Original Research Article

A comparative study on growth rates and length-weight relationships of Snow Trout (*Schizothorax* sp.) from Rasuwa, Nuwakot, and Okhaldhunga districts of Nepal

ABSTRACT

Aims: Snow trout (*Schizothorax* spp.) are vital to Nepal's aquatic biodiversity and economy, yet little research has addressed their growth potential under controlled conditions. This study aimed to evaluate the growth performance of snow trout from three regions of Nepal (Okhaldhunga, Nuwakot, and Rasuwa) in captivity.

Study design: Original Research Article.

Place and Duration of Study: Fisheries Research Station (FRS), Trishuli Nepal, between August 18 to November 24, 2023.

Methodology: Schizothorax species were collected from Okhaldhunga, Nuwakot, and Rasuwa districts and acclimated to the environment of the FRS in three separate raceways prior to the feeding trial. From each location, a population of 450 apparently healthy and uniform sized snow trout (initial weight: 20.00 + 1.2g) were then distributed into 3 raceway tanks, altogether 9 raceways for 3 groups, feeding upon the farm made pellet feed turned into dough for 90 days. At the end of the feeding trial, growth parameters, including weight gain, specific growth rate (SGR), condition factor (K) and Length-weight relationship (LWR) were measured. Survival rate and water quality parameters were also measured.

Results: Results indicated Fish from Nuwakot exhibited the highest weight gain (3.61 ± 1.82 g) and SGR (0.23 ± 0.12% per day), though these differences were not statistically significant (P >0.05). The condition factor (K) was highest for Rasuwa fish (0.98), followed by Nuwakot (0.97) and Okhaldhunga (0.97) (P >0.05), indicating that the fish were relatively thin, possibly due to poor nutrition or stressful conditions. The LWR analysis revealed high length-weight correlations for all groups, with Rasuwa fish exhibiting a positive allometric growth pattern (b=3.02), whereas Okhaldhunga (b=2.93) and Nuwakot (b=2.94) fish showed negative allometric growth patterns. This may suggest that snow trotu from Rasuwa were in relatively good physiological condition and adapting well to the rearing conditions at the FRS. Although with no statistical difference, the survival rate was highest for fish from Nuwakot (86.67%), followed by Rasuwa (80.00%) and Okhaldhunga (77.33%) (P >0.05). This may indicate the adequacy of the water quality (average temperature 11.75 ± 0.42 ℃, dissolved oxygen more than 7 mg/L, and pH 7.71 ± 0.16) maintained during the study.

Conclusion: The findings suggest that while the snow trout demonstrated the ability to survive yet grow slowly under captivity, their growth performance may be significantly enhanced by optimizing rearing conditions, particularly slightly higher water temperature. This study underscores the need for targeted improvements in aquaculture practices to support the effective domestication and conservation of snow trout in Nepal.

Keywords: Asala, Snow trout, Coldwater aquaculture, Length-Weight relationship

1. INTRODUCTION

In Nepal, in contrast to the high level of success seen in the warm and freshwater culture of several fish species, the economics of the cold/cool water fish farming are such that only a very limited number of desirable species such as rainbow trout (*Oncorhynchus mykiss*) and common carp (*Cyprinus carpio*) are suitable for cultivation. Although, reports show that more than 80 species are listed as cold-water fish species in Nepal [1], snow trout (*Schizothorax spp*), Mahseer (*Tor spp*), and Katle (*Neolissocheilus hexagonlepis*) are very few of these native species studied for their basic biology and reproduction [2]. Unfortunately, information on commercial traits such as the suitability for intensive cultivation, growth rates, and disease resistance for many cold-water species are still lacking except for few successful attempts on their reproduction [2, 3]. This study was therefore focused on one of such traits, comparative growth rates of snow trout (*Schizothorax sp*.), locally called as Asala (or Asla), collected from mid-hills of eastern, central and western region of Nepal.

