International Journal of Veterinary Sciences and Animal Husbandry

ISSN: 2456-2912
VET 2024; 9(2): 593-599

www.veterinarypaper.com
Received: 02-01-2024
Accepted: 06-02-2024

Aadil Hussain Magloo
Faculty of Fisheries, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Rangil, Ganderbal, Jammu & Kashmir, India

Farooz Ahmad Bhat
Faculty of Fisheries, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Rangil, Ganderbal, Jammu & Kashmir, India

Tasaduq Hussain Shah
Faculty of Fisheries, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Rangil, Ganderbal, Jammu & Kashmir, India

Bilal Ahmad Bhat
Faculty of Fisheries, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Rangil, Ganderbal, Jammu & Kashmir, India

Ashwani Kumar
Faculty of Fisheries, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Rangil, Ganderbal, Jammu & Kashmir, India

Rinkesh N Wanjari
Faculty of Fisheries, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Rangil, Ganderbal, Jammu & Kashmir, India

Corresponding Author:
Aadil Hussain Magloo
Faculty of Fisheries, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Rangil, Ganderbal, Jammu & Kashmir, India

Sex ratio and condition factor of *Schizothorax plagiostomus* in Kashmir Himalaya

Aadil Hussain Magloo, Farooz Ahmad Bhat, Tasaduq Hussain Shah, Bilal Ahmad Bhat, Ashwani Kumar and Rinkesh N Wanjari

Abstract
This research focuses on evaluating the sex ratio and condition factor of *Schizothorax plagiostomus*, a significant fish species in the Kashmir Himalaya valley. The study involved the systematic collection of fish specimens on a monthly basis, spanning a duration of 12 months from September 2021 to September 2022. By analyzing the sex ratio, the research aims to provide insights into the gender distribution of *S. plagiostomus*, crucial for effective fisheries management. Additionally, the assessment of the condition factor during this period contributes to understanding the species' physiological well-being and reproductive dynamics. This comprehensive study not only contributes to the scientific understanding of the Kashmir Valley's ichthyofauna but also offers practical insights for managing and conserving *S. plagiostomus*. By bridging ecological and socio-economic considerations, the research aids in making informed decisions for the sustainable coexistence of indigenous fish species in this unique and biodiverse region.

Keywords: *Schizothorax plagiostomus*, sex ratio, condition factor, Himalaya

Introduction
India ranks eighth globally and third in Asia in terms of freshwater fish species, boasting a total of 788. Of these, more than one-fourth are classified as either vulnerable or endangered, according to research by Kottelat and Whitten (1996) [26] and Gopi and Mishra (2015) [18]. Located in the lap of Indian Himalaya, at the altitude of 5,200 feet above sea level, Kashmir valley harbour a rich fish biodiversity of 23 species (Bhat *et al*., 2020) [10]. The valley maintains a predominantly temperate climate due to its high altitude. It is blessed with a complex network of rivers, streams, and natural springs. These water bodies are teeming with rich biodiversity of fish. The first notable work related to ichthyofauna of Kashmir was presented by Heckel, (1838) [20]. In the last century, many scholars from time to time contributed to the research related to the fisheries of the Kashmir valley. The notable contributions include the works from authors such as Day (1878), Das and Subla (1970) [23], Yousuf (1996) [49], Kullander *et al.* (1999) [27], Balkhi (2007) [7]. A more recent work that likely offers contemporary insights into the ichthyofauna in the Kashmir valley is that of Bhat *et al.* (2020) [10]. The Kashmir Valley is richly endowed with abundant water resources in the form of lakes, wetlands, streams, and rivers. These water bodies, owing to their unique natural conditions, serve as key hubs for cold water fisheries. 44 species of fish have been reported in Kashmir valley (Yousuf, 1996; Balkhi, 2007) [49, 7] but presently not more than 23 species are available (Bhat *et al*., 2010) [8]. Among the documented fish species, 14 are indigenous to the region. These indigenous species include Schizothracines and Schizothoracthies, which are not only unique to the valley but also form a significant part of the commercial catch for local fishers. *Schizothorax plagiostomus*, is known by several common names, including snow trout, snow barble, snow carp, and Swati fish. These names are used to refer to the same species in different contexts. In the local or regional context, *S. plagiostomus* is known as "Khont.". This is the name by which people in Kashmir refer to this fish. *S. plagiostomus* is highly regarded for its nutritional value. It is widely regarded as one of the most valuable and suitable fish for enhancing nutritional status, indicating its importance as a vital source of essential nutrients. Among the seven species of snow trouts found in the Indian Himalayas, *S. plagiostomus* ranks

