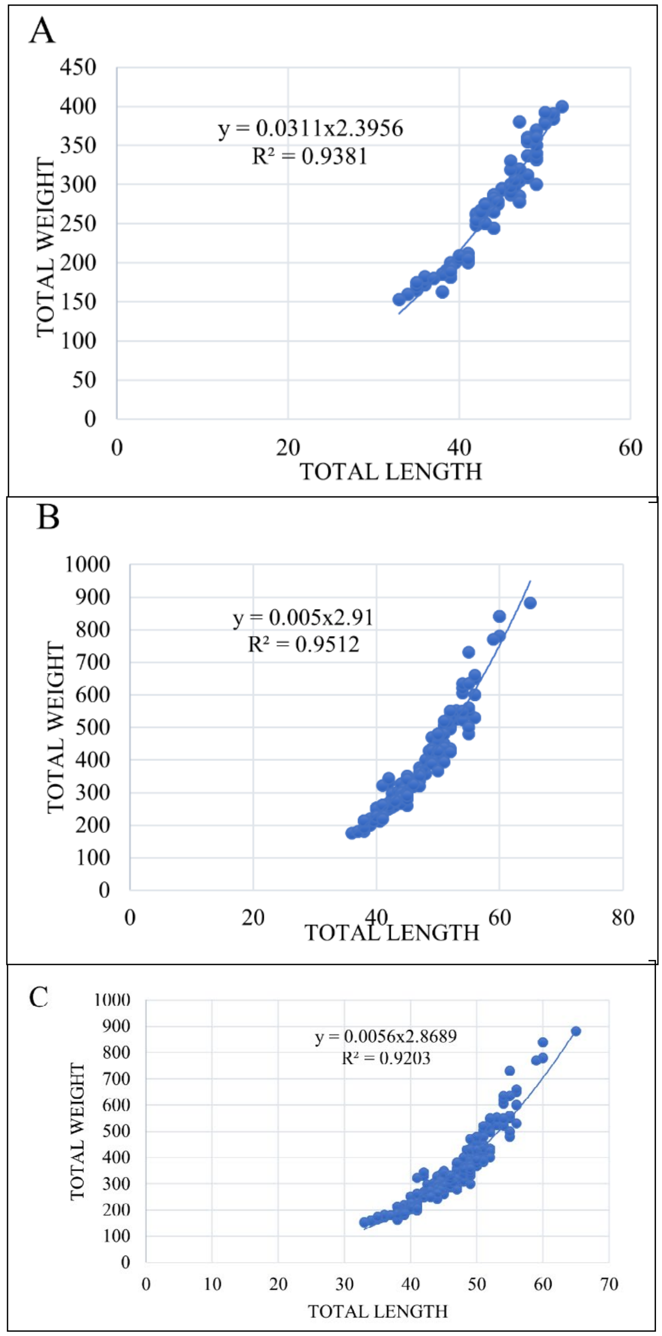

Figure 1: Length-weight relationships of *Scoliodon laticaudus* from Veraval coast: (A) males (n=151), (B) females (n=177), and (C) pooled data (n=328). The allometric equation ($W = aL^b$) and coefficient of determination (R^2) are shown for each group

all b values were significantly less than 3 (p<0.05). Monthly mean total length varied between 440.0 and 490.0 mm, and monthly mean weight ranged from 280.0 to 402.0 g (Table 1).

Table 1: Length-Weight Relationship parameters for Scoliodon laticaudus from Veraval coast, Gujarat

Group	a	b	R^2	Log W=log a+b log L
	0.0311	2.396	0.938	Log W = −1.638+2.418 Log L
Female	0.0050	2.910	0.951	Log W = −1.664+2.546 Log L
Pooled	0.0056	2.869	0.920	Log W = −1.652+2.487 Log L

W: Total body weight (g); L: Total length (cm); a: Intercept; b: Allometric coefficient

The present study provided comprehensive baseline data on the population structure and reproductive biology of *Scoliodon laticaudus* from the Veraval coast, crucial for its management. The regression coefficient (b) was significantly less than 3 for all groups, indicating a consistent pattern of negative allometric growth. This finding aligned with studies across the species' Indian distribution (Fofandi et al., 2013; Sen et al., 2018; Thomas et al., 2020), suggesting a species-level growth pattern. The monthly variations in mean length and weight, coupled with the high R^2 values (>0.92), confirm a robust length-weight relationship and suggested temporal fluctuations in growth and recruitment, validating the LWR as a reliable tool for stock assessment in this region.