In Nepal, about 15 species of snow trout have been reported to be found [4]. However, only few species of genus *Schizothorax* and *Schizothoraichthys* are studies and described based on snout morphology, with *Schizothorax* exhibiting a blunt snout (Buche Asla) and suctorial lip, while *Schizothoraichthys* possesses a pointed snout (Chuche Asla) without a suctorial lip. *Schizothorax plagiostomus* and *Schizothoraichthys progastus*, prevalent and dominant in Nepal's rivers and lakes, are both sport fish and culinary delicacies [3]. *Schizothorax plagiostomus*, known as the golden snow trout, is recognized for its silvery golden hue. These species have been under investigation at the Fisheries Research Centre, Trishuli since 1971. However, their cultivation is hindered by the challenge of formulating suitable feed. Snow trout, a short-distance migratory species, breeds in tributaries, but dam construction impedes its migration which is assumed to have caused significant population to decline of this species [3]. Furthermore, the absence of data on the natural stock of snow trout and persistent fishing as a sport fish and culinary delight, complicates conservation and management efforts. As such, it is of paramount importance for studying and restocking to maintain the species' population. Knowledge of fish growth is important for obtaining the increase in the biomass of a cultured fish which comes from the growth of individual fish in a closed population. It is also important in stock assessment to monitor a population and inform the management decisions such as length and weight limits for harvest from specific locations, and other regulatory measures. The study of growth performance of fish from different latitude and environmental conditions is important because the growth of same fish species often varies by a number of interacting factors such as hereditary and environmental conditions under natural conditions [5].

The scientific community has prioritized the development of Asala reproduction technology, a critical prerequisite for domestication and captive breeding [6] and has succeeded to some extent. However, due to lack of suitable feed in captivity due to its specialized feeding habit linked to its mouth structure, a challenge remains for the development of adequate farming systems and feeding practices for larval and juvenile rearing of this species.

The sustainable future of the aquaculture industry may rely partly on the availability of a large number of domesticated fish species, and the conservation of native species is equally important. Therefore, it was essential to identify which locations inhabit Asala that are likely to be feasible for commercial rearing. This investigation was therefore conducted to compare the growth performance of snow trout (*Schizothorax* sp.) populations collected from three different locations on mid-hills of Nepal. Comparative data on growth rates, food conversion efficiencies and survival rates of snow trout from three different locations are intended to provide useful information for domestication, commercialization as well as conservation of snow trout.

2. MATERIAL AND METHODS

2.1 Sample Origin and Rearing Conditions

All specimens of fish utilized in this experiment were procured by a local fisherman from natural water bodies in Okhaldhung (Dudhkoshi river, Silaurighat), Nuwakot (Suryakunda, Dupcheshowr), and Rasuwa (Naukunda, Pungkhola) during June-July 2023. The captured fish were transported to Fishery Research Station (FRS, Trishuli) in viable condition and acclimated for a period of 2 weeks in three separate raceway tanks. Following acclimation, 450 ostensibly healthy and uniformly sized (initial weight: 20.00 + 1.2g) fish from each location were subjected to a 24-hour fasting period and subsequently stocked randomly into three raceways (300L) as replication for each location as a group at a stocking density of 150 fish per tank. Fish in all tanks were fed a commercial feed (Nutrila, 48% CP, formulated and validated by Directorate of Coldwater Fisheries Research, Bhimtal, India) (Table 1.) at 3% of body weight in the form of dough for 90 days. All tanks were supplied with continuous water flow, and stones and wooden structures were introduced to simulate the natural habitat for Asala. It was presumed that the fish consumed algae developed on the stones and wooden structures, as minimal interventions such as water exchange and tank cleaning were performed.

Table 1. Major Ingredients and proximate composition of commercial feed "Nutrila" as claimed by manufacturer.

