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Feeding habits and diet composition of *Schizothorax plagiostomus* in Panjkora River, Malakand region, Pakistan

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Abstract

Feeding habits and diet composition of Schizothorax plagiostomus *in Panjkora River, Malakand region, Pakistan*. Snow trout (*Schizothorax plagiostomus*) is a member of the Cyprinidae familyand commonly found in cold waters. We collected fish samples using cast nets and studied seasonal variations in the food consumption of this species. We analysed the gut content of 160 *S. plagiostomus*. Gut content revealed that *S. plagiostomus* feeds mainly on plant parts (45.14 %), followed by stones and muds (30.01 %), and insect parts (13.97 %), while unidentified detritus matter (5.42 %) and algae (5.33 %) are in small volume regarding the average percentage on a monthly basis. Maximum food consumption occurred in the summer and minimal food consumption occurred in winter. Seasonal variation in consumption of foods items showed that in summer it feeds mainly on plant parts (0.54 ± 0.86), followed by animal parts (0.19 ± 0.41), and algae (0.06 ± 0.25). In winter it feeds at a relatively minimal level (0.28 ± 0.56), (0.05 ± 0.22), (0.02 ± 0.16), respectively. Detritus (unidentified) was also observed as part of its diet, with a maximum in summer (0.06 ± 0.24), and less in autumn (0.03 ± 0.18). Lastly, materials uch as stones and mud were observed at a maximum level in winter (0.58 ± 0.76) and a minimum level in summer (0.12 ± 0.34). In conclusion, we found that the diet composition of *S. plagiostomus* changes with season, revealing a diverse diet that includes plants and animal fragments (caddis flies), algae, detritus, stones, and mud.

Key words: Snow trout, Caddis flies, Algae, Detritus, Stones, Mud

Resumen

Hábitos alimentarios e ingredientes de la dieta del Schizothorax plagiostomus *en el río Panjkora, en la región de Malakand, Pakistán*. El *Schizothorax plagiostomus* pertenece a la familia de los ciprínidos, que habitualmente viven en aguas frías. Se recogieron ejemplares con un esparavel. Se analizaron 160 intestinos de *S. plagiostomus* para estudiar diferencias en la comida consumida por esta especie según la estación del año. El contenido de los intestinos reveló que el *S. plagiostomus* sobre todo se alimenta de partes de plantas (45,14 %), piedras y barro (30,01 %), y partes de insectos (13,97 %), mientras que los detritus de elementos

sin identificar (5,42 %) y las algas (5,33 %) representan un volumen pequeño de su ingesta, según los porcentajes medios de un mes. En verano es cuando el *S. plagiostomus* registra el nivel máximo de ingesta y en invierno, el nivel mínimo. Las diferencias entre los diferentes alimentos que consume el *S. plagiostomus* según la estación indican que durante el verano se registran los niveles más altos de consumo de partes de plantas (0,5 ± 0,86), partes de animales (0,19 ± 0,41) y algas (0,06 ± 0,25), los cuales son mínimos en invierno (0,28 ± 0,56, 0,05 ± 0,22 y 0,02 ± 0,16, respectivamente). Los detritus (elementos sin identificar) también forman parte de su dieta, con un consumo máximo en verano (0,06 ± 0,24) y más bajo en otoño (0,03 ± 0,18). Finalmente, se observó que elementos como piedras y barro registran el nivel de ingesta más elevado en invierno (0,58 ± 0,76) y el más bajo en verano (0,12 ± 0,34). La composición de la dieta del *S. plagiostomus* cambia según la estación, e incluye fragmentos de plantas y animales (tricópteros), algas, detritus, piedras y barro.