second in terms of protein content. The first position in terms of protein content is held by another species, *S. labiatus* (Joshi *et al*., 2018) [23]. The ichthyofauna of Kashmir has been classified into three distinct groups: species of central Asiatic origin, those of Indian origin, and exotic species introduced in the recent past (Das and Subla, 1963) [12]. The important fish species, which exist today in the waters of J&K are: *Cyprinus carpio* var. *conummunnis* (Punjabi Gad), *Cyprinus carpio* var. *specularis* (Parim Gad), *Carassius carassius* (Ganga), *Schizothorax esocinus* (Churu), *Schizothorax labiatus* (Chaush), *Schizothorax curvifrons* (Satter Gad), *Schizothorax plagiostomus* (Khont), *Schizothorax niger* (Ale Gad), *Bangana diplostoma* (Roput), *Crossochielus diplochilus* (Tethur) *Puntius conchonius, Glyptothorax kashmirensis, Glyptothorax pectinopterus, Glyptosternon reticulatum, Triplophysa kashmirensis, T. marmorata* (Kullandar *et al*., 1999; Bhat *et al*., 2013; Bhat *et al*., 2020) [27, 9, 10].

The mountain range that extends from the Hindu Kush region through the Pamir, Karakoram, and Himalayas is primarily used for subsistence and recreational/sport fishing, with commercial fishing being limited to a small number of lakes and reservoirs (Petr and Swar, 2002) [33]. This range runs through six countries, namely Nepal, Bhutan, Pakistan, India, Afghanistan, and China. The majority of native fish found in streams and rivers belong to the Schizothoracinae subfamily of the Cyprinidae family. This subfamily encompasses snow trout (*Schizothorax* spp.) and other significant genera crucial for fisheries. Schizothoracines are native to the Himalayan and sub-Himalayan regions of the Indian subcontinent, Afghanistan, Central Asia, Kazakhstan, China, and Burma. They inhabit rivers, streams, and lakes up to 3,323 meters in Nepal, with water temperatures ranging from 8 to 22 °C, as documented by Petr and Swar (2002) [33]. Within the Himalayan and sub-Himalayan regions, including China and Pakistan, there exist 28 distinct species of snow trout, as reported by Sharma (1989) [41]. Currently, there are 65 recognized species of the genus Schizothorax under the family Cyprinidae worldwide. However, as per the report of FishBase (2023), 62 species of this genus are present. The subfamily Schizothoracinae is mainly distributed in Central Asia, with a few species found in the southern face of the Himalayas. The distribution of this subfamily may be due to the origin of several major rivers, such as the Sutlej, Indus, and Brahmaputra, which allowed people to travel to lower levels (Rai, 2002) [36]. Snow trout can be found in frigid waters from Jammu and Kashmir to Nainital in the Tran-Himalaya region of India. In Jammu and Kashmir's upland waterways, *S. plagiostomus* (McClelland) is an important indigenous fishery, accounting for 10–20% of all commercial landings (Raina *et al*., 1985) [37]. *S. plagiostomus* can be found between 1,180 and 3,000 meters in height, ranging from Assam to the eastern Himalayas, through Bhutan and Sikkim (Jhingran, 1982) [21]. Snow trout, scientifically known as Schizothorax richardsonii, holds significant importance as an indigenous coldwater species, alternatively referred to as asaila or mountain barbel. It is extensively distributed in India, spanning the entire Himalayan region from Jammu & Kashmir to Uttarakhand, Assam, Sikkim, Nagaland, and Bhutan, within an elevation range of 300 to 2810 meters above sea level. The Kashmir floodplain lakes, including Wular, Dal, and Manasbal, situated in the Kashmir Valley, are positioned at altitudes ranging from 1,537 to 1,587 meters. The major fish group found in these lakes is the Schizothoracines, which include several species such as *S. niger, S. micropogon, S. curvifronis, S. planifrons,* and *S. esocinus*. Other species, such as *Labeo dero, L. dyocheilus, Puntius conchonicus, Crossocheilus latus,* and *Glyptothorax kashmiriensis*, have also been caught (Qadri *et al*., 2018) [34]. Schizothoracines are highly prized fish and are favored over many other fish species. Schizothoracines are typically found in cold regions, particularly in localities with snow-fed rivers that often lead to lakes and have evolved specialized adaptations for life in hill streams. In Kashmir, Snow trout, locally known as Alegad (*Schizothorax niger*), can be found in both standing and flowing water bodies throughout the Valley. Schizothoracines are highly prized fish, preferred over most other fish species. The region boasts five native species of snow trout: *Schizothorax esocinus* (Chirru), *S. curvifrons* (Satter gad), *S. niger* (Ael gaad), *S. plageostomus* (khont), and *S. labiatus* (Chhush) (Bhat *et al*., 2020) [10]. The indigenous schizothoracines, or snow trouts, are highly favored by local communities due to their nutritional value and delectable taste, commanding high prices in the market (Singh and Paul, 2010) [42]. Schizothoracids contribute significantly, comprising 15-25% of the total fish catches in Kashmir. However, the introduction of exotic species for commercial purposes has led to a loss of diversity. The introduction of the exotic common carp, *Cyprinus carpio* L., in 1956 resulted in a dramatic decline in population and nearly wiped out the Schizothoracine fishes in the Kashmir valley (Zutshi and Gopal, 2000) [50]. In Kashmir, the fish catch is predominantly common carp in lakes and schizothoracids in riverine water bodies (Yousuf, 1996; Balkhi, 2007; Bhat *et al*., 2010) [49, 7, 8]. Schizothorax, the indigenous cyprinid, dominates the turbulent mountain streams of the Himalayas and Central Asia, inhabiting both flowing and still water bodies of Kashmir (Sehgal, 1999) [38]. Heckel (1838) [20] while documenting fish fauna from Kashmir valley, described a Freshwater, benthopelagic fish *S. plagiostomus*. It is a species of ray-finned fish in the genus *Schizothorax*. Locally known as Khont, snow carp, Swati fish, snow barbel, and snow trout, *S. plagiostomus* possesses a streamlined and somewhat cylindrical body. This body shape is well-suited for swimming in flowing water. The fish has a projecting snout, which is a distinctive feature. The mouth is positioned on the lower side of the head. It is wide, and the lower jaw is pappilose meaning it has papillae or small fleshy projections. This mouth structure is adapted for scraping on the algal mats attached to stones. The fish feed on detritus material, which includes decaying organic matter and small food particles in the substrate of water bodies. The detritivorous feeding strategy is common is *Schixothorax* species. The species is widely distributed across various rivers, streams, and tributaries throughout the Himalayan regions, spanning from China, Afghanistan, Nepal, Pakistan, Ladakh, Tibet, North East India, to Bhutan (Kullander *et al*., 1999) [27]. It is considered one of the most valuable and suitable fish for enhancing nutritional status and improving dietary quality. The fish breeds in streams. This is a common reproductive strategy for many fish species, as streams often provide suitable conditions for egg laying, fertilization, and early development of the offspring. It would be more specific if we say it is one of the potamodromous fish species. The population of Schizothorax has thus far maintained a satisfactory conservation status according to conservation lists, but in the water bodies of Jammu and Kashmir, they are experiencing a decline due to factors such as habitat destruction, overfishing, competition for food and breeding grounds with exotic carps, and the absence of captive breeding facilities or artificial breeding programs (Akhtar *et*