Ingredients*	Proximate composition (%)	
Fish meal, Soybean meal, Wheat product, Rice product, Fish oil, Lecithin, Amino acid, Vitamins, and Minerals	Crude protein	48
	Crude fat	16
	Crude fiber	2
	Moisture	12

**Percentage inclusion of individual ingredients (formulation) is not available due to trade secrets (Intellectual property protection).*

2.2 Sampling and growth

After starving for 24 hours, twenty percent of fish from each tank were sampled every 15 days for their body weight to calculate the growth and determine the amount of ration needed. At the end of the experiment, all fish were measured for their weight and length, and the weight gain, specific growth rate, condition factors, and length-weight relationship were calculated using following formula:

Specific growth rate (SGR, %/day) = 100 × [In (Final weight) – In (Initial weight)]/Duration

The length-weight relationship (LWR) between total length (L, cm) and body weight (W, g) was determined from transformed total length and body weight using the following allometric growth equation [7,8]

$$W = aL^b$$
$$\text{Log } W = \text{Log } a + b \text{ Log } L$$

Where, W = weight of fish in (g), L = Total length (TL) of fish in (cm), a = constant related to body form (intercept) and b = the length exponent (slope). The parameters a and b were estimated by linear regression on the transformed equation given by [7].

The condition factor (K) was calculated by the following formula
$K = 100W/ L^3$

2.3 Survival Rate and Water Quality Parameters

The number of dead fish were recorded every day, if noticed at the time of feeding, to calculate the survival rate.
Survival rate (SR, %) = 100 × (Number of fish survived/initial number of fish)

Water quality parameters such as temperature, dissolved oxygen, and pH were recorded daily using multimeter probe. Throughout the experimental period, the average water temperature was 11.75 ± 0.42 ℃, pH at 7.71 ± 0.16, and dissolved oxygen levels was above 7 mg/L in all the tanks.

2.4 Statistical Analysis

The data for the growth parameters, survival and water quality are presented as mean ± standard error of mean (mean ± SE) for three replicates. One-way ANOVA test was conducted on mean data of three replicates followed by TukeyHSD for pairwise comparison when significant difference among the groups were observed using “aov” and “TukeyHSD” function respectively in R Studio (version 4.3.3). The probability level for rejection of the null hypotheses was 0.05.

3. RESULTS AND DISCUSSION

Freshwater fish populations exist in complex environments, with limnological and fisheries factors affecting their dynamics. It has been shown that life history characteristics of fish vary

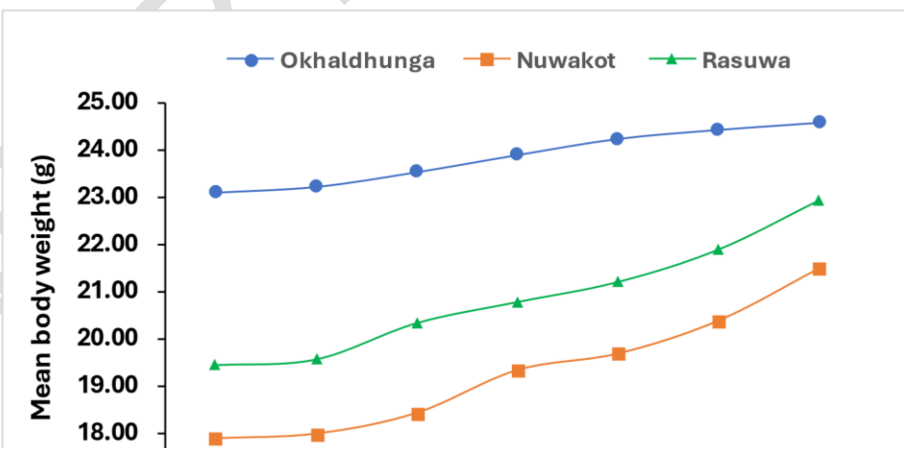

Fig. 1. Growth in weight of Asala collected from Okhaldhunga (rounds), Nuwakot (squares), and Rasuwa (triangles) over a period of 90 days

in space and time [9]. Growth is an important aspect of the life history of fishes and reflects the adaptation to local environments via a wide range of phenotypic plasticity and variations [10]. Consequently, different fish species have been extensively studied but relatively few species have been studied for the intra-specific variation in growth rate within a natural habitat or river system. In our research, we examined the growth rates and length weight relationship (LWR) of snow trout sampled from Dudhkoshi river in Silaurighat Okhaldhung, Suryakunda in Dupcheshowr Nuwakot, and Naukunda in Pungkhola Rasuwa. The growth patterns of Asala sourced from these locations are shown in Fig. 1. Over a span of 90 days in the raceways of the Fisheries Research Station, Trishuli, all groups of fish experienced a gradual yet slow increase in body weight. Starting with a mean body weight of 17.89 ± 2.81 g, the group of fish collected from Nuwakot (Suryakunda, Dupcheshowr) grew to 21.50 ± 1.49 g, exhibiting the highest body weight gain of 3.61 ± 1.82 g in 90 days.