Palabras clave: *Schizothorax plagiostomus*, Tricópteros, Algas, Detritus, Piedras, Barro

Resum

*Hàbits alimentaris i ingredients de la dieta de l'*Schizothorax plagiostomus *al riu Panjkora, a la regió de Malakand, al Pakistan.* L'*Schizothorax plagiostomus* pertany a la família dels ciprínids, que habitualment viuen en aigües fredes. Se'n van recollir exemplars amb un rall, es van analitzar 160 intestins de *S. plagiostomus* per estudiar diferències en el menjar que consumia aquesta espècie segons l'estació de l'any. El contingut dels intestins va revelar que l'*S. plagiostomus* s'alimenta sobretot de parts de plantes (45,14 %), de pedres i fang (30,01 %), i de parts d'insectes (13,97 %), mentre que els detritus d'elements sense identificar (5,42 %) i les algues (5,33 %) representen un volum petit del que ingereix, segons els percentatges mitjans d'un mes. A l'estiu és quan l'*S. plagiostomus* registra el nivell màxim d'ingesta i a l'hivern, el nivell mínim. Les diferències entre els diferents aliments que consumeix l'*S. plagiostomus* segons l'estació mostren que durant l'estiu es registren els nivells més alts de consum de parts de plantes (0,54 ± 0,86), de parts d'animals (0,19 ± 0,41) i d'algues (0,06 ± 0,25), els quals registren mínims d'ingesta a l'hivern (0,28 ± 0,56, 0,05 ± 0,22 i 0,02 ± 0,16, respectivament); els detritus (elements sense identificar) també formen part de la seva dieta, amb un consum màxim a l'estiu (0,06 ± 0,24) i més baix a la tardor (0,03 ± 0,18); i, finalment, es va observar que elements com ara pedres i fang registraven el nivell d'ingesta més elevat a l'hivern (0,58 ± 0,76) i el més baix a l'estiu (0,12 ± 0,34). La composició de la dieta de l'*S. plagiostomus* canvia segons l'estació, i inclou fragments de plantes i d'animals (tricòpters), algues, detritus, pedres i fang.

Paraules clau: *Schizothorax plagiostomus*, Ticòpters, Algues, Detritus, Pedres, Fang

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Introduction

Fish play a highly significant role in human life as they provide a cheap source of protein and demand is continuously growing in line with the ever–increasing human population. (Ahmad and Hasan, 2011). Studies of fish are therefore vital (Ahmad and Hasan, 2011). It is very important to study the morphology, feeding habits, diet composition, habitat, length–weight relationship, and seasonal fluctuation of fish and to understand how induced breeding in the culture system often provides a potential source of food and many eggs in a short time (Khan et al., 2013, 2020).

Species of the *Schizothorax* (Heckel, 1838) genus are commonly known as snow trout and consist of fifteen genera and more than 100 species worldwide (Mirza, 1991). They are one of the most abundant and diversified groups of fish with 68 species in a variety of places, including Central Asia, the Himalayas, India, Pakistan, and the Tibetan Plateau (Mir et al., 2013; Jan et al., 2016). Twelve species of the subfamily of Schizothorancinae have been reported from Pakistan (Javed et al., 2012).

S. plagiostomus (Heckel, 1838) are commercially important freshwater herbivorous species that inhabit the reservoirs of Central Asia and Eastern Persia West of Mekong and East of Yangtzekiang. Their slow growth rate, low fecundity, and late sexual maturation are major characteristics of their rigorous environment (Ganai et al., 2011). This herbivorous fish becomes sexually mature at 18–24 cm in length and spawns in natural and artificial environments twice a year, i.e. September–October and March–April. Clear water with a depth of 10–30 cm depth is best for the spawning of snow trout and the appropriate water current is from 2.8–4 m/sec.Optimal ph is 7.5. The ideal concentrations of dissolved oxygen are 10 to 15 mg/l (Chen and Cao, 2000).

