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An Ecological Investigation on the Eating Habits and Breeding of the Small Fishes

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I. INTRODUCTION

The existence of fishes is more than 450 million years ago. Fishes are generally considered an economically important group of cold-blooded aquatic vertebrates. In prehistoric times, the availability of fish as a food was distinctly limited and totally depended upon capture fisheries. Fishing and eating fishes were well established practices from ancient time. Fishes have a very special consideration and place in human civilization from times immemorial and fishes influenced human life by various ways. The name of the Canadian city of Coquitlam, British Columbia is derived from *Kwikwetlem*, which is said to be derived from a Coast Salish meaning "Little red fish". China is the first country that used fish for medicine and considered fish as a symbol of wealth and prosperity. Afterwards, the whole world tried to work on fishes.

Although the fish was considered to be a symbol of Christianity, however in prehistoric western world attitudes had more ambivalent towards fish and fisheries. In classical Rome there were numerous *vivaria* (fish tanks), as a status symbols but not for food. Only in the present century the seafood has been fully accepted in the western world as an admirable source of nourishment. More specifically, it is only in recent decades that the importance of fish oil for health has been fully recognized. Later, from the early Middle Ages onwards, fishponds became almost ubiquitous in Europe, particularly in association with religious institutions such as monasteries. More than 30,000 species of predominantly cold-blooded vertebrates found worldwide in fresh water and salt water. It is also abundantly clear that in early historic times the art of fishing and the scale of consumption developed rapidly by the work of early Chinese writers and of classical Greek authors. At that time India has no significant contribution in the world fisheries.

Fishes are the important components of the aquatic ecosystem because they make a vital link between primary producers and various levels of consumers of food chain. Fishes have the equal importance aquatic ecosystem as well as for mankind. Because of their nutritional, medicinal and recreational values these species are considered to be the highly precious gift of nature. A fish contains protein about 16-26 % of its weight which includes several essential amino acids, 1-10 % fat, small quantities of glycogen, 1-2 % mineral, vitamin A, D, B complex, and leonelic acid (ώ-3 fatty acid), etc. which are crucial components of human diet. Early humans might have known that fish constituted a balance food. One of the main reasons is that fish needs a less elaborate skeleton than land animals, since its weight is supported by the water in which it lives to provide it more flesh in relation to body weight. Fish is not only an important food item but it also provides several important by-products, so it developed into a flourishing fish industry.

Among the various varieties of fishes available in literature, *Labeo dyocheilus* belong to family Cyprinidaea and it is the largest family of the class Pisces. Members of the family Cyprinidaea are often referred as “Carps” or “Cyprinids”. Cyprinids have major economic importance in world fisheries. *Labeo dyocheilus* is a well known nutritious fish thus has highquality food value.

II. AIM OF STUDY

A little information is available in literature on ecological study of feeding and breeding biology of *Labeo dyocheilus*. Hence, the present research set to focus on feeding and reproductive biology of *Labeo dyocheilus* (McClelland). The other aim of this work is to fill up the gap in literature as no such records were available in the literature regarding to feeding and reproductive biology of *Labeo dyocheilus* in the Western Ramganga River from Kumaun Himalays. The study on feeding and breeding biology of this cold water fish is aim to provide the information to the scientists for scientific cultural of this indigenous fish species and management aspect.

III. OBJECTIVES OF STUDY

The objectives of our study comprise several aspects of fish biology. We aim to study about the food and feeding behavior; maturation biology and the factors regulating the spawning; the reproductive capacity and sex ratio of fish population; the cyto-morphological changes in the gonads; the changes of gonadal lipid, protein and water content in various stages of gonadal cycle; the habitat ecology; also about the feeding ecology and breeding ecology of fish *Labeo dyocheilus.*