Similarly, Asala from Rasuwa (Naukunda) from its mean body weight 19.46 ± 1.17 g, grew to 22.91 ± 1.58 g, with weight gain of 3.45 ± 0.46 g. Likewise, beginning at mean weight of 20.15 ± 1.95 g, Asala from Okhaldhung (Dudhkoshi river) showed the least increase, 1.47 ± 0.28 g in its mean body weight ending at 22.99 ± 1.75 g in the duration of 90 days. Similarly, during this period, the Asala from Nuwakot exhibited the highest specific growth rate (SGR) at 0.23 ± 0.12% per day, followed by Rasuwa Asala (0.18 ± 0.02% per day), and Okhaldhunga group (0.07 ± 0.02% per day) (Fig. 2). However, the weight gain and SGR in current study for Asala of either of the locations did not vary significantly (P >0.05).

We observed that these fish gained almost 3 grams body weight over a period of 90 days, surpassing the growth rate observed by Rai et al. and Dhar et al. [3, 11]. Dhar and Rai authors reported that Chuche Asala (*Schizothoraichthys progastus*) grew very slow in captivity reaching 7.2 g from 0.7 g in 359 days, while Bucche Asala (*S. plagiostomus*) grew from 1.8 g to 17 g in 295 The current study, in conjunction with previous research, indicates that snow trout exhibit slow growth when cultivated in flow-through raceways. This sluggish growth is likely due to their specialized feeding habits, which involve scraping periphyton and microbiota from riverbed rocks and other substrates, as influenced by their mouth structure [12, 13] which was not a case in captive condition. Another contributing factor to their slow growth in captivity may be the lower temperature (average 11℃) in the current experiment, which may have reduced feed acceptability. Chandra & Ganie [13] reported that optimal feed intake for snow trout occurs at water temperatures between 17℃ and 24℃, with intake gradually decreasing during the winter months.

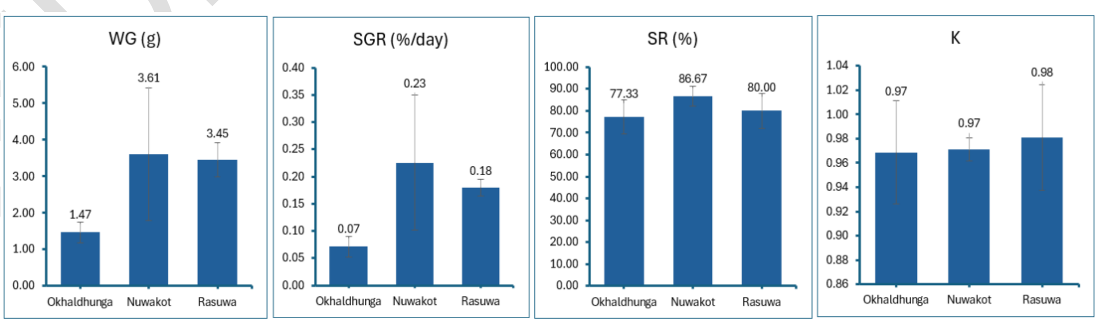

Fig. 2. Production performance of Asala during the experimental period.

In addition, the attainment of maturity at a small size, evident from the oozing of eggs and milt from fish (observed during sampling), can also be attributed to the slower growth of snow trout in captive conditions in the current study. It is because, many authors have considered this as the major constraints for growth [14-16] because the given feed and energy is diverted to develop the gonad and cause the slow growth in the captive condition (Fig. 3).

Fig. 3. Female Asala oozing eggs during sampling. **Photo courtesy: Krishna Paudel, FRS-Trishuli**

Nuwakot snow trout demonstrated the highest survival rate at 86.67% followed by group of fish sourced from Rasuwa (80.00%) and Nuwakot (77.33%) with no significant different in these rates (*P* >0.05). The overall survival rate of over 77% observed in this study suggests that while the water quality parameters were suitable for Asala survival in captivity, they may not have been optimal for promoting faster growth. In fact, this condition was perhaps suitable for the breeding/spawning of the Asala evident by the oozing of eggs and milt from gravid fish during sampling, in line with the report of [13].