The fishing community today is affected by multiple factors, such as the introduction of new species, pollutants, domestic sewage, industrial effluents, agricultural runoffs and changes due to damming and water deviations both in freshwater and marine environments (Dubey et al., 2012; Jalal et al*.,* 2012). The greatest threat to many species of fish is environmental distortion resulting from a rapidly increasing human population alongside river basins ultimately destroying their natural aquatic ecosystems (Litvaitis, 2000; Ahmad et al., 2021). Fish populations require adequate amounts of usable resources to sustain life. The long–standing question in ecology is which resources a particular fish species requires to survive. Therefore, it is important to classify the resources used by fish and document the availability of those resources of foods (Simpfendorfer et al., 2011). Understanding the diet composition and feeding habits is an introduction to the natural history which is most important for any fish species (Ahlbeck et al., 2012). Many other issues also affect characteristics of fish, such as their size, and metabolic rate (Yousuf et al., 2003). The aim of the present study was to determine the composition of diet and the seasonal variation in food consumption of snow trout in the study area, and also to determine the percent frequency (*F*%) and percent volume (*V*%) of occurrence of prey items in the gut (*S. plagiostomus*). We also aimed to determine prey species richness (*S*), the diversity index (*H*') and evenness index (*E*) of *S. plagiost*omus in the Panjkora River, Pakistan.

Material and methods

Study area

The present study was conducted in Lower Dir, Northern region of Khyber Pakhtunkhwa, Pakistan; located within 34º 37' and 35º 07' North and 71º 310' and 72º 140' East respectively. The area is approximately 2,700 feet above sea level and the geographical area is 1,585 km^2. The Panjkora River originates from the Dir Upper district (Kohistan) and flows continuously to southern areas, dividing district Dir Upper and Lower into two halves. This

Fig. 1. Visceral organ of fish specimen after the dissection of *S. plagiostomus*.

Fig. 1. Vísceras de un ejemplar de S. plagiostomus *después de su disección.*

river joins with River Swat at Bosaq bridge, Sharbatti (district Malakand). Four seasons are dominant in the collection area: winter is very cold, while summer is pleasantly warm. Temperatures in winter range from 06–38 ºC and from 15–40 ºC in summer. The relative range of humidity is 30 % to 70 % (Rashid et al., 2018).

Data collection

Fish samples were collected from several sites of the Panjkora River (Lower Dir). These included Bagh Dushkhel, Shago Kas, and many others. Collection was performed on a monthly basis from November 2017 to November 2018, Sampling was carried out using various types of nets, mainly cast nets. The average samples of fish ranged in size from 6 cm to 40 cm.

Transportation of the collected specimens

Before transportation, the samples were preserved in 10 % formalin. They were then transported to the Parasitology Laboratory, Department of Zoology, University of Malakand. The container was labelled with all the relevant information.

Laboratory investigation

The collected fish were longitudinally dissected using scissors and sharp knives and the gut was removed using fin forceps (fig. 1). Most diet samples were not examined directly as they should be preserved by freezing or by fixing to protect them from constant digestion (Chipps and Garvey, 2007). Gut–weight was almost 0.01 g. We used 70 % ethanol for further preservation of gut contents. Contents were placed in Petri dishes, and to obtain a homogenous mixture, the gut was immersed in diluted water. Sub–samples were prepared from the mixture and examined by light microscope to identify each collected food item. The total value was obtained by pictorial examination, divided among the food items according to their relative volume, and prey items were identified by examination of experts.

Identification of fish

The collected fishes were identified following the keys provided by Desai (2003) and Mirza and Sandhu (2007). They were all given a serial number. Morphometric characters determined were total length, fork length, and total weight.

Gut content analysis

Gut contents were analysed by two methods, volumetric and diversity and index methods.

Volumetric method

This method was used exclusively for the quantitative analysis. The volume usually showed the food item's volume percentage of the total volume of gut contents. The result was obtained using the following formula:

$$\%VI = (Vi / Vt) \times 100$$

where %*VI* showed the percentage of item i, *V*i is the volume of item i, and *V*t indicates the total volume of the food item.

Diversity index method

Diversity index (*H*') and Evenness index (*E*)

Seasonal variation of diet composition considered the four seasons. Prey species richness (*S*), diversity index (*H*') and evenness index (*E*) indicate how close in an environment the species are to each other; this was calculated from the data on seasonal variation in the diet composition of *S. plagiostomus.*

Calculation of prey species richness index (*S*):
Total numbers of plant and animal prey species consumed by each fish in a specific season, where S is the number of prey species present per fish sample

Calculation of diversity index (*H*'): calculated by Shannon's index:

$$H' = -\Sigma Pi \times \log Pi$$

where Pi is the proportion (n/N) of individuals of particular prey items n divided by a total number of prey items N.

