LENGTH - WEIGHT RELATIONSHIP, CONDITION FACTOR AND STOMACH CONTENT ANALYSIS OF SNOW TROUT (*Schizothorax richardsonii*, Gray 1932) FROM KHANIKHOLA, KAVREPALANCHOK

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A thesis submitted
In partial fulfillment of the requirements for the award of the degree of Master of Science in Zoology with special paper Fish Biology and Aquaculture

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September, 2019

DECLARATION

I hereby declare that the work presented in this thesis entitled **"Length - weight relationship, Condition factor and Stomach content analysis of snow trout (*Schizothorax richardsonii*, Gray 1932) from Khanikhola, Kavrepalanchok"** has been done by myself, and has not been submitted elsewhere for the award of any degree. All the sources of the information have been specifically acknowledged by reference to the author(s) or institution(s).

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RECOMMENDATION

This is to recommend that the thesis entitled **"Length - weight relationship, Condition factor and Stomach content analysis of snow trout (*Schizothorax richardsonii*, Gray 1932) from Khanikhola, Kavrepalanchok"** has been carried out by Miss Sangita Neupane for the partial fulfillment of Master's degree of Science in Zoology with special paper Fish Biology and Aquaculture. This is her original work and has been carried out under my supervision. To the best of my knowledge, this thesis work has not been submitted for any other degree in any institutions.

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LETTER OF APPROVAL

On the recommendation of supervisor **"Prof. Dr. Kumar Sapkota"** this dissertation submitted by **Miss Sangita Neupane** entitled **"Length - weight relationship, Condition factor and Stomach content analysis of snow trout (*Schizothorax richardsonii*, Gray 1932) from Khanikhola, Kavrepalanchok"** is approved for the examination of the requirements for Master's degree of science with special paper Fish Biology and Aquaculture.

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CERTIFICATE OF ACCEPTANCE

This thesis work submitted by Miss Sangita Neupane entitled **"Length - weight relationship, Condition factor and Stomach content analysis of snow trout (*Schizothorax richardsonii*, Gray 1932) from Khanikhola, Kavrepalanchok"** has been approved as a partial fulfillment for the requirements of Master's degree of Science with special paper Fish Biology and Aquaculture.

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ABSTRACT

Schizothorax richardsonii is the major fishery of the riverine ecosystems in Khanikhola. The main aim of present study is to investigate the length-weight relationship, condition factor and stomach content analysis of *Schizothorax richardsonii*. A total of 116 fish samples including 40 male, 32 female and 44 juveniles were collected seasonally from October 2018 to April 2019. The total length ranged from 7.8cm to 27.8cm and the weight ranged from 4.8g to 255.1g. The length weight relationship was $W = 0.0041 * TL\hat{}3.2979$ ($R^2 = 0.9311$), $W = 0.01144 * TL\hat{}2.913$ ($R^2 = 0.9551$) and $W = 0.02234 * TL\hat{}2.63$ ($R^2 = 0.9956$) were separately calculated for Autumn, Winter, Spring season respectively. The values of b for Autumn, Winter, Spring season were 3.29, 2.91, 2.63 respectively, which show allometric growth pattern in *Schizothorax richardsonii*. There was strong correlation between the length and weight of this fish in different season. The condition factor (K) range of between 0.75 and 1.21 was an indication that the fishes were thriving well in the River. Dissection of fish samples were made for food and feeding habits determination. . From the total number (104) of fishes, 92(88.46%) stomach were observed with food and remaining 12(11.54%) were empty. The major food items found in the stomach content was phytoplankton and detritus. Frequency of occurrence, and volumetric analysis index method were applied for stomach content analysis. Basic food of this fish mainly comprised of Bacillariophyceae (80.25%), Chlorophyceae (6.25%), Cyanophyceae (5.705%), Charophyceae (0.54%), insects (0.54%) and miscellaneous items (6.52%). In conclusion, the fish was found allometric in growth and herbivorous in nature.

Keywords: Length-weight relationship, Condition factor, isometric, allometric, gastrosomatic index

1. INTRODUCTION

1.1 Background

Fishes are the most fascinating and remarkable form of animal life in the world, which dominates the water of the world through a marvellous variety of the morphological, physiological and behavioural adaptations. The fresh water sources like rivers, canals, springs etc. have different type of fish species owing to different habitats; as such they develop different types of feeding habits. The fishes have become adapted to a wide variety of food and are either herbivorous or carnivorous or omnivorous in habits. Feeding is the dominant activity of their entire life cycle as food is an important factor in the biology extending to the basic functions of an organism for example growth, development, reproduction, feeding and migratory movements, and these entire takes place at the expense of energy which enter the organism through its food.

Pic.1: *Schizothorax richardsonii* (Gray 1832)

Schizothorax richardsonii (Gray 1832) is a coldwater fish, commonly known as Asala or Snowtrout, formed a substantial natural fishery in the major riverine ecosystem of Nepal. The distribution of this cyprinid species is confined to the rivers and streams of Himalayan foot hills across the country. Besides Nepal, this species is distributed in India, Bhutan, Pakistan and Afghanistan (Talwar and Jhingran 1991). Although *S. richardsonii* is widely distributed along the Himalayan foothills, its populations have been declined from many areas due to introduction of exotic species, damming and overfishing (Negi and Negi 2010). *Schizothorax* sp. generally prefers to dwell in snow-fed rivers or streams with temperature ranging between 8-22 °C.

1.1.1 Length-weight relationship

Growth is a fundamental characteristic of all living organisms and growth pattern and growth rates are highly species specific. Various patterns of growth occur among organisms, for example in fishes both isometric and allometric growths occur in fishes. Isometric growth occurs when an organ grows at the same rate as the rest of the body while allometric growth occurs when an organ grows at a different rate from the rest of the body (Taylor et al. 2005). The growth pattern may be positive or negative. Positive growth occurs when anabolism exceeds catabolism and the fish becomes relatively stouter or deeper-bodied as it increases in length, whereas negative growth occurs when catabolism exceeds anabolism and fish becomes more slender as it increases in weight.

Length-weight relationship (LWR) is of great importance in fishery assessments (Ayoade et al. 2007). Length and weight measurements in conjunction with age data can give information on the fish stock, age maturity, life span, mortality, growth and reproduction (Kumar et al. 2014). Length-weight relationship of fish is widely recognized as an important tool in fisheries science especially in ecology population dynamic and stock management (Abdoli et al. 2008). The Length-weight relationship (LWR) is also essential for predicting the condition of growth pattern. The Length-weight relationship permits estimating the weight of a specimen easily when the total length is known, these relationships are useful when rapid estimation of biomass is necessary (Froese 1998). The analysis of length-weight data is aimed at describing exactly the relationships between length and weight to allow adaptation of one to another. It also measures the changes from the predictable weight for length of separate fish (Dan-Kishiya 2013).

1.1.2 Condition factor

The condition factor in fish serves as an indicator of physiological state of the fish in relation to its welfare (Le Cren 1951) and also provides information when comparing two populations living in certain feeding density, climate and other conditions (Weatherly and Gills 1987). Thus, condition factor is important in understanding the life cycle of fish species and it contributes to adequate management of these species, hence, maintaining the equilibrium in the ecosystem (Imam et al. 2010). The higher value of the condition factor indicates the better condition of the species as well as the ecosystem.

1.1.3 Stomach content analysis

Stomach content analysis (qualitative and quantitative) provides important insight into fish feeding patterns and quantitative assessment of food habits is an important aspect of fisheries management. Diets of fishes represent an integration of many important ecological components that included behaviour, condition, habitat use, energy intake and inter/intra specific interactions. A food habit study might be conducted to determine the most frequently consumed prey or to determine the relative importance of different food types to fish nutrition and to quantify the consumption rate of individual prey types. It is well known that food and feeding habits, not only show great variation among different species, but it also brings morphological variations and modifications in their body parts especially in mouth. Further, the study of feeding behaviour at different stage of life as well as the qualitative and quantitative study of its stomach has great importance.

