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Impact of Temperature and pH in modulating the behavioural changes of *Labeo calbasu*

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Abstract:

Fish behavior is strongly influenced by environmental variables, particularly temperature and pH, which play crucial roles in survival, growth, and reproduction. The present study was carried out to evaluate the behavioral responses of *Labeo calbasu* under varying temperature (25–35°C) and pH (6–9) conditions. The study was conducted for a period of seven weeks, with the experimental fish kept in different pond enclosures under controlled parameters. Behavioral responses such as swimming activity, feeding response, aggression, and resting pattern were recorded. The results indicated that at moderate temperatures and pH (25–28°C; pH 6–7), fish displayed normal activity and feeding behavior with aggression. However, under extreme temperature and pH conditions (32–35°C; pH 8–9), swimming activity and feeding rate decreased, aggression was absent, and resting behavior was prolonged., qualitative trends suggested that extreme pH and temperature conditions negatively affect the behavior of *Labeo calbasu*. The findings highlight the importance of maintaining suitable environmental conditions for aquaculture practices and provide a baseline for understanding stress-induced behavioral changes in freshwater fishes.

Keywords: Temperature tolerance, pH sensitivity, Behavioral response, Aquatic physiology, *Labeo calbasu*

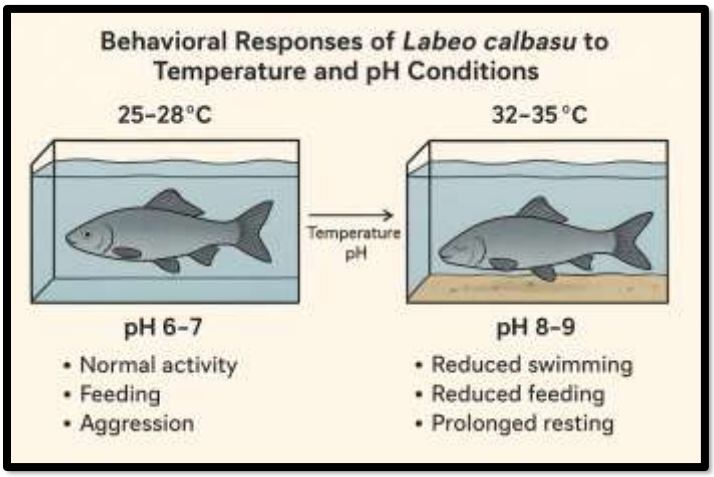

Fig: Scheme representation of behavioral responses of Labeo calbasu *under varying temperature and pH conditions*

Introduction:

Freshwater ecosystems support a wide diversity of fish species that play significant roles in maintaining ecological balance and providing economic benefits through fisheries and aquaculture. Among these, *Labeo calbasu* (commonly known as Calbasu) is a commercially important freshwater fish species belonging to the family Cyprinidae. It is widely distributed in rivers, reservoirs, and aquaculture ponds across South and Southeast Asia, particularly in India, Bangladesh, Nepal, and Myanmar **(Jhingran, 1991; Rahman, 2005).** *Labeo calbasu* is highly valued for its nutritive qualities, growth potential, and adaptability to varied aquatic environments, making it an important candidate for aquaculture practices **(Naeem et al., 2011).** It is primarily a bottom-feeding species, with a diet consisting of detritus, algae, and small benthic organisms **(Hossain et al., 2009).** Due to its hardy nature, it can withstand moderate fluctuations in environmental conditions. However, critical physical factors such as temperature and pH greatly influence its physiology, growth, survival, and overall behaviour **(Boyd, 1990; Das et al., 2012).**

Temperature is a fundamental abiotic factor regulating the metabolic processes, growth rate, and reproductive success of fish.Temperature is a master variable that governs the feeding efficiency and Locomotor activity of fishes **(Fry, 1971).**Variations beyond the optimal temperature range may induce stress, alter feeding activity, and reduce survival **(Brett, 1979; Beitinger et al., 2000).** In *Labeo* species, sub-optimal or elevated temperatures have been associated with altered swimming activity, reduced feed intake, and abnormal stress-related behaviours **(Das et al., 2014).**For instance, studies on *Labeo rohita* demonstrated that higher water temperatures disrupted larval development and altered behavioural performance, indicating a strong temperature–behaviour linkage in Indian major carps **(Rahman et al., 2021).**Similarly, *L. calbasu* fingerlings showed enhanced growth and feed utilization near optimal thermal ranges but displayed stress and reduced activity at elevated temperatures **(Mohanty et al., 2017).**

Similarly, pH plays a crucial role in determining water quality and fish health. Extreme acidic or alkaline conditions can impair metabolic functions, disturb osmoregulation, and adversely affect growth and reproduction **(Boyd & Tucker, 1998; Hossain et al., 2011).**Water pH influencing the fish behaviour. Extreme acidic or alkaline conditions disrupt ion regulation, impair gill function, and induce stress responses in freshwater fishes **(Heath, 1995).**Behavioural manifestations of pH stress include erratic swimming, increased opercular movement, surface respiration, and changes in feeding and shoaling behaviour **(Iwama et al., 2004).**Although limited, research on *L. calbasu* has shown that exposure to acidic pH alters stress physiology and potentially modulates behaviour, with supplementation of herbal extracts such as *Cynodondactylon* mitigating adverse effects **(Singh et al., 2019).**

Given the increasing anthropogenic activities and environmental fluctuations in freshwater habitats, it is essential to understand how variations in physical factors such as temperature and pH affect the biology and behavior of *Labeo calbasu*. Such knowledge will not only enhance aquaculture management practices but also contribute to the conservation and sustainable utilization of this economically significant species.