Calculation of Evenness index (*E*): using Pielou's formula:

$$E = H' / \text{Log } S$$

where *H*' represents Shannon's index and S represents the prey species richness index.

Identification of prey items

Prey items were identified through keys provided by Borror et al. (1989) and Merritt and Cummins (1996).

Statistical analysis

Statistical data were analyzed using GraphPad Version5 by testing the Chi–square test of analysis of variance. A p value below 0.05 was considered significant at a 95% confidence interval.

Results

During the study period 2017–2018 we collected 160 samples of fish from various sites of the Panjkora River and its tributaries at District Dir (L), Khyber Pakhtunkhwa, Pakistan in 2017–2018. The aim of the collection was to assess and analyse gut content in order to study the diet composition and seasonal variations in the feeding habits of (*S. plagiostomus*), a commercially important fish

Percentage frequency (%F) and percentage volume (%V) of prey items

Five food items were found in the gut of *S. plagiostomus* in Panjkora River and its tributaries. From a total of 9,592 slides, the frequency (n) of recovered prey items was 368 % plant parts, 116.9 % insect body parts, 44.5 % algae 43.66 %, unidentified detritus, and 226.1 % stones and muds (table 1; fig. 2–4).

The annual percentage of volume (%V) of food items was highest for plant parts (45.14 %), followed by stones and muds (30.01 %) and insect parts (13.97 %). The volume of detritus (unidentified matter) was 5.42 %, and algae were the least identified (5.33 %) content in the stomach of *S. plagiostomus* (table 2).

Seasonal variation in food consumption of *S. plagiostomus* in the Panjkora River

The food habits of *S. plagiostomus* differed in the four seasons (autumn, winter, spring, and summer). The highest–consumed food items were plant parts in autumn (0.43 ± 0.69), winter (0.28 ± 0.56), spring (0.41 ± 0.61), and summer (0.54 ± 0.86), and the lowest food items were detritus in autumn (0.03 ± 0.18), winter (0.04 ± 0.21), spring (0.03 ± 0.19) and summer (0.06 ± 0.24) (table 3). The variation between seasons and food items consumed was significant (< 0.0001).

Prey species richness (*S*), diversity index (*H'*) and evenness index (*E*)

Variation was found in the diet composition of snow trout over the four seasons of the year and these data were processed to compute prey species richness (*S*), diversity index (*H'*), and evenness index (E) of *S. plagiostomus* in the Panjkora River. Prey species richness *S* was 2 in every collection and the diversity index *H* for each each prey item differed each season of the year. The diversity index of plant parts was highest in spring (0.15 %) and lowest in summer (0.14 %). The evenness index of plant parts was highest in spring and lowest in summer (table 4).

Discussion

The study of food and feeding habits of fish is of great importance in fishery management. The present study was designed to explore the food composition of *S. plagiostomus* and its seasonal variations on the basis of fish samples collected at various sites along the Panjkora River, including Bagh Dushkhel and Shago Kas. *S. plagiostomus* (snow trout) is a unique fish in fast–flowing waters. Water of a good quality and light sediment attract upstream migration of fish to these tributaries, both for spawning purposes and in search of food, in agreement with findings of Yousuf et al. (2003) who determined that species of *Schizothoraxine* generally prefer clean waters and, and also in agreement with other authors who have studied the feeding habit of *S. plagiostomus* (Bahuguna et al., 2008).

Shannon's index and Pielou's formula were used to calculate the occurrence, volumetric analysis, prey species richness (*S*), diversity index (*H'*), and evenness index (*E*) of the gut contents of *S. plagiostomus.* The composition of diet suggests they are herbivores due to

Table 1. Percent frequency (%F) of the prey items recovered from the stomach contents of S. plagiostomus collected from the River Panjkora: PP, plant parts; IP, insect parts; A, algae; D, detritus; SM, stone and muds; FS, fish samples; FSb, fish subsamples.