The study of the feeding habits of different animals based upon examination of stomach content has turned into a standard practice (Hyslop 1980). Stomach content analysis provides important insight into fish feeding patterns and quantitative assessment of food habits is an important aspect of fisheries management. Accurate description of fish diets and feeding habits also provides the basis for understanding trophic interactions in aquatic food webs. Stomach content analysis is important to determine the relative importance of different food types to fish nutrition and to quantify the consumption rate of individual prey types. The present investigation on food and feeding habits of *Schizothorax richardsonii* is important in fisheries biology study and therefore aims at providing further information on growth pattern, condition factor, nourishment and abundance of foods, needed by fish.

1.2 OBJECTIVES

1.2.1 General objective

- To investigate the length - weight relationship, condition factor and stomach content analysis of snow trout (*Schizothorax richardsonii*, Gray 1932) from khanikhola, kavrepalanchok.

1.2.2 Specific objectives

- To investigate the length - weight relationship.
- To determine condition factor.
- To determine gastrosomatic index.
- To analyze the stomach content.

1.3 RESEARCH QUESTIONS

- What is the growth pattern and condition (well being) of *Schizothorax richardsonii* of Khanikhola?
- How does the growth pattern of fish is affected by seasonal variation?
- What is the feeding habit of *Schizothorax richardsonii*?

1.4 RATIONALE

1.4.1 Justification of the study

In the field of research in fisheries, morphological study with stomach content analysis of indigenous fish, *Schizothorax richardsonii* is still unexplored. Food and feeding habit, growth performance and condition factor are important aspects in fish life, fisheries management and conservation. So, the investigation of length weight relationship, condition factor, and stomach content analysis of *Schizothorax richardsonii* from Khanikhola, will provide some valuable information about the growth of the fish, its general wellbeing, and fitness which has great importance in management and conservation of species.

2 LITERATURE REVIEW

Growth and reproduction, like all the vital processes of life, require energy which is provided by the food. Study of food and feeding, growth and condition factor are important aspects of life. Understanding food, feeding and nutrition of fish is one of the essential prerequisite for successful aquaculture production. Many workers have studied feeding, and growth in a number of fishes in nature and in captivity. In the following pages an attempt has been made to review the important contribution made by different workers on the food and feeding, length - weight relationship fishes from different parts of the world.

2.1 Length - weight relationship

The Length-weight relationship of fish also known as growth index is an important fishery management tool. It is vital in estimating the average weight at a given length group (Abowei and Davies 2009; Abowei 2010). Jomabo et al. (2009) reported that LWRs of fishes are important in fisheries biology and population dynamics where many stock assessment models require the use of LWR parameters. Study showed that growth patterns of *Tilapia zilli, Tilapia mariae, Oreochromis niloticus, Barbus occidentalis* and *Barilius loati* were negatively allometric with "b" value range of between 1.4 and 2.3 (Dan – Kishiya 2013). Similar results were reported on length-weight relationship of *Leuciscus niloticus* by Olopade et al. (2015) exhibiting negative allometric growth pattern with "b" values 2.56, 2.62 and 2.38 for pooled, male and female was LogW = -1.679 + 2.559 log TL, Log W = -1.759 + 2.618 log TL, Log W = -1.449 + 2.384 log TL respectively. Moreover, the length weight relationship of *Synodontis schall* was LogW =Log - 1.0458 +2.5290 LogL, LogW = log - 1.0198 + 2.4977 LogL, LogW = Log -1.2072 + 2.6749 LogL for male, female and combined sex respectively indicating negative allometric growth pattern (Akombo et al. 2014). Hashim et al. (2017) observed similar results on *Scatophagus argus* with negatively allometric growth pattern ($b<3$) indicating the weight increment lesser than length increment. The growth pattern of *Aleste baremose* was also negative allometric however, male *A. baremose* had better ‘b’ value (2.83) than the female (2.76). Hanjavanit et al. (2013) reported that *Syncrossus helodes* exhibited negative allometric growth in both dry-hot and the dry-cool season. Similar results were also reported by (Muchlisin et al. 2015) in keureling fish (*Tor tambra)* with b<3.

The exponent ‘b’ of spotted snake head *Channa puntata* was in the range of 2.7675 to 4.3922 under different feeding regimes (Datta et al. 2013). The growth pattern of tilapia species (*Tilapia zillii* and *Oreochromis urolepis*) was found to be negative allometric growth in fresh water and positive allometric growth in full strength sea water (FSSW) (Nehemia et al. 2012). This study also revealed that the farming of tilapia species in FSSW can be feasible if water quality parameters are properly monitored. Hanjavanit et al. (2013) found that *Yasuhikotakia modesta* exhibit positive allometric growth with b>3 in both dry-hot and the dry-cool season. Similar results were obtained on LWR of *Phycis blennoides* with exponent 'b' value greater than 3 (Romdhani, et al. 2013).

The results on length weight relationship of *Phycis phycis* indicated that the growth is isometric b=3 (Romdhani et al. 2013). Similar result were obtained by (Marcus 2015) when analyzing of length weight relationship of *Labeo barbus intermedius* and indicated that the relation between TL and TW is curvilinear and significant (TW = 0.014 TL=2.9) showing isometric growth pattern. Khan et al., (2017) found that the 'b' value of *Oreochromis mossambicus* for combined, male and female were 3.01, 3.02 and 2.99 respectively, showing isometric growth. The length weight relationship was represented as logarithmic form as Log W = -1.751+3.0071 × Log L, Log W= 1.7719+3.0212×Log L and Log W= -1.7272+2.9913×Log L for combined, male and female population respectively.

2.2 Condition factor

The condition factor depends on various ecological and biological factors such as the gonadal development of the species, age, food availability, stress and suitability of the environment (Gregoer 1959) and (Khallaf et al. 2003). The greater value of the condition factor indicates the wellness of the species as well as the ecosystem. Romdhani et al. (2013) found better condition for *Phycis phycis* between January and August while decreases in condition factor between September and November. However, changes in condition factor were increased during March to August and remain the same during rest of year for *P. blennoides*. The condition factor ‘K’ of spotted snake head *Channa puntata* was above 1.0 (1.094 - 1.235) indicating robustness or well being of experimented fish (Datta et al. 2013). Similar results were obtained for tilapia species (*Tilapia zillii* 2.07 and *Oreochromis urolepis* 0.86) in fresh water (Nehemia et al. 2012). Akombo et al. (2014) observed mean condition factor of 2.874, 2.83 and 2.855 for the females, males and combined sexes of *Synodontis schall* respectively, indicating better condition of fish. Similar results were reported by (Nwachi 2016) on *Chrysichthys nigrodigitatus* (Lacepede) (Km=1.67). Hashim et al. (2017) also found condition factor greater than 1 for *Scatophagus argus* indicating the wellbeing of fish. Condition factor of female *Aleste baremose* is higher than in male (Apochi et al. 2017). The K values for *Syncrossus helodes* in the dry-hot season and *Yasuhikotakia modesta* in both (dry-hot and dry-cool) seasons were greater than one, showing that they were in good condition (Hanjavanit et al. 2013). Similar results were obtained by (Muchlisin et al. 2015) on *Oreochromis mossambicus* indicating the rivers were still in good condition and supported fish life.

Olopade et al. (2015) found mean condition factor (k) of 0.55 ± 0.08 for pooled, 0.54 ± 0.08 and 0.55 ± 0.09 for both male and female *Leuciscus niloticus* respectively, indicating poor adaptation of this fish in the Epe lagoon. Similar results were obtained by (Nehemia et al. 2012) on *Tilapia zillii* and *Oreochromis urolepis* (K=0.74 and 0.53 respectively) in full strength sea water. The condition factor (K) for *Syncrossus helodes* in the dry-cool season was lower than one, which indicated that the fish was in poor condition (Hanjavanit et al., 2013).