Materials and Methods

Specimens of *Labeo calbasu* were collected from Pimpalgaon Joga Dam (Pune, Maharashtra) and acclimatized for one week in tanks with aerated pond water. The experiment was conducted for seven weeks under controlled laboratory conditions, where temperature was maintained using aquarium heaters and pH was adjusted with dilute NaOH or HCl using a digital pH meter**.**

Five groups were maintained: (i) Control – 27 °C, pH 7.0; (ii) Group 1 – 25 °C, pH 6.0; (iii) Group 2 – 28 °C, pH 7.0; (iv) Group 3 – 32 °C, pH 8.0; (v) Group 4 – 35 °C, pH 9.0. Each group was kept in triplicate tanks with uniform stocking.

Fish were fed commercial pellets at 5% body weight daily in three feedings, and uneaten food was removed after 30 minutes to maintain water quality.

Behavioral responses were observed weekly for 30 minutes, focusing on **swimming activity, feeding response, aggression, and resting behavior**, following standard fish ethology approaches **(Hossain et al., 2009; Rahman et al., 2021).**

Results

The behavioral responses of *Labeo calbasu* showed distinct variations across the experimental conditions. Fish in the control and Group 1–2 exhibited active swimming, normal feeding, and signs of aggression. In

contrast, those in Group 3 (32°C; pH 8.0) and Group 4 (35°C; pH 9.0) demonstrated suppressed activity with decreased feeding rates, complete absence of aggression, and extended resting behavior.

Group	Temperature (°C)	pH	Swimming	Feeding	Aggression	Resting
Control	27	7.0	Active	High	Present	Normal
G1	25	6.0	Active	High	Present	Normal
G2	28	7.0	Active	High	Present	Normal
G3	32	8.0	Reduced	Low	Absent	Increased
G4	35	9.0	Reduced	Low	Absent	Increased

Table 1. Behavioral responses of Labeo calbasu under different temperature and pH conditions

Discussion

The findings of this study reveal that *Labeo calbasu* maintains optimal behavioral performance under moderate environmental conditions, while extreme fluctuations in temperature and pH lead to suppressed activity. Fish maintained at 25–28 °C and near-neutral to slightly acidic pH (6–7) displayed active swimming, high feeding response, and normal aggression, indicating tolerance to moderate environmental variation. These results support earlier reports suggesting that *L. calbasu* and other cyprinids are well adapted to natural pond conditions within these ranges **(Das et al., 2012; Mohanty & Sahoo, 2010).**

However, at elevated temperatures (32–35 °C) and alkaline pH (8–9), the fish displayed noticeable stress responses, such as reduced swimming, loss of feeding activity, and increased resting. Aggressive interactions, which were observed under normal conditions, were absent under stress, suggesting a decline in energy allocation to social and competitive behavior. Such behavioral changes are consistent with previous studies indicating that thermal and pH extremes disrupt metabolic and osmoregulatory balance, leading to visible suppression of activity in freshwater fishes (**Beitinger et al., 2000; Boyd & Tucker, 1998; Randall & Tsui, 2002).**

The prolonged resting observed under stressful conditions may be a compensatory mechanism to conserve energy and minimize metabolic demand in unfavorable environments. Similar trends have been reported in other Indian major carps, such as *Labeo rohita* and *Catla catla*, under suboptimal pH and temperature regimes **(Jha et al., 2017; Rahman et al., 2021).** Furthermore, increased alkaline pH has been linked to ion imbalance and respiratory stress, which could explain the behavioral suppression observed in Groups 3 and 4 **(Heath, 1995; Perry & Gilmour, 2006).**

Although statistically significant differences were not obtained, the qualitative behavioral variations are biologically meaningful. Such outcomes may be due to the relatively small sample size and the short experimental duration. Nevertheless, the observed behavioral changes align with ecological expectations and previously documented patterns in freshwater fish **(Somero, 1995; Abele et al., 2002).** The findings underline the sensitivity of *L. calbasu* to environmental fluctuations, particularly those associated with climate change, and emphasize the importance of maintaining suitable water quality in aquaculture systems **(Boyd, 2017; Ding et al., 2019).**

Conclusion

This study concludes that *Labeo calbasu* thrives best under moderate environmental conditions (25–28°C; pH 6–7), displaying active swimming, feeding, and aggression. Elevated temperature and alkaline pH conditions resulted in stress responses characterized by reduced swimming, low feeding, absence of aggression, and increased resting. While statistical significance was not observed, the behavioral trends clearly demonstrate that unfavorable abiotic factors can compromise fish welfare and aquaculture productivity. Maintaining optimal water quality is therefore essential for the sustainable culture of *Labeo calbasu*.

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