Tabla 1. Frecuencia porcentual (%F) de las partes de presas recuperadas en el contenido estomacal de los ejemplares de S. plagiostomus *recogidos en el río Panjkora: PP, partes de plantas; IP, partes de insectos; A, algas; D, detritos; SM, piedra y barros; FS, muestras de pescado; FSb, submuestras de pescado.*

			Prey items				
			PP	IP	A	D	SM
Month	**FS**	**FSb**	**%F**	**%F**	**%F**	**%F**	**%F**
Jan	10	580	140	30	10	40	360
Feb	11	682	209	55	22	33	363
Mar	12	696	312	108	36	24	216
Apr	12	708	396	120	48	36	108
May	13	728	338	143	65	65	117
Jun	14	812	518	182	28	14	70
Jul	16	1,104	560	288	96	80	80
Aug	15	1,050	585	195	75	75	120
Sep	14	812	448	112	56	56	140
Oct	14	728	392	98	28	42	168
Nov	14	882	308	42	56	14	462
Dec	15	810	210	30	15	45	510
Total	160	9,592					
Mean (%)			368.00	116.92	44.58	43.66	226.16
SD			142.73	77.05	26.05	21.84	155.69

their consumption of grass, carnivores if they consume animal parts, and omnivores if they have a mixed diet comprising both plant and animal elements. Our analysis of gut contents of *S. plagiostomus* show this fish is principally herbivorous in nature because it scrapes and consumes *Spirogyra* and *Ulothrix* plants attached to stones and pebbles. A similar finding was reported by Sharma (1994) who determined the inferior side of *S. plagiostomus* is a wide, deep lower jaw with a sharp keratinized cutting edge. Numerous papillae are present on the lower lip and these help the fish scrape away algae attached to stones and pebbles. Other authors (Ullah et al., 2022) studied grass carp and found they were herbivorous in nature because they consumed vegetation and grasses along the water edge. Whereas, Lima–Junior and Goitein (2004), reported adaptations in the mouth of *S. plagiostomus.*

The analysis of gut contents confirmed that *S. plagiostomus* consumed plant parts, insect parts (including caddis flies), algae, detritus (unidentified), stone and mud. The average rate of the contents revealed that the snow trout fed mainly on plant parts, 45.14 %, followed by