3.2. Sex ratio

The overall sex ratio for *S. laticaudus* was 1:1.17 (M:F), with 151 males and 177 females captured. A chi-square test (χ^2=2.06, p> 0.05) indicated this female bias was not statistically significant. However, significant monthly deviations were observed: females dominated significantly in October 2024 (1:2.09, χ^2=4.23) and March 2025 (1:2.10, χ^2=3.90), while males were significantly more abundant in November 2024 (1:0.50, χ^2 =3.66) as in (Figure 3).

The overall sex ratio of 1:1.17 (M:F) showed a non-significant female bias, consistent with findings from other regions of India (Sen et al., 2018; Fofandi et al., 2013). The significant monthly deviations, with female dominance in October and March and male dominance in November, likely reflect seasonal reproductive movements and habitat segregation related to breeding and parturition, a pattern also noted by Thomas et al. (2020

3.3. Gonadosomatic index (GSI) and hepatosomatic index (HSI)

The GSI exhibited distinct monthly variation. Peak gonadal activity was observed in March, 2025 (GSI: 2.65) and November, 2024 (GSI: 2.53), with elevated values generally sustained from October to April. The lowest GSI values were recorded in May, August, and February. Females generally exhibited higher GSI values than males as in (Figure 2).

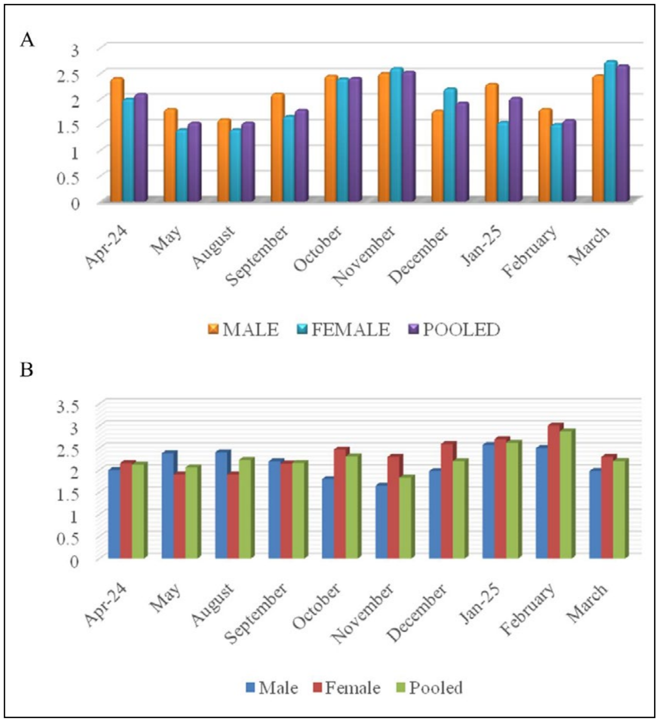

Figure 2: Monthly variations in (A) gonadosomatic index (GSI) and (B) hepatosomatic index (HSI) of *Scoliodon laticaudus* from April, 2024 to March, 2025. Values represent mean±SD

Monthly HSI trends revealed sex-specific patterns. Male HSI remained relatively stable, ranging from 1.65 to 2.57. Female HSI showed greater fluctuation, increasing from a low of 1.90 in May to a peak of 3.01 in February. The pooled HSI was lowest in November (1.83), peaked in February (2.88), and declined in March as in (Figure 2).

The clear seasonal pattern in GSI, with peaks in November and March and elevated activity from October to April, indicated an extended spawning period for *S. laticaudus*. The low GSI values in mid-year months suggested a post-spawning recovery phase. These results were largely consistent with the biannual peak breeding activity reported by Sen et al. (2018). The sex-specific HSI trends, particularly the marked pre-spawning rise in female HSI peaking in February, suggested a strategy of enhanced hepatic energy storage to support vitellogenesis and embryo development. The subsequent decline in HSI coinciding with peak GSI demonstrated a clear energy shift from somatic reserves to reproductive investment, as documented by Sen et al.