2.3 Food and feeding habit

The food and feeding ecology of fish species has been a subject of great interest to ichthyologist world over. Kaundal (2012) reported that *Sizothorax richardsonii*, *Garra gotyla gotyla* and *Crossocheilus latius latius* is bottom feeder, with ventrally situated mouth whereas in *Barilius bendelisis*, *Puntius ticto* and *Mastacembelus armatus* mouth was anterior. *P. ticto* and *M*. armatus have adopted column feeding habit while *B. bendelisis* is a surface feeder. *Chrysichthys nigrodigitatus* (Lacepede) is bottom dwelling fish (Nwachi 2016). Mangi and Memon (2017) shown that in *Cyprinus carpio*, the highest percentage of fullness (100%) of the gut was found in the month of August, September and October and the lowest percentage of fullness (28.6%) was found in January. Hynes (1950) has reviewed several methods used in the study of food of fish. These methods are the occurrence method, the number method, the dominance method, the volume and weight method, the fullness of stomach method and point method. In frequency of occurrence method, the number of stomach containing each food item will be quantified and expressed as a (%) of all stomachs (Frost 1954). In number method, the number of individuals in each food category will be recorded for all stomachs and the total will be expressed as a proportion, usually a percentage, of the total individuals in all food categories (e.g. Crisp et al. 1978; Ikusemiju and Olaniyan 1977). The mean number of individuals per stomach in each food category may be calculated (Bulkley et al. 1976; Neill 1938; Smyly 1952; Straskraba et al. 1966). In point method, the food items in each fish stomach will be listed as common, frequent, etc., on the basis of rough counts and judgment by eye, due regard being given to the size of the organisms as well as to their abundance. Each category will be then allotted a number of points and all the points gained by each food item will be summed and scaled down to percentage, to give percentage composition of the food of all the fish examined (Hynes 1950; Hyslop 1980).

Indivarid and Upalis (2014) applied frequency of occurrence method for estimation of diet composition of *Ehirava fluviatilis* and shown that this fish is omnivorous. Bakhtiyar (2017) found that *Labeo rohita* is omnivore-planktophage in early stages of life and hervi-omnivore in adult stage. Mangi and Memon (2017) reported that *Cyprinus carpio* is omnivorous in its feeding with considerable seasonal variations. *Synodontis schall* is an omnivore feeding on variety of food items comprising of different types of algae, plant materials, insects parts and larvae, fish parts, worms, molluscs, diatoms, crustaceans, artificial corn meal, different types of grain, detritus, mud and many unidentified food items (Akombo et al. 2014). Similar results were found by (Nwachi 2016) in *Chrysichthys nigrodigitatus* (Lacepede) that the feeding habit of the fish is omnivore. *Scatophagus argus* is omnivorous and opportunistic feeder with dominant food item algae and detritus followed by crustaceans and fish (Hashim et al. 2017).The most preferred food item by *Labeo barbus intermedius* is detritus, insects, phytoplankton and gastropods showing omnivorous in nature (Marcus 2015).

Similar results were obtained by (Muchlisin et al. 2015) suggesting that keureling (*Tor tambra*) is omnivorous, feeding on freshwater green algae and earthworms. Khan et al. (2017) applied point volumetric method (Pillay 1952) and frequency of occurrence method (Hynes 1950) for analysis of stomach content of *Oreochromis mossambicus* and revealed that the basic food of this fish mainly comprised of cynophyta and bacillariophyta followed by euglenophycea, chlorophyta, miscellaneous, copepod, plant matter, rotifers and algae indicating omnivorous in nature.

Hanjavanit et al. (2013) reported that *Syncrossus helodes* and *Yasuhikotakia modesta* are carnivorous fish feeding on dipteran larvae, trichopteran larvae, ephemeropteran larvae, hemiptera, terrestrial dipteran adults, green algae and zooplankton. The proportion of cladocerans in stomach contents of threadfin shad differed significantly from spring to winter in Las Vegas Bay whereas the proportion of copepods did not show statistically relevant differences regarding seasonality (Loomis et al. 2011).

It could be seen from the above literature that the food and feeding habits, length-weight relationship have been studied by a number of workers from time to time. Though there are few reports in feeding habit of *Schizothorax* but there is no detailed information so far on the Length- weight relationship, condition factor, food and feeding habit of *Schizothorax richardsonii*, the indigenous fish in the context of Nepal. So, the present work was undertaken to fill this gap and it is hoped that stomach content analysis will be useful in preparation of artificial feed and it will help in rearing this fish under controlled conditions which will help in preventing the decline of this fish by producing fully viable seed ready for release into different rivers and lakes of the country.

3 MATERIALS AND METHODS

3.1 Study area

Khani Khola, present study area is the main river of Kavrepalanchok district. It originates from foothills of Narayanthan and flows from east to west through Phalametar and joins with Bagmati at Hattisar and reach to Makwanpur district. Water of Khani khola is clear except at rainy season and is the source of drinking water of that area. Rocks are the dominant river bed at upstream whereas pebbles, gravel and sand are the dominant river bed at downstream.