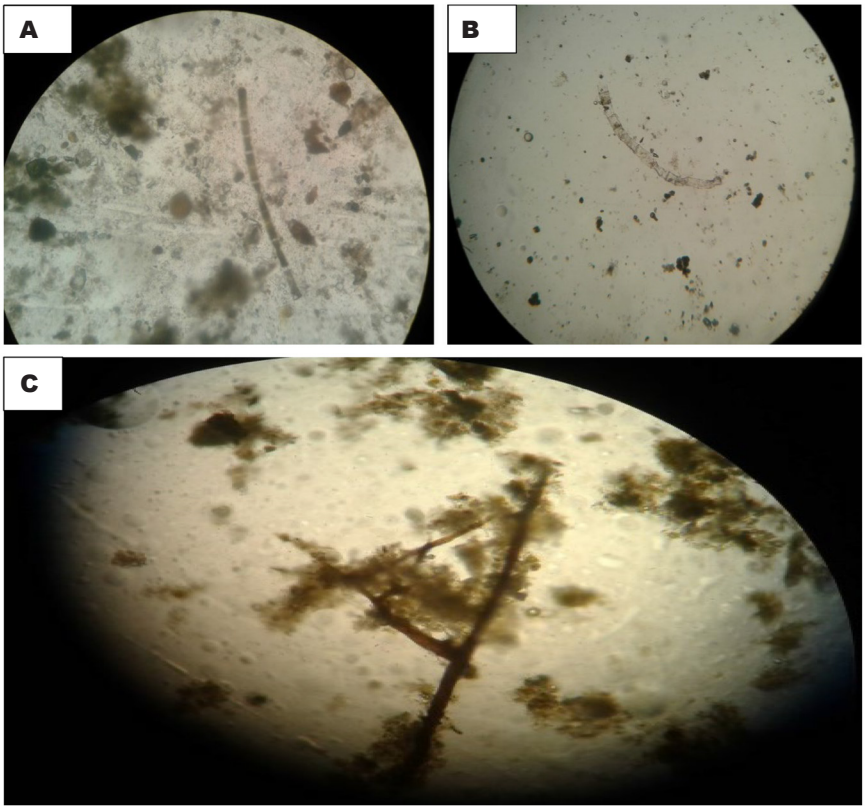

Fig. 2. Gut content of *S. plagiostomus*: A, C, plants' body parts; B, algae.

Fig. 2. Contenido intestinal de S. plagiostomus*: A, C, partes de plantas; B, algas.*

stones, mud 30.01 %, insect parts 13.97 %, detritus (unidentified) 5.42 % and algae 5.33 %; these latter in a very small volume. On the basis of month–wise, the average percentage of *S. plagiostomus* revealed that it feeds mainly in the summer and minimally in winter. The highest average percentage of *Bothriocephalus* spp. was 45 % and the lowest was *Rhabdochona* spp. 15 %. The highest value of *Bothriocephalus* spp. was recorded in the summer season and the lowest was recorded in winter.

The food items of snow trout consumed in the different seasons in the present study showed that it feeds more on plant parts in summer (0.54 ± 0.86). The rates or algae are maximal in summer (0.06 ± 0.25) and minimal in winter (0.02 ± 0.16). Comparison of the present study with the study of (Khan et al., 2022) underscores the season–wise prevalence of parasites in the gut of snow trout at River Panjkora and Swat. In Khan et al. (2022)'s study the maximum rate of prevalence was recorded in the summer (26.6 %) and the minimum rate was in winter (20 %).

In the present study, when we calculated prey species richness (*S*), which represents the number of species per sample, we found the richness index of prey species (*S*) was 2 in every season of the year.