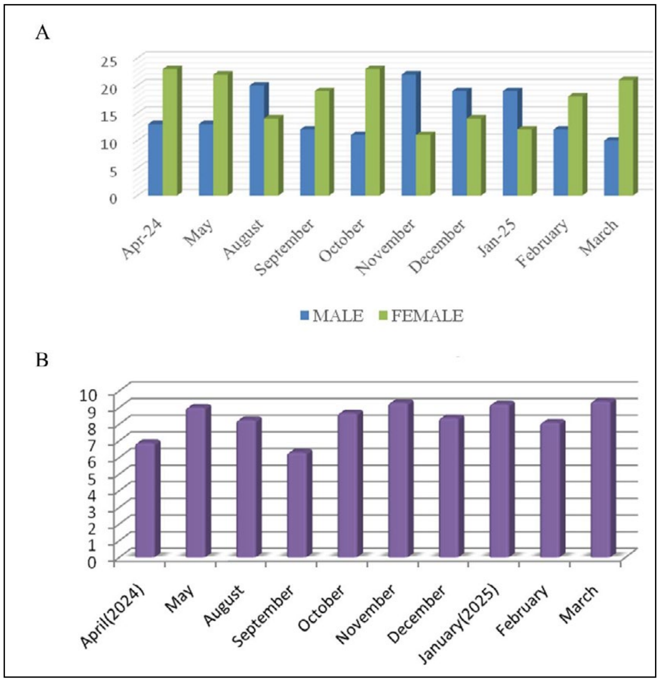

Figure 3: Monthly variations in reproductive parameters of *Scoliodon laticaudus*: (A) Sex ratio, and (B) number of embryos per female (mean±SD)

(2018). The differing HSI cycles reported in congeneric species (Zhao et al., 2022) underscored the region-specific nature of these physiological cycles.

3.4. Uterine fecundity

Uterine fecundity showed clear temporal variation. The mean number of embryos per female was highest in March (9.4), November (9.3), and May (9.0), and lowest in September (6.3). Embryo length increased progressively from a minimum in December (3.7 cm) to a maximum in August (14.0 cm). The number of pregnant females peaked in January (n=10), May (n=11), and February (n=9) as in (Figure 3).

The observed uterine fecundity (6–9 embryos/female) was lower than ranges reported in previous studies (Thomas et al., 2020; Sen et al., 2018). These disparities, along with differences in the timing of peak pregnancy, likely reflected regional variations in environmental conditions, maternal size, and resource availability, highlighting population-specific reproductive investment. The progressive increase in embryo length from December to August indicated a continuous gestation period, with parturition likely occurring around August-September, as inferred from the low number of pregnant females during this period.

4. CONCLUSION

Scoliodon laticaudus from the Veraval coast exhibited consistent negative allometric growth and a region-specific reproductive strategy. An extended spawning season, distinct energy allocation between liver and gonads, variable fecundity, and fluctuating sex ratios reflected adaptation to local environmental conditions and fishing pressure. The findings highlighted significant regional variability, emphasizing the need for science-based, location-specific management strategies to ensure sustainable exploitation of this species.

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6. REFERENCES

Akhilesh, K.V., Kizhakudan, S.J., Muktha, M., Najmudeen, T.M., Thomas, S., Karnad, D., Gopalakrishnan, A., 2023. Elasmobranch conservation, challenges and management strategy in India: recommendations from a national consultative meeting. Current Science 124(3), 292–303. https://doi.org/10.18520/cs/v124/i3/292-303.

Anonymous, 2023. Annual report 2022–23. CMFRI, Kochi, India. Available from: 30 Nov 2023. Accessed on: 14 November 2025. https://eprints.cmfri.org.in/17732/.

Anonymous, 2023. Handbook on fisheries statistics 2023. Ministry of Fisheries, Animal Husbandry & Dairying, Government of India. Retrieved from: https://dof.gov.in/sites/default/files/2024-06/Handbook.pdf. Retrieved on: 14 November 2025.

Anonymous, 2024a. Marine fish landings in India 2023. CMFRI, Kochi, India. Available from: https://eprints.cmfri.org.in/18344/. Accessed on: 14 November 2025.

Anonymous, 2024b. Marine fish landings in India-2023 (Technical Report). Kochi, India. Available from: https://eprints.cmfri.org.in/18344/1/Marine%20Fish%20Landings%20in%20India_2023.pdf. Accessed on: 14 November 2025.

Beyer, J.E., 1987. On length-weight relationships: Computing the mean weight of the fish of a given length class. Fishbyte 5(2), 11–13. Available from: https://hdl.handle.net/20.500.12348/3367.

Compagno, L.J.V., 1984. Sharks of the world: An annotated and illustrated catalogue of shark species known to date. Part 2 (Carcharhiniformes). FAO Fisheries Synopsis 125(4/2), 251–655. Available from: https://www.fao.org/4/ad123e/ad123e00.htm.