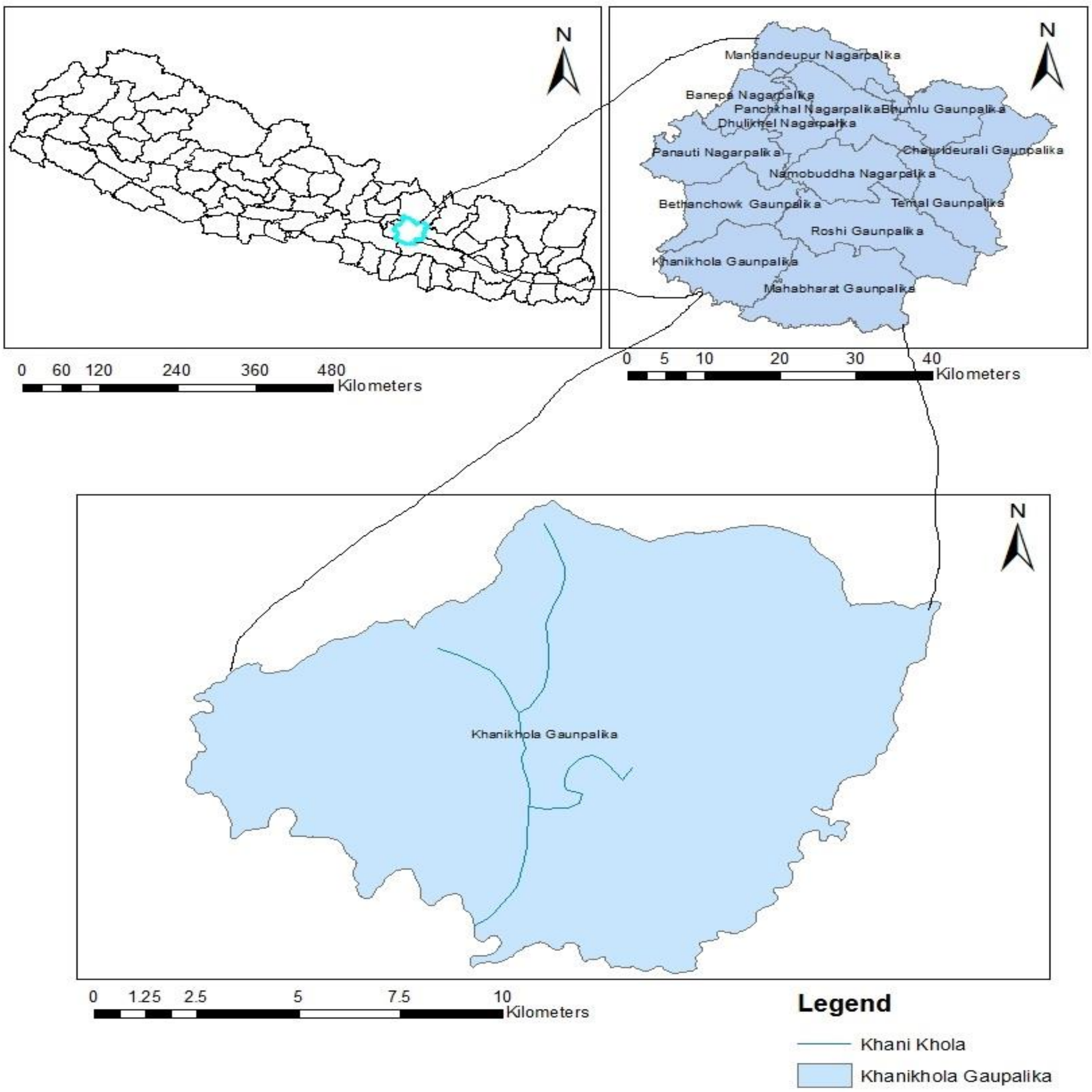

Fig2. Map of study area

3.2 Materials

- Cast net (10mm mesh size)
- Weighing balance
- Dissecting equipments
- Dissecting pan
- Compound microscope

3.3 Methods

3.3.1 Length and Weight measurement

Measurement of Total Length (TL) and standard length (SL) of fish was done with a ruler nearest to 0.1cm. Total length of fishes was measured from the tip of the snout to the tip of tail fin and standard length was measured from tip of the snout to the base of caudal fin. Body weight of fishes was measured nearest to 0.1g using with a weighing balance.

3.3.2 Fish dissection

The fishes were dissected by using a surgical scissors, and then their stomachs were taken and preserved in 100% ethanol. After completion of field work, stomach samples were immediately transported to the CDZ fisheries laboratory for further analysis.

3.3.3 Diet analysis

Weight of the stomach was measured with a weighing balance to determine the Gastrosomatic index. The stomachs were dissected vertically and the contents were measured and emptied into a petri-dish for microscopic examination. Volumetric and frequency of occurrence method were employed to analyze stomach contents for the determination of diet composition as described by Hyslop (1980).

3.3.4 Data analysis

3.3.4.1 Length weight relationship

To study the length weight relationship, the Total length (TL) and total weight (W) were observed to find out the variation from the expected weight of an individual fish with a specific length in order to ascertain the pattern of growth and standard well being, of the fish. The data of length weight relationship were analyzed by following the (Le cren's 1951) method.

$W = a\ TL^b$

$\text{Log } W = \log a + b \log TL$

W is the total weight, TL is the total length, (a) is the coefficient related to body form and (b) is an exponent indicating isometric growth when equal to 3 and allometric growth when different to 3 (the allometry is majorant if $b > 3$ and minorant if $b < 3$) (Froese 2006). The degrees of association between variables (TL and W) were assessed by the coefficient of determination (r^2).

3.3.4.2 Condition factor (K)

The condition factors (K) will be calculated for individual fish species for each season using the conventional formulae described by (Worthington and Richardo 1930) as:

$$K = \frac{W \times 100}{L^3}$$

3.3.4.3 Gastro-Somatic-Index (G.S.I)

The variation in the feeding intensity of *Schizothorax richardsonii* in different season was calculated by using the standard formula (Bhatnagar and Karamchandani 1970) given as below:

$$\text{G.S.I} = \frac{\text{Weight of stomach}}{\text{Weight of fish}} \times 100$$

3.3.4.4 Qualitative and quantitative analysis of gut content

Methods of gut contents analysis are broadly divisible into two categories viz., qualitative and quantitative. The qualitative analysis consists of a complete identification of the organisms in the stomach contents. Quantitative methods of analysis are three types, viz., numerical, gravimetric and volumetric. All these types of analysis are widely employed by different workers. But in the present study the volumetric method and numerical method (Wolfert and Miller 1978) were used.

3.3.4.5 Index of fullness

An important fact assessed by the examination of the stomach is the state or the intensity of feeding. This was judged by the degree of distension of the stomach or by the quantity of food contained in it. The distension of the stomach was observed and classified as 'full or distended', 'moderate', 'half and 'empty' by eye estimation.

3.3.4.6 Frequency of occurrence method

The simplest way of recording data obtained from stomach contents is to record the number of stomachs containing one or more individuals of each food category by using the frequency of occurrence method. The number of stomach containing each food item will be quantified and expressed as a (%) of all stomachs (Frost 1954).

$$\text{Frequency of occurrence} = \frac{\text{No. of fish containing particular food item}}{\text{No. of fish with food in their stomach}} \times 100$$

3.3.4.7 Volumetric Analysis Index

Volumetric Analysis Index indicates the relative abundance of a particular item found in the stomach samples. Its calculation is based on points ascribed to distinct food items after a simple visual inspection of the stomach's food contents (Lima-Junior et al. 2001). This procedure should be executed by a constant reference called Standard Weight (SW).

The Standard Weight (SW) is the arithmetic mean of weights of stomach contents of specimens. The calculated SW in the first sample was used as a constant value for the analysis of the subsequent samples, so that comparisons could be made. To analyze seasonal variations for fish diet, SW was calculated based on the material of the first sample and used it as a constant to analyze what has been reported in other seasons. Once SW has been adopted, the next step was to ascribe points (using integers) in a separate way to each stomach for analysis, according to its proportional weight in relation to the SW. Thus, a practically empty stomach with its total contents representing a weight of approximately 25% of the SW was ascribed only 1 point. On the other hand, a stomach whose total contents were double the SW received 8 points. In the next step, the points were distributed obtained for each stomach content, among the items in this stomach, in proportion to the volume each item occupied.

If necessary, points ascribed may be fractions, but, as inspections are somewhat subjective, such values should not differ from 0.5. So, if a stomach content composed of several items received, as a whole, only 1 point, this point was divided between the two most abundant items. Consequently, the less abundant items present in this stomach failed to receive any punctuation. The points ascribed to each food item found in a sample of stomachs were transformed into an arithmetical mean:

$$M_i = \sum i / n$$

Where, M_i: mean of the ascribed points for the i food item

$\sum i$: sum of the ascribed points for the i food item

n: total number of stomachs with food in the sample.

The value of M_i, calculated for each food item, showed values from 0 to 4. This value was transformed in a percentage for an easy interpretation of results by using the following formula:

$V_i = 25 M_i$

Where: V_i: Volumetric Analysis Index of the *i* food item in the sample

25: multiplication constant to obtain a percentage

M_i: mean of ascribed points for *i* food item.

i: individual food item

4 RESULTS

4.1 Length, weight and condition factor of fish

In the present study, a total of 116 samples of *Schizothorax richardsonii* were collected seasonally from October 2018 to April 2019 by using cast net and analyzed to investigate the main objectives of the study. In Autumn season, 36 individuals of *S. richardsonii* ranging between 11 - 27.8cm TL with mean 14.57 and 14 - 255.1g of body weight with mean 40.27 were collected (Table 1.1). A total of 46 samples of TL ranging between 12.4 - 27.2cm with mean 17.11 and 10.5 - 144.1g of body weight with mean 53.025 were analyzed during the winter season. During spring season, 34 specimen comprising of TL 78 – 17cm with mean 12.19 and body weight of 4.8-40.9 with mean 18.876 were analyzed (Table 1.1).