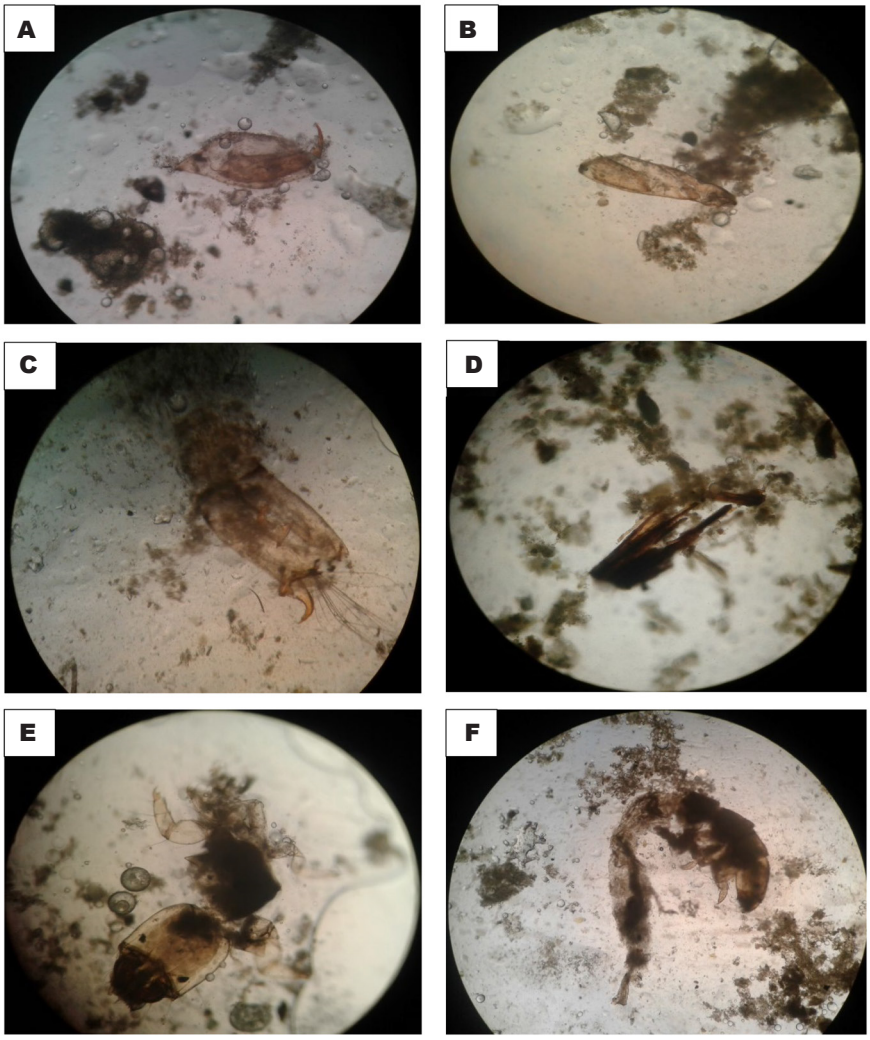

Fig. 3. Microscopic examination of insect different body parts found in the gut of snow trout.

Fig. 3. Estudio en el microscopio de varias partes del cuerpo de insectos encontradas en los intestinos de S. plagiostomus.

The diversity index of plant parts was maximum in spring (0.15) and minimum in summer (0.14); the diversity index of animal parts was maximum in summer (0.13) and lowest in winter (0.06). Algae was higher in summer (0.07) and lower in winter (0.04); detritus was highest in summer (0.07) and lowest in autumn (0.04) and the diversity index of stones, including muds was maximum in autumn (0.15) and minimal in summer (0.11), a finding similar to that of Askeyev et al. (2017) in their study of the overall range of elevation gra-

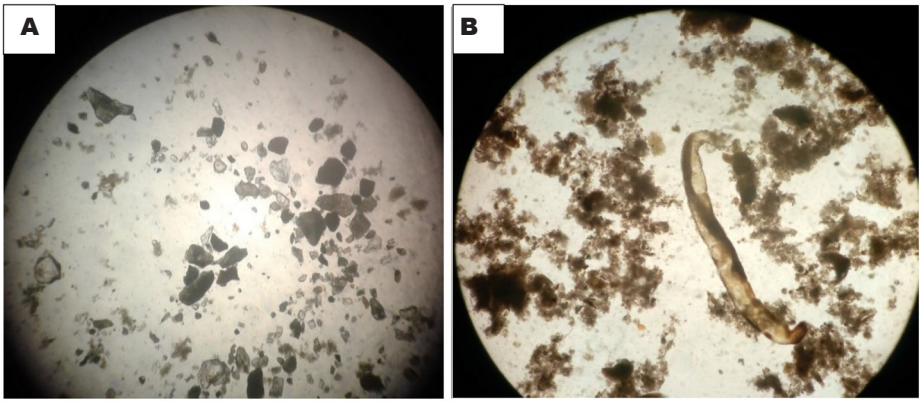

Fig. 4. Prevailed materials gut content of *S. plagiostomus*: A, stones, mud; B, detritus (unidentified).

Fig. 4. Materiales predominantes del *contenido intestinal de* S. plagiostomus*: A, piedras, barro; B, detritus (sin identificar).*

Table 2. Percent volume (%V) occurrence of the prey items recovered from the stomach contents of *S. plagiostomus* collected from the River Panjkora: PP, plant parts; IP, insect parts; A, algae; D, detritus; SM, stone and muds.

Tabla 2. Distribución del volumen porcentual (%V) de las partes de presas recuperadas entre el contenido del estómago de los ejemplares de S. plagiostomus recogidos en el río Panjkora: PP, partes de plantas; IP, partes de insectos; A, algas; D, detritos; SM, piedra y barros.