al., 2014) [2]. Sex ratio data are fundamental for assessing reproductive capacity and estimating the stock size of fish populations (Stratoudakis *et al*., 2006) [44]. The length-weight relationship is invaluable for estimating weight when only length measurements are available, providing insights into the fish's condition and enabling comparisons of relationship parameters among species from different regions (Oscoz *et al*., 2005) [30].

The main objective of this study was to examine the sex ratio and condition factor of *S. plagiostomus* in the Kashmir Himalaya Valley. These measurements are essential for effective fisheries management, enabling the establishment of sustainable fishing quotas to prevent overfishing and safeguard fish stocks. A comprehensive understanding of these parameters is crucial for informed fisheries management practices (Pauly, 1980; Pauly and Munro, 1984) [32, 31]. By gaining insights into the growth and fluctuations of fish populations over time, policymakers can formulate laws and regulations to safeguard these populations and their habitats. In the Kashmir Himalayas, water bodies are continually exposed to pollutants, toxic chemicals, and agricultural runoff. These contaminants disrupt fish reproduction, growth, and overall health, contributing to declines in population. This information is indispensable for the management and conservation of *S. plagiostomus.* Through the examination of the species' life history traits, the objective is to ensure sustainable exploitation and uphold its ecological significance in the ecosystem.

Materials and Methods

Fish collection

Every month 30 specimen of *S. plagiostomus* were collected collected on random basis (Taherdoost, 2016) [46] from river Jhelum over a period of 12 months from September 2021 to September 2022. The Jhelum River originates from the Verinag spring in Anantnag district and flows in a north-westward direction from the northern slope of the Pir Panjal Range through the Vale of Kashmir. It flows in loops through the valley till it enters the Wular Lake; flows out from its other side to Baramulla in south-west direction and then it enters the boundary of Pakistan. The fish was identified using the standard taxonomical tools (Talwar and Jhingran, 1991) [47]. The most prominent distinguishing feature that sets it apart from other fish species in the *Schizothorax* genus is the presence of a callous disc on its lower lip. Upon touching it, a tactile sensation similar to a rough texture was perceived. After collection the specimens were immediately preserved in 5% formalin and brought to Fisheries Resource Management (FRM) Laboratory, Faculty of Fisheries, SKUAST-K, Rangil, Ganderbal for further analysis.