Table 1.1: Length, weight and condition factor of fish in autumn, winter and spring season

	Autumn season	Winter season	Spring season
No. of fish examined	36	46	34
Total length (cm) (range)	11 - 27.8	12.4 - 27.2	7.8 - 17
Standard length (cm) (range)	9 - 23.2	8.6 - 23	6.6 - 13.9
Weight (g) (range)	14 - 255.1	10.5 - 144.1	4.8-40.9
Total length (Mean)	14.57	17.11	12.19
Weight (Mean)	40.27	53.025	18.876
ln(TL) (range)	2.39 - 3.32	2.36 - 3.3	2.05 -2.83
ln(W) (range)	2.34 - 5.54	2.35 -5.2	1.57 -3.71
Condition factor (K) (range)	0.9 - 1.19	0.76-1.21	0.75-1.15
Condition factor (Mean)	0.97	0.88	0.90

The mean condition factor (K) of collected fish was 0.97, 0.88, 0.90, for Autumn, Winter, Spring season respectively. This result showed that *S. richardsonii* was in better condition in Khanikhola.

4.2 Length weight relationship

A total of 116 individuals of *S. richardsonii* (32 females, 40 males and 44 juveniles) ranging between 7.8-27.8cm TL and 4.8-255.1g body weights were investigated. The length-weight relationships of *S. richardsonii* as calculated on pulled data can be expressed by the equations: $W = 0.0041 \times TL^{3.297}$ (r^2=0.9311) for autumn season, $W = 0.01144 \times TL^{2.913}$ (r^2=0.9551) for winter and $W = 0.02234 \times TL^{2.63}$ (r^2=0.9956) for spring season (Fig: 1; 2; 3).

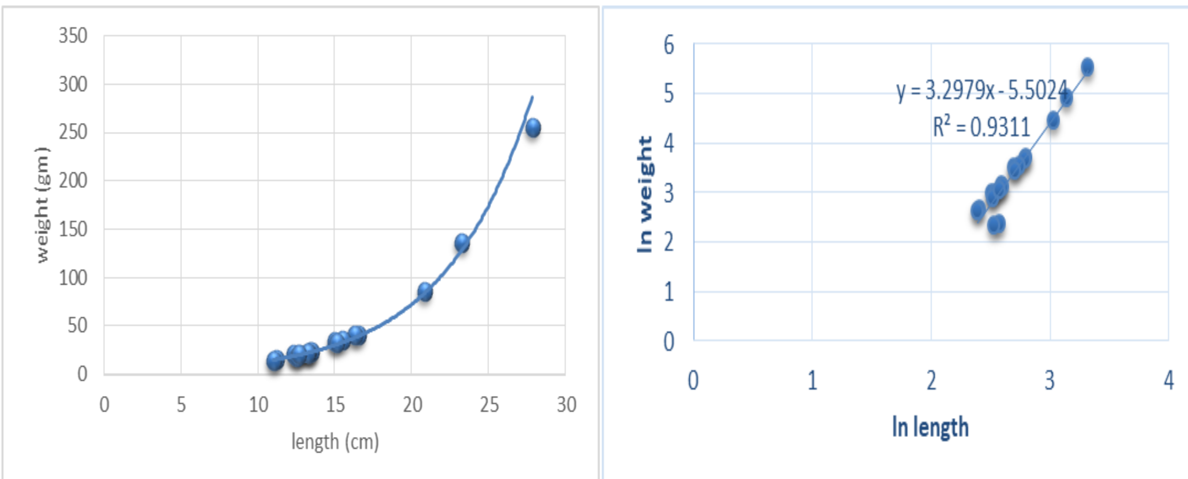

Fig: 1: Length and weight (left) with logarithmic relationship (right) of *S. richardsonii* in Autumn season

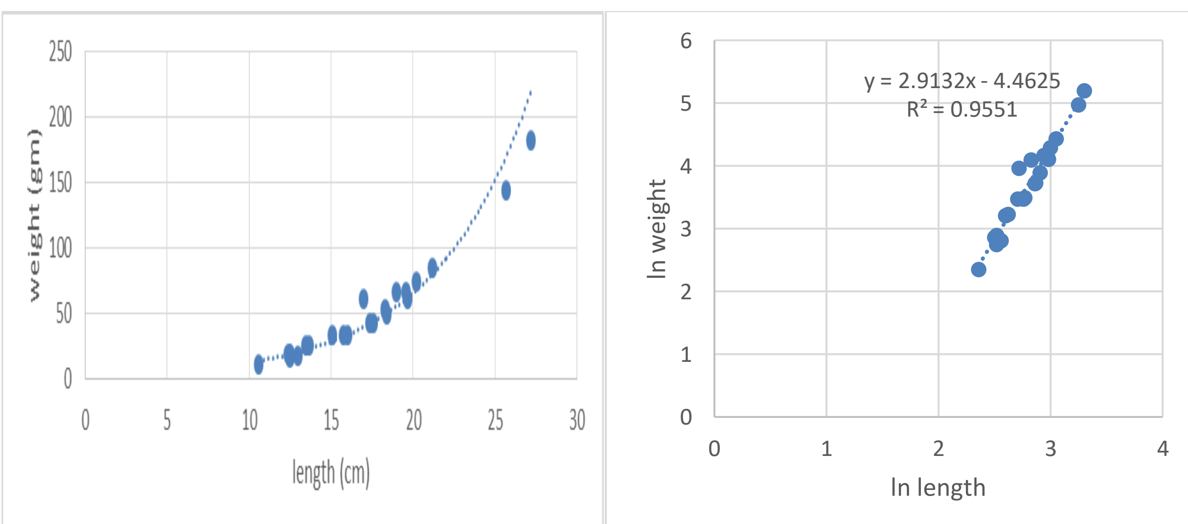

Fig: 2: Length and weight (left) with logarithmic relationship (right) of *S. richardsonii* in Winter season

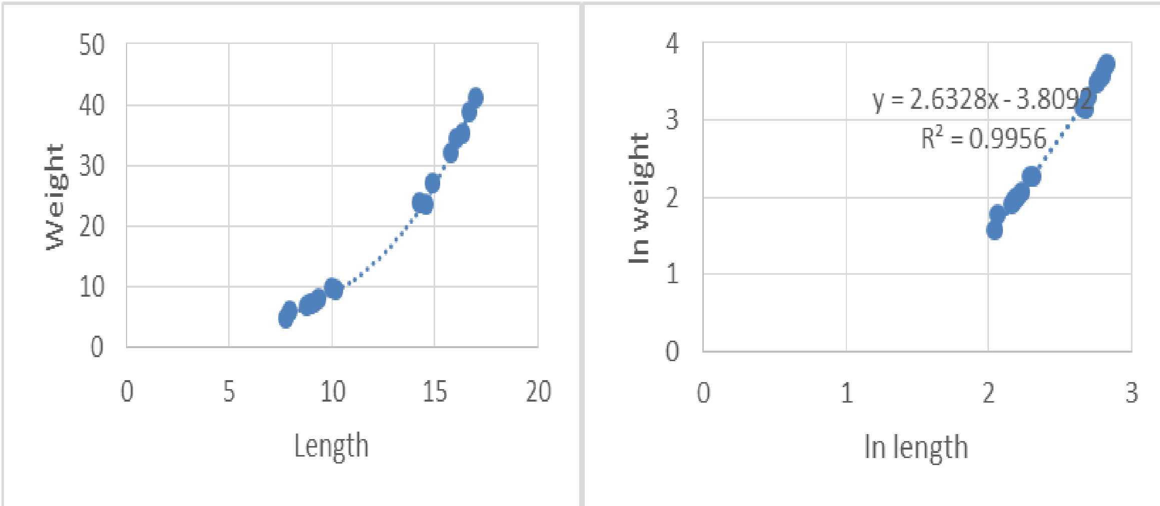

Fig: 3: Length and weight (left) with logarithmic relationship (right) of S. richardsonii in Spring season

The value of *b* greater than 3 in Autumn season showed that the fish possessed positive allometric growth pattern however the fish possessed negative allometry in Winter and Spring season with *b* value 2.913 and 2.63 respectively. Apart from this, the coefficient of determination (r^2) was closer to 1 indicating positive correlation between length and weight (Table 1.2).