There were no significant differences in the condition factors (K) among the fish collected from any of the locations (*P* >0.05). However, the condition factor of fish collected from Rasuwa appeared slightly highest (0.98) followed by Nuwakot and Okhaldhunga group sharing identical K values of 0.97. A K-value of 0.98 or less obtained in this study may indicate that the fish is relatively thin or lacking in body mass. And factors contributing to a low K value could include poor nutrition as they could not properly capture or utilize feed in captive condition [17], stressful condition due to silt in the water, and disease during the culture period.

Similarly, the length-weight relationship (LWR) of Asala were also determined from the transformed total length and body weight form pooled data by the equation ($W = aL^b$) (LeCren, 1951). The calculated weight for the length according to the equation demonstrated that the correlation (R) between LWR was high in all the Asala groups in this experiment indicating strong connections between length-weight relationship (Fig. 4). This research finds support from earlier studies of fish from different water bodies of different locations [18].

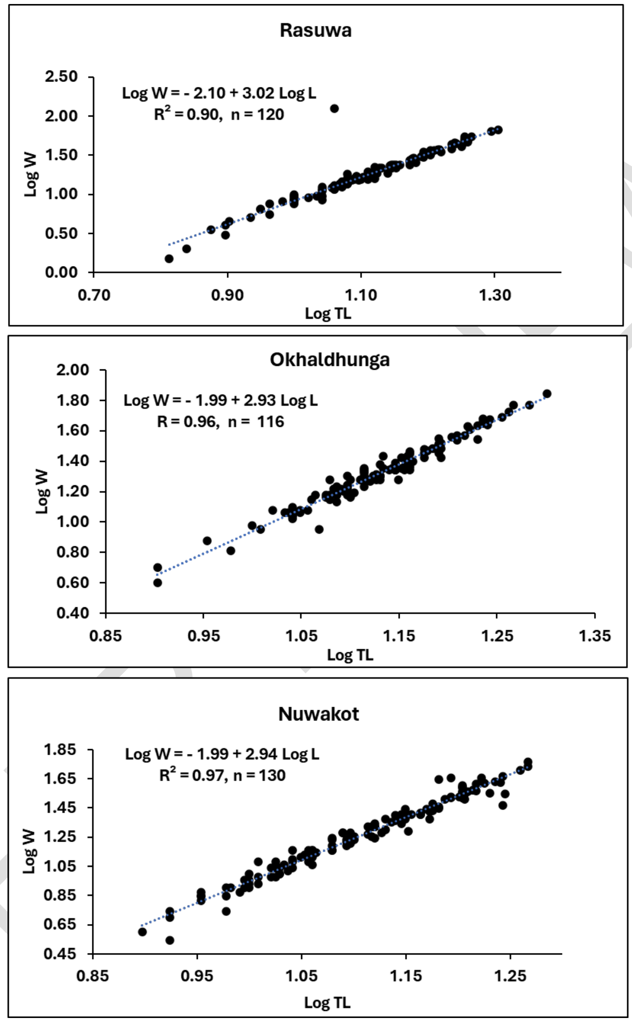

Fig. 4. Length Weight Relationship of Asala from Rasuwa, Okhaldhunga, and Nuwakot.

The LWR gives information of the condition and growth pattern of fish [8]. The log transformed length fitted over weight gives linear growth indicating the three dimensional growth structures of most fish species [19]. Because the value of exponent 'b' for isometric growth is '3' and values greater or less than '3' indicate allometric growth (Wootton, 1990), it was assumed that the Asala from Rasuwa exhibited positive allometric growth patterns (b=3.02) in the current culture condition at the FRS-Trishuli while Asala from Okhaldhunga (2.93) and Nuwakot (2.94) showed negative allometric growth patterns (Fig. 4). Therefore, it was considered that Asala from Rasuwa were in relatively good physiological state being in good welfare condition as reflected by the slightest higher condition factor (K) compared to other groups. Higher condition factor and positive allometric growth pattern exhibited by the Asala from Rasuwa may indicates that this group was making good use of its feeding resources [20] or have well adopted to the raceways of the FRS in comparison to other groups. Condition factor provides information for comparing different populations of fishes living in certain feeding [20] density, climate, and other conditions [19].