Sex ratio

The study recorded the occurrence of males and females in the sampled catch over the course of one year, and the probable ratio of males to females occurring in nature was calculated for different months. The sex ratio, indicating the proportion of males to females in the population, is expected to be 1:1 in nature. Any deviation from this ratio may suggest the dominance of one sex over the other, influenced by factors such as differential behavior between sexes, environmental conditions, and fishing pressure (Bal and Rao, 1984) [6]. The equality of sex ratios for different months was assessed using a Chi-square test. Additionally, to assess the homogeneity of sex distribution, a Chi-square test as outlined by Snedecor and Cochran (1967) [43] was applied.

$$\chi^2 = \sum(O-E)^2/E$$

Where, "O" is observed frequency and "E" is expected frequency.

Condition Factor

The relationship between the length and weight of individual fish will be utilized to compute Fulton's Condition Factor Index, employing the following equation (Fulton, 1904) [17]:

$$K = \frac{W}{L_3} x\,100$$

Where, 'W' represents the weight of the fish in grams and 'L' denotes the total length of the fish in mm. The condition factor (K) was determined separately for each sex on a monthly and seasonal basis. The mode in the 'K' values can serve as an indicator of gonadal maturity, spawning season, or improved feeding conditions (Anderson and Gutreuter, 1983).

Result

Sex ratio

The sex ratio was analyzed concerning different months, and the data are presented in Table 1. The observed ratios were tested against 1:1 using the chi-square (χ^2) test. Due to the lack of sexual dimorphism in the case of *S. plagiostomus*, the sex of each individual was determined macroscopically by observing the gonads. In the current study, the proportion of males (n=242) was notably higher than that of females (n=118). The overall sex ratio (2.2:1, d.f. = 1, $p<0.05$) differed significantly from 1: 1 with 80.6% males and 39.3% females. The chi-square (χ^2) test revealed a significant difference in the distribution of sexes in the months of February, March, May, July, September, November, and December, favoring males. The month-wise sex ratio of 2.2:1 (M: F) for the entire study period indicates a significant dominance of males.

Condition factor (K)

The monthly mean condition factor (K) in the Males of *S. plagiostomus* varied from 0.89 in the month of November to 1.75 in the month of May. In case of Females, the maximum mean value of 1.84 was found in the month of May and minimum value of 0.64 was found in the month of November. The graphical representation of the month-wise and season-wise condition factor of *S. plagiostomus* is given in Fig. 1 & 2 and Table 2 & 3.

Discussion

Sex ratio

In the current study, the sex ratio was examined across different months, showing variation from 1:1 in April to 3.3:1 in November (Male: Female). The chi-square (χ^2) test highlighted significant male dominance in February, March, May, July, September, November, and December. Across the entire study period, the month-wise sex ratio was 2.2:1 (Male: Female), indicating a notable male dominance. Comparable findings were reported by Sunder (1984) [45] in the same fish species, indicating a higher proportion of males among smaller size groups (Below 290 mm), while females were more abundant in larger specimens (Above 290 mm Understanding the sex composition of catches is crucial for determining whether there is any differential fishing and its potential impact on fishable stocks (Kesteven, 1942) [24]. The

sex ratio, indicating the proportion of males to females in a population, is expected to be 1:1 in nature, but variations from this ratio are commonly observed in fish. These variations may signify segregation or aggregation of sexes based on feeding, breeding, migratory behavior, environmental conditions, or fishing pressure. Qasim (1966) [35] suggested that these variations may indicate differences in the growth rates of the two sexes. Shafi and Yousuf (2012) [39] observed a preponderance of females over males (1:0.79) in *Carrasius carrasius*, a trend also noted by Olurin and Savage (2011) [29] in the case of African snakehead, *Parachanna obscura*, from the River Oshun. Fagade *et al*. (1984) attributed this natural phenomenon as a potent mechanism for population regulation.