Table 1.2: The length-weight relationship of S. richardsonii for different season

Season	a	b	r^2	$W = aTL^b$	Growth pattern
Autumn	0.0041	3.297	0.9311	$W = 0.0041 \times TL^{3.297}$	Positive allometric
Winter	0.01144	2.913	0.9551	$W = 0.01144 \times TL^{2.913}$	Negative allometric
Spring	0.02234	2.63	0.9956	$W = 0.02234 \times TL^{2.63}$	Negative allometric

4.3 Gastro-Somatic-Index (G.S.I)

Out of 116 stomach samples collected, 12 samples were discarded because of degradation. Gastro-Somatic-Index (G.S.I) of 104 specimens was determined individually. The maximum mean G.S.I. (2.011) was obtained in Autumn season whereas minimum G.S.I. was found in

Winter season. The G.S.I. varied slightly among the collected samples, indicating that fish feed at different rates. The mean value of G.S.I. was determined and summarized in Table1.3.

Table 1.3: G.S.I. of *S. richardsonii* for different season

Season	No. of fish examined	Mean Total length	G.S.I. (range)	Mean G.S.I.
Autumn	30	14.57	0.77 - 4.2	2.011
Winter	40	17.11	0.18 - 2.48	1.165
Spring	34	12.19	1.25 - 3.41	1.726

4.4 Qualitative and quantitative analysis of stomach content

The stomach of 104 specimens ranging from 8 -27.8cm were analyzed to depict the food and feeding habit. A total of 14 genera of Bacillariophyceae, 3 of Chlorophyceae and Cyanophyceae and 1 of Charophyceae were recorded from their stomach respectively. Bacillariophyceae constituted the major part in the diet of fish. The most dominant genera were *Navicula, Synedra, Fragilaria, Surrirella, Pinnularia, Amphora* and *Cymbella*. The Chlorophyceae contributes as second major component of fish food. The genera like *Nitzchia, Gomphonema, Epithemia, Acnanthes, Asterionella, Gyrosigma and Rhoicosphenia* in Bacillariophyceae and *Ulothix, Spirogyra, Chlorella* in Chlorophyceae and *Oscillatoria, Anacystis* and *Rivularia* found to be comparatively less than other genera. Charophyceae constituted a small portion in food items which was represented by *Chara*. Animal matter consisted of insect parts. Some sand particles/ detritus organic matter/ undigested material categorised as miscellaneous matter were also found in the stomach.

Table 1.4: Food items in the stomach of S. richardsonii

	Food groups	Food items
Plant Matter (93.28%)	Bacillariophyceae	*Amphora, Synedra, Navicula, Gomphonema, Cymbella, Pinnularia, Fragillaria, Nitzschia, Asterionella, Surirella, Epithemia, Gyrosigma, Rhoicosphenia*
	Chlorophyceae	*Spirogyra, Ulothrix, Chlorella*
	Cyanophyceae	*Oscillatoria, Anacystis, Rivularia*
Animal Matter (0.54%)	Insect	Insect parts
Miscellaneous items (6.52%)		Sand, detritus, unidentified materials

4.5 Index of fullness

The feeding intensity was investigated from the percentage of gut fullness or emptiness. It was observed that out of 104 stomachs, 92 guts contained food while 12 were found to be empty.

Table 1.5: Percentage of stomach fullness

Season	% of full stomach	% of moderate stomach	% of half stomach	% of 25% stomach	% of empty stomach
Autumn	46.67	20	13.33	6.67	13.33
Winter	35	5	20	20	20
Spring	29.41	23.53	29.41	17.65	-

The fish inferred the percentage of full stomach as 46.67%, 35%, 29.41% in autumn, winter, spring, season respectively. Similarly, highest percentage (23.53%) and lowest percentage (5%) of moderate stomach were observed in autumn and spring season respectively. In autumn and winter season, 13.33% and 20% of fishes were with empty stomach respectively

(Table 1.5). But in case of spring season 100% of fishes were with at least considerable amount food in their stomach as shown in table 1.5.

Among all the food groups the highest frequency of occurrence and volumetric analysis index was noticed in case of Bacillariophyceae and miscellaneous items like debris/detritus/sand/unidentified materials etc., being followed by Chlorophyceae and Cyanophyceae. The frequency of occurrence of Bacillariophyceae and miscellaneous items was 100(%) with volumetric analysis index 80.75% and 6.52% respectively. The respective value of frequency of occurrence, ascribed points and volumetric analysis index for each food component was investigated and summarized in Table1.6 and 1.7. The overall percentage of plant based diet was 93.24 (%) while animal based diet and miscellaneous items accounted for 0.54(%) and 6.52(%) only which attributed its herbivorous feeding habit.

Table 1.6: Diet composition based on frequency of occurrence

	No. of fish in which occurred	Percentage of occurrence
Insect parts	14	15.21
Bacillariophyceae	92	100
Chlorophyceae	56	60.87
Cyanophyceae	50	54.35
Charophyceae	4	4.35
Miscellaneous items	92	100

Table 1.7: Diet composition based on volumetric analysis index

	Ascribed points	Mean (M*i*)	Volumetric analysis index (25M*i*)
Insect parts	1	0.022	0.54
Bacillariophyceae	149	3.239	80.75
Chlorophyceae	11.5	0.25	6.25
Cyanophyceae	10.5	0.228	5.705
Charophyceae	1	0.022	0.54
Miscellaneous items	12	0.261	6.52

5 DISCUSSION

5.1 Length weight relationship

Length weight relationship and relative condition factor for *S. richardsonii* in this area have never been reported elsewhere before (www.fishbase.org). Therefore for the first time, this study revealed the length weight relationship and condition factor of *S. richardsonii* from Khanikhola, Nepal. Generally growth in fish stocks is considered to be isometric when "b" value is 3.0. Although weight depends largely on the stomach content, the length-weight relationship can be used as an indicator of fish condition as well (Froese 2006). However, the growth depends on species, sex, age, seasons and feeding (Le Cren 1951; Bagenal and Tesch 1978) and may be lower or higher than 3 indicating negative and positive allometric growth, respectively. When the growth was evaluated in terms of length, it was found that the growth of *S. richardsonii* in this investigation was allometric (b=3.297, b=2.913, b=2.63 for autumn, winter, and spring season respectively. High values of correlation coefficient r^2 indicated a high degree of positive correlation between the total length and total weight of this species. Similar results were observed by (Tyagi et al. 2014) when they studied the length-weight relationship of *S. richardsonii* from different rivers. Mohan (2006) found that the value of 'b' 3.0556954 and 2.9695189 for male and female fish respectively for *S. richardsonii* in the Kumaon hills. Similar results (b= 2.40 - 3.08) were found by (Lohani et al. 2018) when they studied length-weight relationship and condition factor of cold water fish (*S. richardsonii*) from different habitats of Himalayan region. Sharma and Dhanze (2010) reported isometric growth for the *S. richardsonii*. Though, many fishes do not follow the cube law and may be due to intensity of feeding, spawning stresses and the prevailing water chemistry. According to Hile (1936) and Martin (1949) the value of exponent 'b" ranges between 2.5 and 4 and remain constant at 3 for an ideal fish which is similar with present findings. Further, Tesch (1968) reported that the exponent 'b' values of 3 which shows the specific gravity of the tissue remains constant throughout its life for an ideal fish. It is known as cube law. Though the value of 'b' varies as per different species but variation with in the species is under the influence of several factors such as seasonal, physiological condition of the fish at the time of collection, sex, gonadal development and nutritive condition of the environment. Goel et al.

(2011) also reported allometric growth patterns in length-weight relationship of *S. richardsonii* which coincide the present findings.