IV. SIGNIFICANCE OF STUDY

This study will be helpful to explore the significance of several scientific aspects of fish biology. Firstly, it will useful to check the malnutrition problem of the region where *Labeo dyocheilus* is taken as food. Another significance of present research is to protect the aquatic eco-friendly environment, conservation of biotic diversity leading to the concept of sustainable development in the cold climate and geographical realm of hilly area of Uttarakhand. In addition to above, this study will also helpful to understand the culture and management of fishes in the hill state. Our work would useful to determine the breeding period, breeding strategy, breeding ground, breeding capacity and would also tell about the feeding habit, which will give the idea about the culture, nature of food, habitable and nonhabitable condition of river and pollution level of the river. This study will also provide scientific information regarding fish eco-biology

V. RESEARCH METHODOLOGY

This study was conducted to collect fish samples from the western region of Ramganga River located in Chaukhutiya. Labeo dyocheilus specimens were obtained through collaboration with indigenous fishers over a 12-month period spanning from September 2019 to August 2020. The specimens' total length (TL) was measured with a precision of 0.1 cm, and their weight was measured with a precision of 0.1g. Following the acquisition of morphometric measurements, the fish specimens were subsequently preserved in a 5% formalin solution to facilitate further investigation. The measurements of the fish's total length and weight were documented while in a fresh state. However, other parameters were measured within a two-week period of collection. For the present investigation, a sample of 160 individuals was chosen, comprising 101 males and 59 females.

5.1 The Gonado-somatic index (GSI)

The Gonado-somatic index (GSI) is a metric utilized to signify the reproductive phase. The GSI is determined through microscopic examination of the gonads, involving the physical examination of the testes and ovaries, as well as the measurement of their length and weight. To compute the Gonadosomatic Index (GSI), the weights of both the fish's body and gonads (comprising testes and ovaries) were recorded as the initial step. The GSI (Global Sensitivity Index) was computed utilizing the formula provided as follows:

$$GSI = \frac{Weight\ of\ Gonads}{Weight\ of\ Fish} \times 100$$

5.2 Determination of Maturity stages:

The maturity stages were estimated on the basis of growth rate of ova throughout the year. The different maturity stages determined were modified in ICES scale (Wood, 1930) as follows:

Stage I	Immature 1st	(03 - 25 Omd)
Stage II	Immature 2nd	(05 - 50 Omd)
Stage III	Maturing 1st	(15 - 80 Omd)
Stage IV	Maturing 2nd	(25 - 100 Omd)
Stage V	Mature 1st	(35 - 140 Omd)
Stage VI	Mature 2nd	(60 - 170 Omd)
Stage VII	Spent	(15 - 60 Omd)

Spawning seasion deermined by analyzing the GSI value followed by calculating the monthly variation of different maturity stages of fish samples. The months were considered as spawning season, in which the spent fishes were available. After that the occurrence of eggs and fries in its natural habitat can be seen.

5.3 Determination of spawning grounds:

Throughout the spawning period, it was observed that Labeo dyocheilus exhibited a tendency to aggregate in specific patches located on the lateral side of the stream. Therefore, these locations were regarded as potential breeding habitats for the fish. During the course of our study, we gathered eggs, fries, and mature fish specimens from the aforementioned areas. The reproductive habitats of Labeo dyocheilus were analyzed through visual observation. The physico-chemical properties of the water in the spawning grounds were analyzed using Welch's method (1948) to ascertain the ideal conditions necessary for successful spawning. Throughout the study, various physico-chemical parameters were taken into account, including but not limited to water temperature, water current velocity, turbidity, pH, dissolved oxygen, total alkalinity, and total hardness

VI. RESULT AND FINDINGS

The spawning behavior of fish is a subject of great interest due to the diverse range of spawning behaviors exhibited, which parallels the vast array of structural and feeding habits observed among fish species. Hickling and Rutenberg (1936) conducted a study on the spawning behaviors of various fish species, focusing on the size distribution of intraovarian eggs as a measure of diversity in spawning behavior.