Condition factor

In this it was observed that the highest values of K during May (Spawning months) were mainly due to maturity of gonads while the lowest values were observed during November. The present study highlights the significant influence of the breeding cycle on the condition factor of the fish. Le Cren (1951) [28] has linked the condition factor (K) with the attainment of maturity, feeding intensity, and spawning behavior of a fish. The mean condition factor of *S. plagiostomus* from the Kashmir Himalaya demonstrates clear seasonal variability, consistent with other published findings on unisexual female populations (Leonardos, 2006) [48], bisexual populations of Prussian carp (Tsoumani, 2006; Kirankaya, 2013) [48, 25]. Yousuf and Shafi (2012) [39] suggested, in their study on the condition factor of Schizothorax niger, that the fish's condition factor varied seasonally in close association with gonadal development and feeding intensity. Dar *et al*. (2012) [11] explored the relative condition factor (Kn) of *Schizophyge esocinus* from the Jhelum River, Kashmir, revealing that fluctuations in 'Kn' values could be attributed to the spawning cycle as well as feeding intensity. Shah *et al*. (2013) [40] investigated the ponderal index of rainbow trout (*Onchorynchus mykiss*) from the Dachigam stream in Kashmir, estimating the condition factor as 1.15±0.013. In fisheries science, the condition factor serves as a valuable tool for comparing the condition, fatness, or overall well-being of fish (Ahmed *et al*., 2011) [1]. It operates on the premise that heavier fish of a given length are in better physiological condition (Bagenal and Tesch, 1978) [5]. The condition factor also acts as a useful indicator for monitoring feeding intensity, age, and growth rates of fish (Johnson and Ndimele, 2010) [22]. It is significantly influenced by both biotic and abiotic environmental factors and can be utilized as an index for assessing the status of the aquatic ecosystem in which the fish inhabit (Anene, 2005) [4]. Hart (1946) [19] noted that ponderal indices provide a good overview of the seasonal cycle for the species under study. According to him, seasonal variations in the ponderal index coincide with increasing age. Additionally, he observed a lower level of condition throughout the seasonal cycle, attributed to the increased metabolic strain of spawning. Hart also found that the point of inflection on the curve serves as a reliable indicator of the length at which the fish attains sexual maturity.