Growth is a characteristic feature of living beings. Generally, growth is taken as an incremental change or as a rate of change in any dimension of any organism. However, the growth is usually context specific and is defined as any change in size or amount of body materials, regardless of whether that change is positive or negative, temporary, or long-lasting [21]. Like almost every organism, fish also grow and attain their normal size because of a combination of adaptive responses to varying environmental conditions and genetically determined differences [22]. While environmental conditions are similar, genetic selection plays a crucial role in aquaculture development to characterize these differences. Genetically improved stocks often exhibit more favorable traits than their parent species. Therefore, gene expression, which influences fish health and production, particularly growth rates, must be consider while studying population of fish, particularly wild collected Asala on which such study is currently scarce in Nepal. Such a study would help to obtain data on the genetic basis of variation in snow trout when production performance like growth rate alone could not account the difference among the population like in the current study. Genetic studies are also essential to enhance and develop genetically superior Asala for domestication and will help to identify the population of snow trout with higher growth potential among the Asala populations. Genetic approaches like interspecific hybridization may also help to develop strain with improved growth rates, tolerance of intensive culture conditions and higher survival rates through metamorphosis.

Moreover, deteriorating natural habitat due to agricultural practices, deforestation, pollution, use of poisonous chemicals for fishing, construction of roads and dams, and heavy fishing pressure, have put cold-water fish population including Asala on the verse of low to moderate vulnerability in Nepal, and conservation efforts are not significant. To address these challenges, it is essential to implement a multi-faceted conservation strategy. This should include the establishment of protected areas and no-fishing zones, promoting sustainable fishing practices, and enhancing habitat restoration efforts [23]. Community-based conservation programs should be encouraged to engage local communities in preserving their natural habitat. Additionally, strict regulations and enforcement against the use of harmful chemicals and illegal fishing methods are crucial. Public awareness campaigns and educational programs can also play a significant role in fostering a culture of conservation and sustainability among the local populace.

It is of utmost importance to understand that findings in this study are valid only for the given set of conditions (species, water temperature, diet composition, etc.) and should not be applied blindly at least at this point for snow trout. For instance, findings of this study were obtained at the stocking density of 10 kg/m3 and suitable stocking density for this species is yet to be determined. In fact, there is a need for research that would focus on the best conditions for Asala domestication which may include culture unit, stocking density, illumination regime that mimics a natural photoperiod, thermal regime, sufficient water flow and the use of natural feed for larval, juvenile rearing [23]. Therefore, these gaps needed to be answered to support fully domestication of this species. Beside these, broodstock management techniques which involves technology to culture high quality broodstock, to induce maturation and spawning and to collect gametes and eggs, and successfully incubate eggs should be optimized for breeding in captivity to make the year-round availability of Asala and also to restore declining wild population in the conservation side.

4. CONCLUSION

In conclusion, this study underscores the complexity of snow trout growth dynamics within captive environments, revealing less variability in growth rates and condition factors across different river populations. Despite showing overall slow growth compared to historical data, with similar growth patterns among groups from Nuwakot, Rasuwa, and Okhaldhunga, the results highlight critical aspects of their physiological and environmental adaptation. The observed low growth rates are likely influenced by factors such as suboptimal temperatures and specialized feeding habits, which diverge from the Asala's natural conditions. Notably, the study demonstrates that the current captive environment is conducive to survival and spawning, although genetic and environmental factors might have played a pivotal role in growth performance. Future research should focus on optimizing captive conditions and exploring genetic improvements to enhance growth rates and overall performance. Addressing the challenges of habitat degradation and promoting sustainable practices are also vital for the conservation of this species. The insights gained from this study contribute valuable knowledge to the aquaculture and conservation fields, emphasizing the need for targeted approaches to improve the management and preservation of snow trout populations.

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