The present study observed fluctuations in the gonado-somatic index in relation to gonadal maturation. The Graduated Severity Index (GSI) demonstrated a positive correlation with the proportion of mature fish. Various researchers have considered the macroscopic Gonado Somatic Index as an indicator of spawning periodicity in fish. The highest GSI values for male and female L. dyocheilus were recorded during the month of July, which coincides with the attainment of full maturity in these fish. The current study observed a decline in GSI values during the month of August, which suggests the occurrence of full fish spawning.

The majority of ichthyologists adhere to the ICES scale established by Wood (1930) when determining maturity stages. The current study involved the determination of seven distinct stages of maturity for Labeo dyocheilus. These stages were identified and classified as follows: immature 1st, immature 2nd, maturing 1st, maturing 2nd, mature 1st, mature 2nd, and spent. Several fishes, including Crossocheilus latius latius, S. curvifrons, P. sulcatus, Tor chelynoides, N. botia, Barilius bendelisis, B. barna, Tor tor, and Gudusia chapra, have been studied by various researchers to identify their seven maturity stages. Negi and Dobriyal (1997), Sunder (1984), are some of the authors who have conducted research on these fishes.

The current investigation revealed that Labeo dyocheilus engages in spawning activities between the months of August and September within the Western Ramganga River. This deduction is based on the fact that the initial collection of spent fish occurred in August, and the proportion of spent fish in the collection consistently rose until September. During the spawning season, which typically occurs between August and September, the fish undergoes a transition from stage VI to stage VII. The study is corroborated by Hora and Mishra's (1938) research, wherein they observed that Tor khudree breeds between the months of August and September. According to Hora (1939) and (1940), it was suggested that both Tor putitora and Tor mosal engage in breeding activities during the same period, which occurs between August and September. Variations in the spawning season among species have been observed, as noted by Sarojini (1957), who reported that breeding in Mugil parsia occurred from December to March. According to Badola and Singh's (1984) findings, Schizothorax sinuatus, S. plagiostomus, and S. richardsonii exhibit an intermittent spawning behavior between the months of July and January. The breeding season of Labeo dyocheilus can be succinctly characterized as commencing with the onset of rainfall, typically occurring between August and September. The aforementioned sources, namely Anon (1965), Jackson and Coetzee (1982), and Skelton et al. (1991), are present in the literature. The synchronization of sexual maturation and reproduction with the onset of rainfall in the genus Labeo has been documented by Weyl and Booth (1999). According to Fryer and Whitehead's (1959) and Cadwalladr's (1965) findings, it appears that reproduction tends to be synchronized with the season of rainfall. The spawning of certain freshwater fish species was hypothesized by Alikunhi and Rao (1951) to be triggered by the flooding of rivers during the monsoon season.

The study findings indicate that during the period of October, there was a notable absence of spent fish. Instead, a majority of the fish were either in the resting phase (stage I and II) or had initiated the development of new batches of eggs (stage III and IV), as evidenced by the data presented in Table 4. It can be inferred that the growth rate of ova was hindered during the winter season (November to January) owing to the low water temperature. The ova experienced a significant increase in growth between the months of May and July, attributed to the favorable environmental conditions present during that period. The findings of this study suggest that Labeo dyocheilus exhibits a unimodal spawning pattern, with a single spawning frequency occurring during the months of August and September. The aforementioned spawning pattern is commonly known as either short-duration spawning or protracted spawning in academic discourse. Jhingran (1982) conducted a study which revealed that the majority of teleosts worldwide exhibit seasonal breeding patterns. In the Indian subcontinent, a significant proportion of freshwater fish species engage in breeding activities during the monsoon season. Antony Raja (1966) has reported a comparable spawning pattern for Sardinella longiceps, in which the species was observed to be a solitary spawner. Dobriyal and Singh (1989) conducted a study on Glyptothrox pectinopterus, which demonstrated that this species is also a single spawner. Dobriyal and Singh (1993) observed protracted spawning in Glyptothrox madraspatanam within the river Nayar. Lal (1970) reported the occurrence of single and restricted spawning in Rita rita and Balan in Sardinella longiceps.