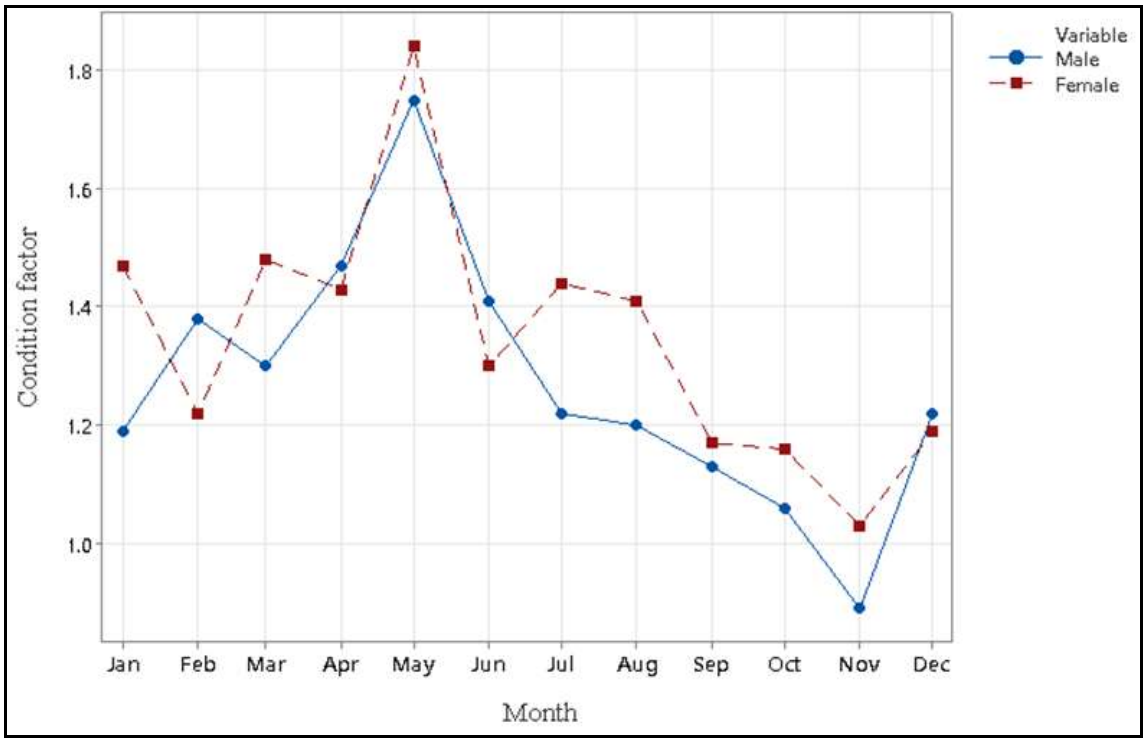

Fig 1: Time series plot of monthly mean condition factor in *S. plagiostomus*

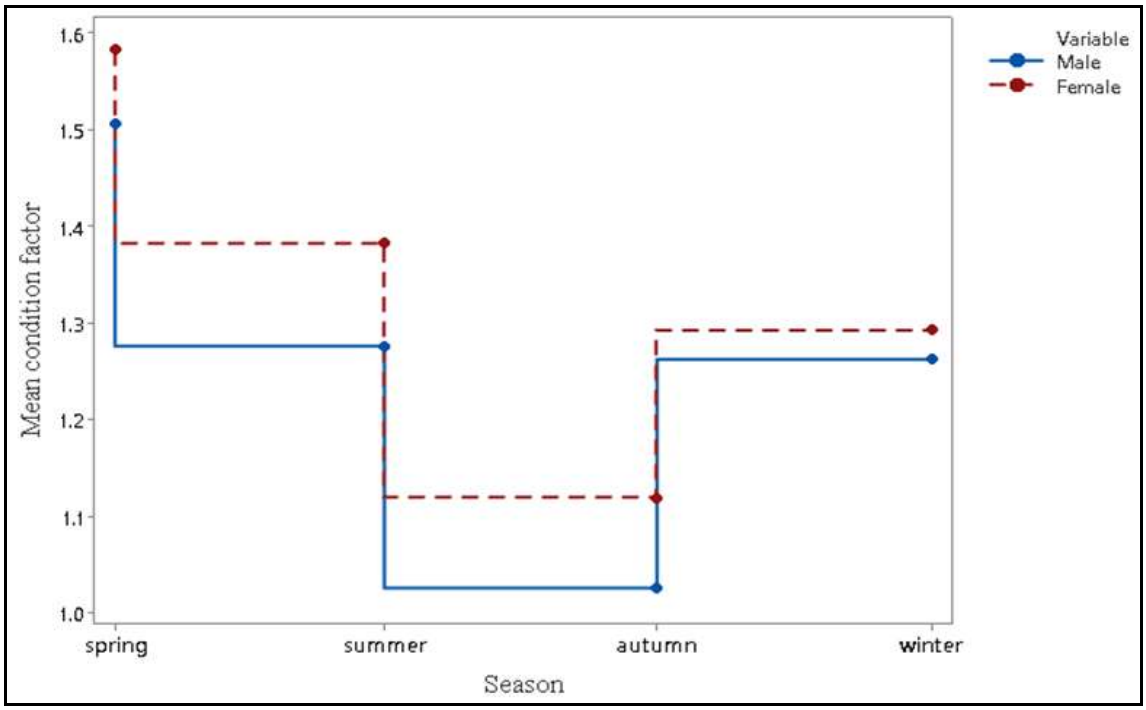

Fig 2: Time series plot of mean seasonal condition factor in *S. plagiostomus.*

Table 1: Month wise estimated sex ratio in *S. plagiostomus*

Month	Total No. of specimens	No. of males	No. of females	Percentage of males	Percentage of females	Sex ratio (M:F)	Chi-square value	P-Value
January	30	18	12	60	40	1.5	0.270	>0.05
February	30	21	9	70	30	2.3	0.020	<0.05 #
March	30	21	9	70	30	2.3	0.020	<0.05 #
April	30	15	15	50	50	1.0	1.000	>0.05
May	30	23	7	77	23	3.3	0.003	<0.05 #
June	30	20	10	67	33	2.0	0.068	>0.05
July	30	21	9	70	30	2.3	0.028	<0.05 #
August	30	20	10	67	33	2.0	0.068	>0.05
September	30	21	9	70	30	2.3	0.028	<0.05 #
October	30	19	11	63	37	1.7	0.144	>0.05
November	30	22	8	73	27	2.8	0.011	<0.05 #
December	30	21	9	70	30	2.3	0.028	<0.05 #
Total	360	242	118	80.6	39.3	2.2		<0.05 #

#- Significant at 5% level

Table 2: Month-wise condition factor of *Schizothorax plagiostomus* (Male and female)

Month	Male	Female
January	1.19	1.47
February	1.38	1.22
March	1.3	1.48
April	1.47	1.43
May	1.75	1.84
June	1.41	1.3
July	1.22	1.44
August	1.2	1.41
September	1.13	1.17
October	1.06	1.16
November	0.89	1.03
December	1.22	1.19
Mean	1.26	1.34

Table 3: Seasonal condition factor of *Schizothorax plagiostomus* (Male and female)

Season	Male	Female
Spring	1.5	1.6
Summer	1.3	1.4
Autumn	1.0	1.1
Winter	1.3	1.3
Mean	1.27	1.35

Conclusion

The study of *S. plagiostomus* in the Kashmir Himalaya Valley revealed a significant male dominance with a sex ratio of 2.2:1. Seasonal fluctuations in the condition factor (K) were noted, reflecting the influence of gonadal development. These observations enhance our comprehension of the reproductive dynamics and physiological state of the species, offering valuable insights for fisheries management and conservation endeavors in the region.

Acknowledgments

The authors extend heartfelt thanks to Dean of the Faculty of Fisheries at SKUAST-Kashmir (J&K) for their necessary contribution in providing crucial facilities.