	Prey items				
Month	**PP**	**IP**	**A**	**D**	**SM**
Jan	24.13	5.17	1.7	6.89	62.06
Feb	30.64	8.06	3.22	4.83	53.22
Mar	44.82	15.51	5.17	3.44	31.03
Apr	55.9	16.9	6.77	5.08	15.2
May	46.4	19.6	8.92	8.92	16
Jun	63.7	22.4	3.44	1.72	8.62
Jul	50.7	26	8.69	7.24	7.24
Aug	55.7	18.5	7.14	7.14	11.4
Sep	55.17	13.7	6.89	6.89	17.2
Oct	53.8	13.4	3.84	5.76	23
Nov	34.9	4.76	6.34	1.58	52.3
Dec	25.92	3.7	1.85	5.55	62.9
Mean (%)	45.14	13.97	5.33	5.42	30.01
SD	13.16	7.27	2.50	2.25	21.53

Table 3. Seasonal variation in consumption of different food items of the *S. plagiostomus*: PP, plant parts; IP, insect parts; A, algae; D, detritus; SM, stone and muds.

Tabla 3. Diferencias en la ingesta de varios alimentos del S. plagiostomus *según la estación: PP, partes de plantas; IP, partes de insectos; A, algas; D, detritos; SM, piedra y barros.*

	Food items				
Season	**PP**	**IP**	**A**	**D**	**SM**
Autumn	0.43 ± 0.69	0.08 ± 0.29	0.05 ± 0.22	0.03 ± 0.18	0.39 ± 0.73
Winter	0.28 ± 0.56	0.05 ± 0.22	0.02 ± 0.16	0.04 ± 0.21	0.58 ± 0.76
Spring	0.41 ± 0.61	0.13 ± 0.36	0.04 ± 0.21	0.03 ± 0.19	0.35 ± 0.52
Summer	0.54 ± 0.86	0.19 ± 0.41	0.06 ± 0.25	0.06 ± 0.24	0.12 ± 0.34

Table 4. Prey species richness (*S*), diversity Index (*H'*), and evenness index (*E*) calculated during four different seasons of *S. plagiostomus*: PP, plant parts; IP, insect parts; A, algae; D, detritus; SM, stone and muds.

*Tabla 4. Riqueza de especies de presa (*S*), índice de diversidad (*H*'), índice de homogeneidad (*E*) relativos al* S. plagiostomus*, calculados durante cuatro estaciones diferentes: PP, partes de plantas; IP, partes de insectos; A, algas; D, detritos; SM, piedra y barros.*

		Prey items									
		PP		**IP**		**A**		**D**		**SM**	
Index	***S***	***H'***	***E***	***H'***	***E***	***H'***	***E***	***H'***	***E***	***H'***	***E***
Autumn	2	0.15	0.52	0.09	0.3	0.06	0.2	0.04	0.13	0.15	0.5
Winter	2	0.15	0.51	0.06	0.2	0.04	0.13	0.06	0.2	0.13	0.43
Spring	2	0.15	0.52	0.11	0.36	0.06	0.2	0.05	0.16	0.15	0.5
Summer	2	0.14	0.46	0.13	0.43	0.07	0.23	0.07	0.24	0.11	0.36

dients at a Russian site. Their study analyzed the diversity index, species richness and abundance of 435 river sites that differed by elevation but they did not describe the diversity index according to season .

The Evenness index of plant parts in the gut of snow trout was maximal in spring (0.52) and minimal in summer (0.46); animal parts were maximum in summer (0.43) and minimal in winter (0.2); algae were maximal in summer (0.23) and lowest in autumn (0.2); detritus (unidentified) was highest in summer (0.24) and lowest in winter (0.2). The Evenness index of stone, including muds, was maximum in winter (0.43) and minimum in spring (0.5). Similarly Baro et al. (2015) measured the Gibson's evenness of various fish fauna in the Sonkosh River using PAST software (version 2.19).

Conclusion

The main observation in this study is that it shows how the diet of *S. plagiostomus* changes with season and age. Food items found in the gut of *S. plagiostomus* over the seasons were insects, stones and muds. These findings may be helpful and taken could be of relevance to take into account when assessing the importance of this fish species within the cultural ecosystem.

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