Dadzie, S., Wangila, B.C.C., 1980. Reproductive biology, length-weight relationship and relative condition of pond raised *Tilapia zillii* (Gervais). Journal of Fish Biology 17(2), 237–242. https://doi.

org/10.1111/j.1095-8649.1980.tb02757.x
Dulvy, N.K., Simpfendorfer, C.A., Akhilesh, K.V., Derrick, D., Elhassan, I., Fernando, D., VanderWright, W.J.,2021. *Scoliodon laticaudus*. The IUCN Red List of Threatened Species 2021. DOI: 10.2305/IUCN.UK.2024-1.RLTS.T161677A254715330.en.
Fofandi, M., Zala, M.S., Koya, M., 2013. Observations on selected biological aspects of the spadenose shark (*Scoliodon laticaudus* Müller and Henle, 1838), landed along the Saurashtra coast. Indian Journal of Fisheries 60(1), 51–54. Available from: https://eprints.cmfri.org.in/9363/
Froese, R., 2006. Cube law, condition factor and weight–length relationships: history, meta-analysis and recommendations. Journal of Applied Ichthyology 22(4), 241–253. https://doi.org/10.1111/j.1439-0426.2006.00805.x.
Gerking, S.D., 1994. Feeding Ecology of Fish. Academic Press, San Diego, CA.pp 84. Available from: https://www.scirp.org/reference/referencespapers?referenceid=785088.
Guy, C.S., Brown, M.L., 2007. Analysis and interpretation of freshwater fisheries data. American Fisheries Society. Available from: https://fisheries.org/bookstore/all-titles/professional-and-trade/55049c/.
Jabado, R.W., 2018. The fate of the most threatened order of elasmobranchs: Shark-like batoids (*Rhinopristiformes*). Fish and Fisheries 19(3), 475–493. https://doi.org/10.1016/j.fishres.2018.03.022
Karnad, D., Sutaria, D., Jabado, R.W., 2020. Local drivers of declining shark fisheries in India. Ambio 49(2), 616–627. https://doi.org/10.1007/s13280-019-01203-z.
Kizhakudan, S.J., Zacharia, P.U., Thomas, S., Vivekanandan, E., Menon, M., 2015. Guidance on national plan of action for sharks in India (CMFRI Marine Fisheries Policy Series No. 2). ICAR-Central Marine Fisheries Research Institute. Available from: https://eprints.cmfri.org.in/10403/.
Le Cren, E.D., 1951. The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Percafluviatilis*). Journal of Animal Ecology 20(2), 201–219. http://dx.doi.org/10.2307/1540.
Narasimham, K.A., 1994. Mortality, spawning and sex ratio of the ribbonfish *Trichiurus lepturus* Linnaeus off Kakinada. Journal of the Marine Biological Association of India 36(1and 2), 199–204. Available from: https://eprints.cmfri.org.in/750/.
Pacoureau, N., 2021. Half a century of global decline in oceanic sharks and rays. Nature 589, 567–571. https://doi.org/10.1038/s41586-020-03173-9.
Sen, S., Chakraborty, S.K., Zacharia, P.U., Dash, G., Kizhakudan, S.J., Bharadiya, S.A., Gohel, J.K., 2018. Reproductive strategy of spadenose shark (*Scoliodon laticaudus* Müller andHenle, 1839) along the north-eastern Arabian Sea. Journal of Applied Ichthyology 34(6), 1304–1313. https://doi.org/10.1111/jai.13794.
Snedecor, G.W., Cochran, W.G., 2014. Statistical Methods (8thEdn.).Wiley-Blackwell. Available from: https://www.wiley.com/en-us/Statistical+Methods%2C+8th+Edition-p-9780813815619.
Thomas, S., Purushottama, G.B., Nataraja, G.D., Kizhakudan, S.J., 2020. Fishery and biological characteristics of the spadenose shark (*Scoliodonlaticaudus* Müller and Henle, 1838) from the Eastern Arabian Sea. Regional Studies in Marine Science 34, 101085. https://doi.org/10.1016/j.rsma.2020.101085.
Wingfield, J.C., Grimm, A.S., 1977. Seasonal changes in plasma cortisol, testosterone and oestradiol-17β in the plaice, *Pleuronectes platessa* L. General and Comparative Endocrinology 31(1), 1–11. https://doi.org/10.1016/0016-6480(77)90184-8.
Wootton, R.J., 1998. Ecology of teleost fishes (2nd Edn.). Kluwer Academic Publishers. Available from: https://www.scirp.org/reference/referencespapers?referenceid=1969921.
Zhao, Y., Jiang, C., Ju, P., Xiao, J., Chen, M., 2022. Reproductive biology of the Pacific spadenose shark *Scoliodon macrorhynchos*, a heavily exploited species in the Southern Taiwan Strait. Marine and Coastal Fisheries 14(4), e10216. https://doi.org/10.1002/mcf2.10216.