References

1. Ahmed EO, Ali ME, Aziz AA. Length-weight relationships and condition factors of six fish species in Atbara River and Khashm et-girba Reservoir, Sudan. Int J Agric Sci. 2011;3(1):65-70.
2. Akhtar N, Khan S, Saeed K. Exploring the Fish Fauna of River Swat, Khyber Pakhtunkhwa, Pakistan. World J Fish Mar Sci. 2014;6(2):190-194.
3. Anderson RO, Gutreuter SJ. Length-weight and associated structural indices. In: Nielson L, Johnson D, eds. Fisheries Techniques. Bethesda, Maryland: American Fisheries Society; 1983:283-300.
4. Anene A. Condition factor of four Cichlid species of a man-made Lake in Imo State, South-eastern Nigeria. Turk J Fish Aquat Sci. 2005;5:43-47.
5. Bagenal TB, Tesch FW. Age and growth. In: Begenal T, ed. Methods for assessment of fish production in fresh waters, IBP Handbook 3. Oxford: Blackwell Science Publications; 1978:101-136.
6. Bal DV, Rao KV. Marine fisheries. New Delhi: Tata McGraw-Hill Publishing Company; 1984:51-73.
7. Balkhi MH. Fish diversity in Jammu and Kashmir and conservation measures. Kashmir Speaks. 2007;6:104-115.
8. Bhat FA, Yousuf AR, Balkhi MH, Shah FA. Length-weight relationship and morphometric characteristics of Schizothorax spp. in the River Lidder of Kashmir. Indian J Fish. 2010;57:73-76.
9. Bhat FA, Balkhi MH, Najar AM, Shah FA, Khan I. Conservation of schizothoracid (*Schizothorax esocius* Heckel) in aquatic environments of Kashmir. Himalayas vis a vis study on its various biological parameters. In: National conference on Status and Conservation of Biodiversity in India with special reference to Himalaya; 2013.
10. Bhat FA, Yousuf AR, Balkhi MH. Biodiversity of Fishes in Jammu and Kashmir. In: Dar GH, Khuroo AA, eds. Biodiversity of Himalaya J & K State. Singapore: Springer Nature; 2020:859-887.
11. Dar SA, Najar AM, Balkhi MH, Rather MA, Sharma R. Length weight relationship and relative condition factor of *Schizopyge esocinus* (Heckel) from Jhelum River, Kashmir. Int J Aquat Sci. 2012;3(1):29-38.
12. Das SM, Subla BA. The ichthyofauna of Kashmir, Part-I. History, topography, origin, ecology and general distribution. Ichthyologica. 1963;2(1-2):87-106.
13. Das SM, Subla BA. Ichthyofauna of Kashmir. Part II: The speciation of Kashmir fishes. Ichthyologia. 1970;3:57-62.
14. Day F. The Fishes of India, Being a Natural History of the Fishes Known to Inhabit the Seas and Fresh Waters of India, Burma and Ceylon, with Descriptions of the Sub-classes, Orders, Families, Genera, and Species, by Francis Day. B. Quaritch; c1878.
15. Fagade SO, Adebisi AA, Atanda AN. The breeding cycle of Sarotherodon galilaeus in the IITA Lake, Ibadan Nigeria. Arch- Hydrobiol. 1984;100:493-500.
16. Froese R, Pauly D, eds. FishBase. World Wide Web electronic publication. www.fishbase.org; c2023.
17. Fulton TW. The rate of growth of fishes. Fisheries Board of Scotland Annual Report. 1904;22 (Part 3):141-241.
18. Gopi KC, Mishra SS. Diversity of marine fish of India. In: Marine faunal diversity in India. Academic Press; c2015. p. 171-193.
19. Hart JL. Report on travelling surveys on the Patagonian continental shelf. Discovery. 1946;23:223-408.
20. Heckel JJ. Fische aus Caschmir gesammelt und herausgegeben von Carl Freiherrn von Hügel, beschrieben von JJ Heckel. Wien Annals and Magazine of Natural History (Series 8); c1838. p. 1-112.
21. Jhingran VG. Fish and fisheries of India. Delhi: Hindustan Publishing Corporation; c1982.
22. Johnson CAK, Ndimele PE. Length-weight relationship and condition factors of twenty-one fish sps. In: Ologe lagoon, Lagos, Nigeria. Asian J Agric Sci. 2010;2(4):174-179.
23. Joshi V, Akhtar MS, Sharma P, Baruah D, Alexander C, Das P, *et al*. Protein and amino acid composition of Indian Himalayan snow trout and their dietary significance. Proc Natl Acad Sci India Sect B Biol Sci. 2018;88:1471-1476.
24. Kesteven GL. Studies on the biology of Australian mullet. Part. 1. Account of the fishery and preliminary statement of the biology of M. dobula Gunther. Coun. Sci. Industry. Res. Bull. Melbourne, No. 157; c1942.
25. Kirankaya ŞG, Ekmekçi FG. Life-history traits of the invasive population of Prussian carp, *Carassius gibelio* (Actinopterigi: Cypriniformes: Cyprinidae), from Gelingüllü reservoir, Yozgat, Turkey. Acta Ichthyol Piscat. 2013;43(1):31–40.
26. Kottelat M, Whitten T. Freshwater biodiversity in Asia with special reference to fish. World Bank Technical Paper No. 343. Washington, DC, USA: World Bank; 1996. 59 p. Available from: http://dx.doi.org/10.1596/0-8213-3808-0.
27. Kullander SO, Fang F, Delling B, Ahlander E. The fishes of the Kashmir Valley. River Jhelum, Kashmir Valley. Impact on the Aquatic Environment. Göteborg: Swedmar; 1999.
28. Le Cren ED. The length weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). J Anim Ecol. 1951;20(2):201-219.
29. Olurin KB, Savage OD. Reproductive biology, length–weight relationship and condition factor of the African snake head, *Parachanna obscura*, from River Oshun, South-west Nigeria. Int J Fish Aquacult. 2011;3(8):146-150.
30. Oscoz J, Campos F, Escala MC. Weight length relationships of some fish species of the Iberian Peninsula. J Appl Ichthyol. 2005;21:73-74.
31. Pauly D, Munro JL. Once more, on the composition of growth in fish and invertebrates. Fish Byte. 1984;2(1):21.
32. Pauly D. On the interrelationships between natural mortality, growth parameters and mean environmental