5.2 Condition factor

The 'K' value is a physiological indicator of general well being of any fish living in a given environment (George et al. 1985 and Raj Kumari et al. 2006). Greater the value of 'K' indicates that the general wellbeing of the fish is good whereas smaller value of 'K' indicates that all is not well in their habitat. The Km values ranged between 0.75-1.21 reflect well being of the fish and coincide with findings of (Jana and Dasgupta 2005). Sharma and Dhanje (2010) investigated K value ranged from 0.87 to 1.10 which is similar to the present investigation. The lowest value of Km in winter season reflects that the fishes are not in good condition in their habitat as compared to other season. If, the weight increases more rapidly than the cube of the length, 'K' would increase with increase in length. When the weight increases less than the cube of the length, 'K' would tend to decrease with the growth of the fish. Hence, in present study the values of 'K' indicated the suitability of water body for proper fish growth in different length range except few exceptions and less value may be due to the competition for food and shelter within different aquatic communities in water body.

5.3 Stomach content analysis

5.3.1 Gastrosomatic index

The values of gastro somatic index were ranged from 0.77-4.2, 0.18-2.48, 1.25-3.41 for autumn, winter and spring season respectively. The highest mean gastrosomatiic index was observed in autumn season and lowest mean gastrosomatic was observed in spring season. The fluctuation in increasing and decreasing trend exhibited a change in feeding intensity with different season. The feeding intensity decreases in spring and winter season as compared to autumn season. Further decrease in the feeding intensity was probably due to decrease in the availability of food in fish in winter season. Kaundal (2012) observed the values of gastro somatic index of *Schizothorax richardsonii*, at different size group and

G.S.I. were ranged from 5.43 to 10.25 which is different from present investigation because of change in the feeding intensity due to decrease in the availability of food.

5.3.2 Qualitative and quantitative analysis of stomach content

From the present investigation it was found that the intensity of feeding changed according to different season. In winter and autumn season, empty stomachs were 20% and 13.33% respectively but 100% of stomach were containing food item in spring season. The percentage of empty, moderate, half and full stomach showed a fluctuation in feeding intensity in different season. The probable reason behind this could be attributed to the scarcity or less abundance of food items present in the habitat of fish. In the present study, it was inferred that a variety of food items belonging to Bacillariophyceae, Chlorophyceae, Cyanophyceae, Charophyceae and insects etc., were identified. Due to its exclusive preference for phytoplankton (diatoms, green and blue green algae followed by detritus, sand and insects parts) the fish in Khanikhola is categorized as herbivorous, periphytonic feeder, feeding by scrapping the food from the rocks and stones. Animal based diet (insects) was also consumed by this fish in lower quantities. The presence of detritus and sand in the stomach of *S. richardsonii* was contributed by (6.52 %) yet 100% percentage of occurrence was noticed in it. This supported the bottom feeding habit of *S. richardsonii*. However, the overall percentage of plant and animal based diet confirmed its herbivorous nature. The results of the present investigation were supported by the previous finding of Sharma (1984) and (Bhatt et al. 1985). Kaundal (2012) found herbivorous nature of *S. richardsonii* with low percentage of animal matter. Shekhar et al. (1993) observed herbivorous nature in the same fish with high percentage of Bacillariophyceae followed by Chlorophyceae, Cyanophyceae, detritus and sand which confirmed the present investigation.

6 CONCLUSION

The present study observed the length-weight relationship, condition factor and stomach content analysis of *S. richardsonii* collected from Khanikhola, Kavvrepalanchok. The results revealed that the relationship varied among the season. *S. richardsonii* from of Khanikhola showed an isometric growth pattern in winter while the rest showed allometric growth pattern. The variation in the growth pattern in different season may be due to availability of food, maturation of gonad, and catchment area of the ecosystem. The value of the condition factor indicated that the natural ecosystem provides the better environment for the growth of the fish species. This study concluded that the fish is herbivorous in feeding habit with different feeding intensity among the season. This research will open the door in continuation to work on other fishes to estimate their length-weight relationships and stomach content analysis.

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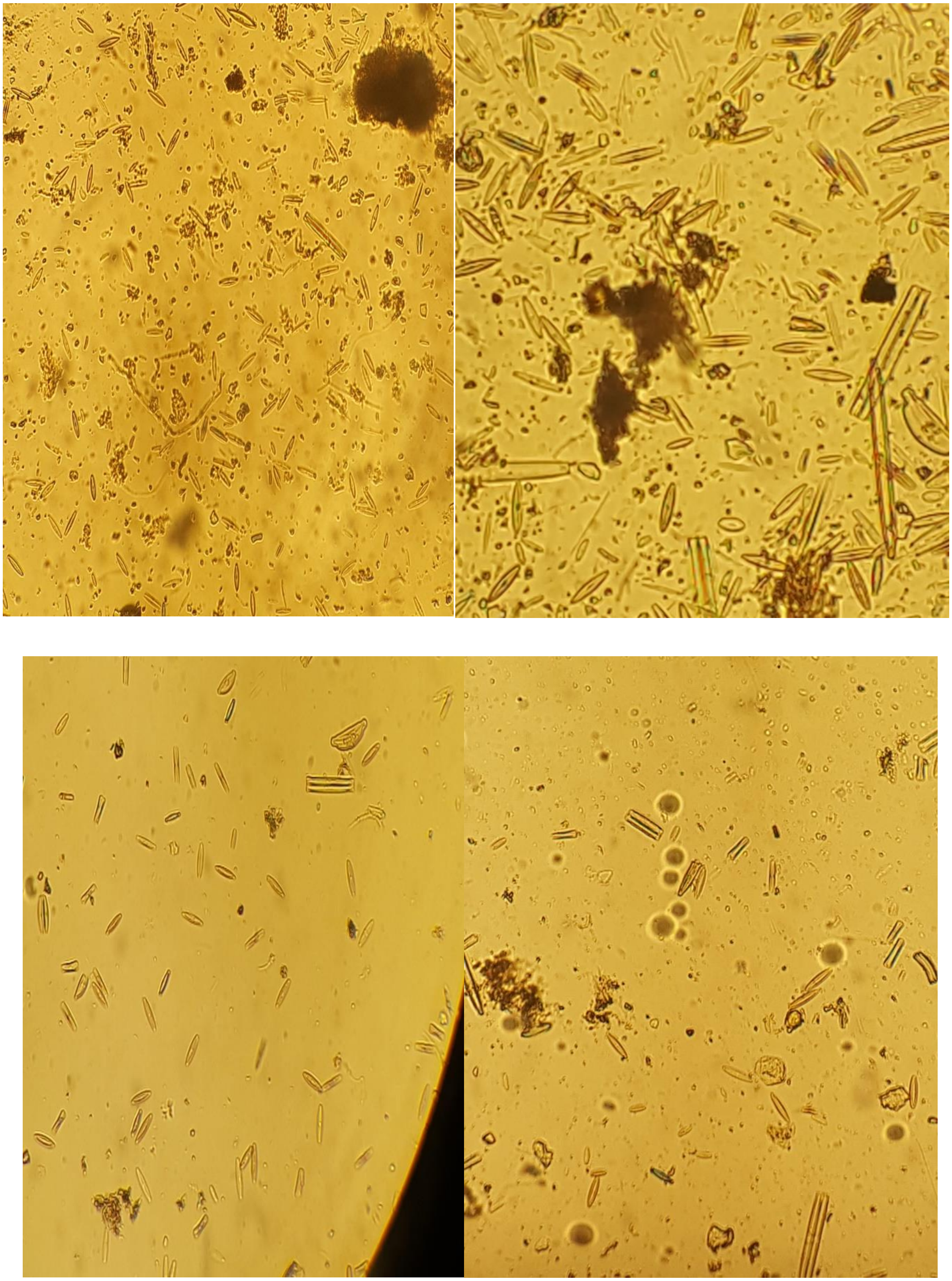
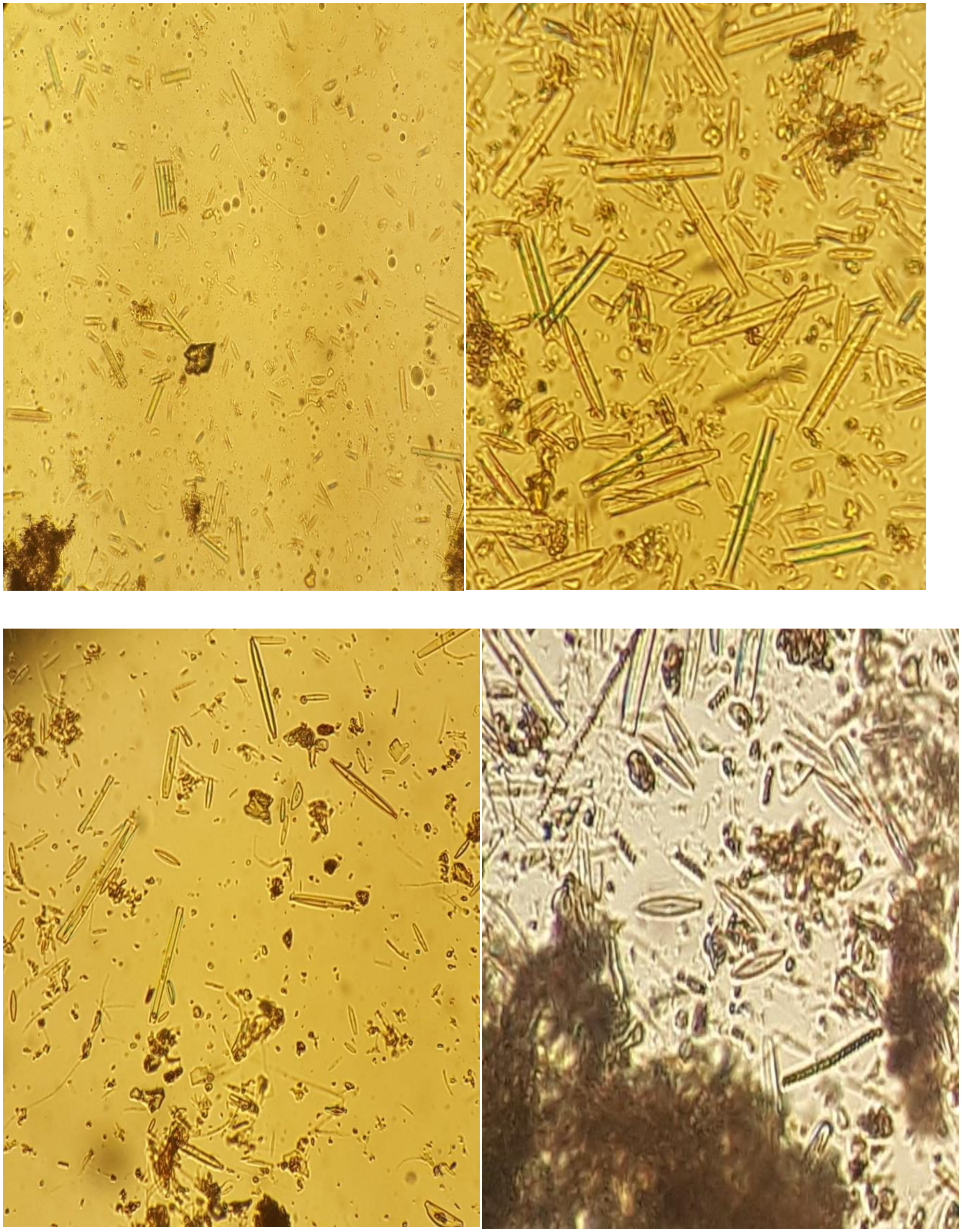
8 PHOTOPATES