The present study has observed that Labeo dyocheilus reproduces in slow-moving water with a velocity range of 0.741 to 0.899 m/s, specifically under stones and pebbles. The optimal water temperature for reproduction falls within the range of 19.92 °C to 21.58 °C, while the ideal turbidity levels range from 94.4 to 58.4 NTU. The pH levels for reproduction were found to be between 7.86 to 7.9, with dissolved oxygen content ranging from 8.08 to 8.92 mg/l. Additionally, the total alkalinity levels were observed to be between 59.34 to 67.24 mg/l, while the total hardness levels ranged from 80.3 to 83.03 mg/l. The study determined that the reproduction of Labeo dyocheilus is contingent upon a particular range of physico-chemical parameters, including seasonal precipitation,

water flow rate, temperature, pH, hardness, and alkalinity. The aforementioned values were observed from the habitat perspective during the spawning period. According to David's (1959) research, the spawning needs of riverine carps may vary not only among different species, but also based on various physico-chemical factors such as photoperiod, seasonal rainfall, and temperature. According to Nikolsky's (1963) research, various environmental factors such as photoperiod, seasonal rainfall, and temperature are significant in controlling the reproductive cycle of teleost fishes. Uniyal (2003) observed that Tor chilinoides spawns in the shallow areas of River Nayer. The study found that the increase in water level, turbidity, and decrease in pH were the main factors responsible for the spawning of this species. Negi (1999) reported that the spawning of Crossocheilus latius latius, a type of fish, occurs during the monsoon season, triggered by the rise in river water levels and the decrease in pH.

Several studies have reported that a specific water temperature serves as a spawning stimulus for numerous fish species. The study conducted by Marriott et. al. (1997) [284] found a significant correlation between the reproductive activity of Amphilius natalensis and the rise in temperature and photoperiod. In their 1945 study, Das and Dasgupta examined the thermal profile during the breeding season and observed that a temperature range of 21°C to 25°C was conducive to the breeding of Himalayan mahseer. The temperature range observed in the current study for Labeo dyocheilus is comparable to that reported by the user.

The study conducted on Labeo dyocheilus revealed that during the spawning season, which coincides with the onset of the rainfall season, the velocity of water current ranged from 0.49 to 0.65 m/sec. It is conceivable that the initiation of spawning could be triggered by an elevation in water flow rate or alterations in water quality, circumstances that may arise during periods of precipitation. The aforementioned finding is corroborated by David's (1967) research, which indicated that the existence of inundated water in the breeding habitat and a moderate flow were crucial factors for the reproduction of major carps. Sehgal et al. (1971) and Sehgal (1972) reported the occurrence of spawning in Tor putitora during the low phase of floods in shallow areas of specific streams in Himanchal Pradesh. According to Dobriyal and Singh's (1989) research findings, it was determined that the spawning of Glyptothorax pectinopterus, a type of catfish, occurs in the flooded areas with high water velocity in Nayar. According to Dobriyal et. al. (2000), Barilius barna was found to spawn in the lateral waters of Khandagad streams, which is a tributary of the Alaknanda river system. The eggs are deposited in secure, murky and shallow aquatic environments beneath stones. According to Thapliyal's (2002) research, it was observed that Pseudecheneis sulcatus is capable of spawning in flooded riverine conditions during the monsoon season.

VII. CONCLUSION

In brief, an analysis was conducted on the monthly fluctuations in the Gonadosomatic Index (GSI) of male and female fishes, revealing that the GSI metric for female fish consistently exceeded that of their male counterparts. It was also determined that the maturation of ovaries and testes occurs in seven distinct stages. The data indicates that during the month of July, the fish population exhibited a peak in maturation, as evidenced by the highest GSI value. Additionally, it was observed that the spawning season of the fish occurred between the months of August and September. The investigation examines the breeding season of Labeo dyocheilus in relation to the onset of rainfall. Additionally, the reproduction of this particular species has been observed to be influenced by various physico-chemical factors, including seasonal precipitation, water flow rate, temperature, pH level, water hardness, and alkalinity.

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