temperature in 175 fish stocks. J Conserv CIEM. 1980;39(2):175-192.
33. Petr T, Swar DB, editors. Cold water fisheries in the trans-Himalayan countries. Food & Agriculture Organisation; 2002. Report No.: 431.
34. Qadri S, Shah TH, Balkhi MH, *et al*. Study on the growth of *Schizothorax curvifrons* (Cyprinidae: cypriniformes) in river Jhelum Kashmir. J Pharmacogn Phytochem. 2018;7(5):1908-1912.
35. Qasim SZ. Sex ratio in fish populations as a function of sexual difference in growth rate. Curr Sci. 1966;35:140-142.
36. Rai AK, Pradhan BR, Basnet SR. Present status of snow trout in Nepal. FAO fisheries technical paper no. 431. Rome: FAO; c2002. p. 213–220.
37. Raina HS, Vass KK, Sunder, Shyam, Moza U, Langer RK. Prospects and problems of snow trout culture in Kashmir. Zoologica Orientalis. 1985;2(1-2):24-30.
38. Sehgal KL. Coldwater fish and fisheries in the Indian Himalayas: rivers and streams. In: Fish and fisheries at higher altitudes: Asia. Food and Agriculture Organization of the United Nations Technical Paper. 1999;385:41-63.
39. Shafi S, Yousuf AR. Length-weight relationship and condition factor of *Schizothorax niger* (Heckel, 1838) Misra from Dal lake, Kashmir. Int J Sci Res Pub. 2012;2(3):1-3.
40. Shah TH, Balkhi MH, Asimi OA, Khan I. Length weight relationship and ponderal index of rainbow trout (*Oncorhynchus mykiss* W., 1792) from Dachigam stream in Kashmir. Afr J Agric Res. 2013;8(4):1277-1279.
41. Sharma BP. Status of *Schizothorax sp.* in the Indian-Chinese sub-continent. FAO fisheries report no. 405 (Supplement). Rome: FAO; c1989. p. 90–94.
42. Singh NO, Paul AK. Fitting of allometric model with expected-value parameters for different species of snow trout from Jhelum River, Kashmir. Indian J Anim Sci. 2010;80(1):85-88.
43. Snedecor G, Cochran WG. Statistical Methods. 6th ed. Ames, Iowa: The Iowa State University Press; c1967.
44. Stratoudakis Y, Bernal M, Ganias K, Uriarte A. The daily egg production method: Recent advances, current applications and future challenges. Fish Fish. 2006;7:35-57.
45. Sunder S. Studies on the maturation and spawning of *Schizothorax curvifrons* Heckel from River Jhelum, Kashmir. J Indian Inst Sci. 1984;65(6):41.
46. Taherdoost H. Sampling methods in research methodology; how to choose a sampling technique for research. How to choose a sampling technique for research. 2016 Apr 10.
47. Talwar PK, Jhingran AG. Inland Fishes of India and Adjacent Countries. New Delhi, Bombay, Calcutta: Oxford and IBH Publishing Co. Pvt. Ltd. 1991;1:402.
48. Tsoumani M, Liasko R, Moutsaki P, Kagalou I, Leonardos I. Length-weight relationships of an invasive cyprinid fish (*Carassius gibelio*) from 12 Greek lakes in relation to their trophic states. J Appl Ichthyol. 2006;22(4):281–284.
49. Yousuf AR. Fishery resources of Kashmir. In: Khan AH, Pandit AK, editors. Ecology, Environment and Energy. Srinagar: University of Kashmir; c1996. p. 75-120.
50. Zutshi DP, Gopal B. State of biodiversity in lakes & wetlands of Kashmir Valley. Environ Biodivers Conserv; c2000. p. 15-16.