Pic.2 Dissection of fish

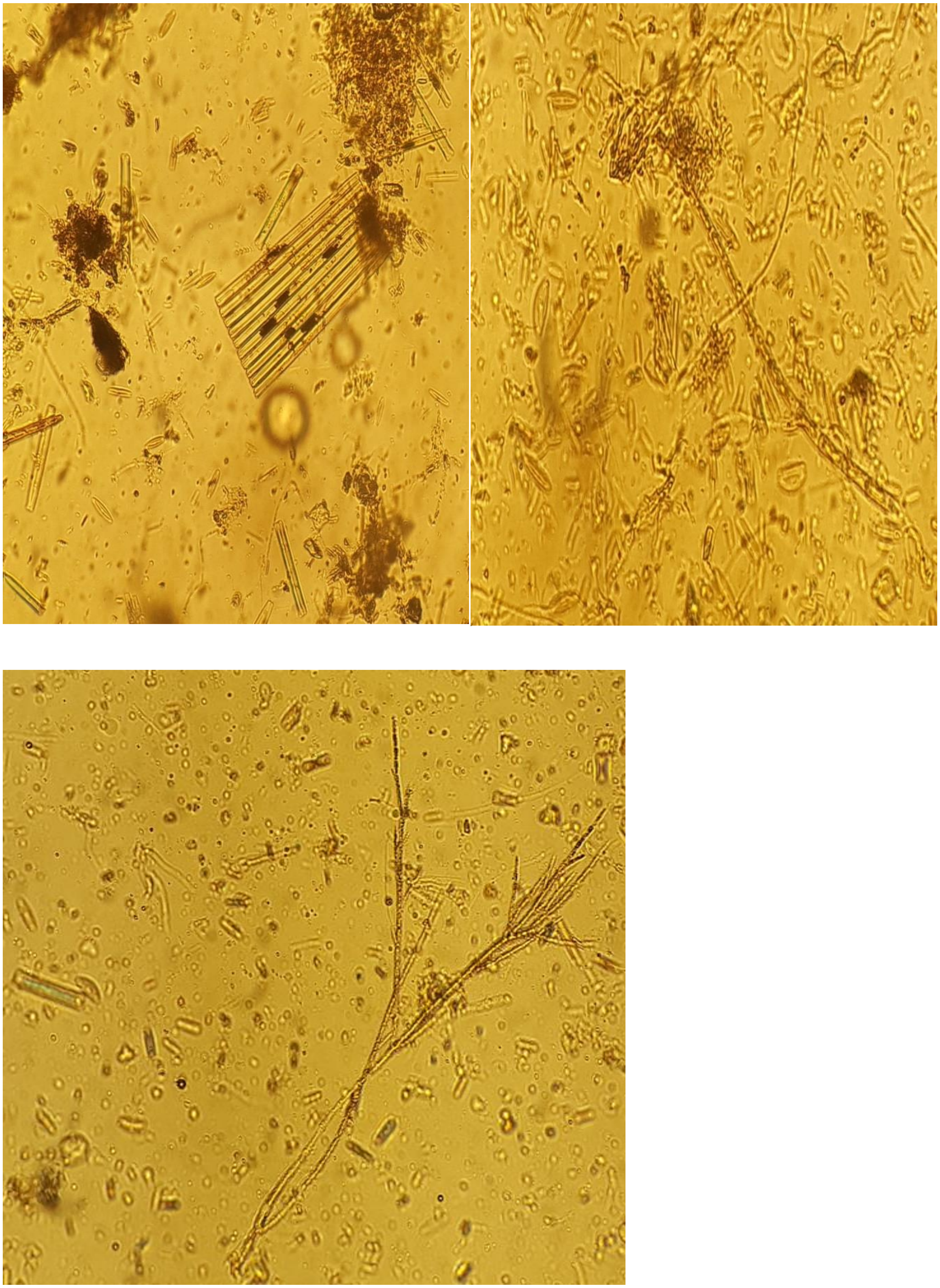
Pic.3 Analysis of stomach content



Pic.4 Content of stomach



Pic.5 Content of stomach



Pic.6 Content of stomach