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Food and Feeding Habit of Indigenous Fish Sucker Head *Garra gotyla gotyla* from Kosi River, Kumoan, Uttarakhand, India

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Abstract: The aim of present investigation was to study the food and feeding habit, relative length of gut (RLG), gastrosomatic index (GaSI) and feeding intensity in relation to gonadal maturity in indigenous fish, *Garra gotyla gotyla.* The study revealed that the fish is phytoplanktyvorous/ benthic herbivorous and feeds on Bacillareophyceae as most preferable food. The RLG value recorded between 3.27 and4.49 while the GaSI was found between 1.85 and 7.92. The feeding intensity of mature fishes was poor during the peak spawning period. The present study will give insights to develop a protocol for seed production and brood banking of *Garra gotyla gotyla* in captive condition and to develop a aquaculture conservation and sustainable fisheries management protocol for this fish.

Keywords: Relative length of gut, Phytoplanktyvorous, Feeding intensity, Sustainable fisheries, *Garra*, Sucker head

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Introduction

A great diversity of micro- and macro-organism in natural habitat offers a variety of food for fishes (Olojo *et al.*, 2003). Food compensates the energy loss during foraging and reproductive activity and help in growth and vital function of body (Begum *et al.*, 2008). Food substance inside gut provides information about diet however, the length of digestive tract determines the feeding habit of a fish species. Food and feeding habit plays an important role in evaluation of growth, productivity of water, habitat preference and conservational strategies programme (Chipps and Garvey, 2007; Sadguru, 2015). Food and feeding habit of fish vary according to season and locality. Seasonal changes influence quantity and quality of food. It plays an important role in fish culture when fish has to live in association with other fish species, complete utilization of available food, selection of a group of species for pond culture and avoid competition for food, optimum production of fish in captive condition (Deewan and Saha, 1979). Successful fishery management requires a continuous research on food and feeding of fish because it constitutes the primary step towards optimum growth, culture and development of fish species (Oronsaye and

Nakpodia, 2005; Sarkar and Deepak, 2009). Fishery management includes water quality management, fish biology and feeding preference (Atique and An, 2020; Momi *et al.*, 2021).

This study is an investigation of qualitative and quantitative analysis of food and feeding habit, GaSI, RLG and feeding intensity in relation to gonadal development of *Garra gotyla gotyla* under captive environment. This fish is native species of Himalayan region and belongs to family Cyprinidae. In India, this hill stream fish is locally known as "Pathorchata" and commonly occur in freshwater river impounded with stone and pebbles. Jha *et al.* (2005) considered it as minor commercial fish. As per local preference, it is preferred as food fish and due to its distinct appearance it is exported from India as "Stone fish" (Mandal *et al.*, 2007). Mandal *et al.* (2007) considered it as a high consumer preference but very low abundance fish. A sharp reduction in fish population has been recorded in local rivers due to overexploitation, and introduction of bleaching powder in water for unethical catching of fish (Agarwal and Singh, 2009). Except Gaur *et al.* (2013) and Gandotra and Rizwan (2018) there exists no other information about gut content analysis of this economically important fish *Garra gotyla gotyla*. Fish restoration and conservation of wild stock in natural habitat mainly performed due to the knowledge of food and feeding habit (Moon *et al.*, 2020). Aim of the present study was to investigate in detail food and feeding habit, gastrosomatic index and relative gut length of indigenous fish *Garra gotyla gotyla* that would help in developing culture technologies, conservation and sustainable fisheries management of this fish in captive condition. Successful mass scale culture of this species in captive condition could only be achieved though precise knowledge of their food preference and feeding biology.

Materials and Methods

In the present study the samples were collected from the natural habitat of *Garra gotyla gotyla* from river Kosi, Kumaoan (Uttarakhand), India. The sampling sites were Khairna (Latitude 29.4961° North and longitude 79.4811 East) and Suyalbadi (Latitude 29.5384° North and longitude 79.5553 East) (Fig. 1). Size of fishes ranged from 3.8 to 18.2 cm. The fishes were dissected for observations and analyzed on monthly basis. Alimentary canal was removed and measured with the help of graph paper and each alimentary canal was preserved in formalin in separate vials. To examine the gut content under microscope (Olympus CKX53, Tokyo, Japan), two drop of water was added to sample and taken on slide. The food content was identified with the help of Keys (Needham and Needham, 1972; Sharma, 2000). A list of food items from gut content was prepared and Quantitative analysis of food items was done by volumetric method (Pillay, 1952; Hynes, 1950).

Gastro- somatic index (GaSI) estimation:

GaSI gives an idea about feeding condition of fish. To determine the gastrosomatic index of fish, at first the body weight of fish is measured before dissection and then the weight of alimentary canal was measured with help of weighing balance**.** Following formula was used to estimate GaSI:

$$GaSI = \frac{\text{Gut Weight}}{\text{Total body weight}} \times 100$$

Feeding intensity in relation with gonadal maturity:

The gut were classified into following groups-- Full stomach, ¾ full gut, ½ full gut, ¼ full gut, and empty gut. The assessment of various maturity stages was performed according to Jaiswar *et al.* (2004).

Relative length of Gut:

To determine the relative length of gut following formula (Al-Hussaini, 1949) was used:

$$RLG = \frac{\text{Total length of the gut}}{\text{Total length of fish}}$$

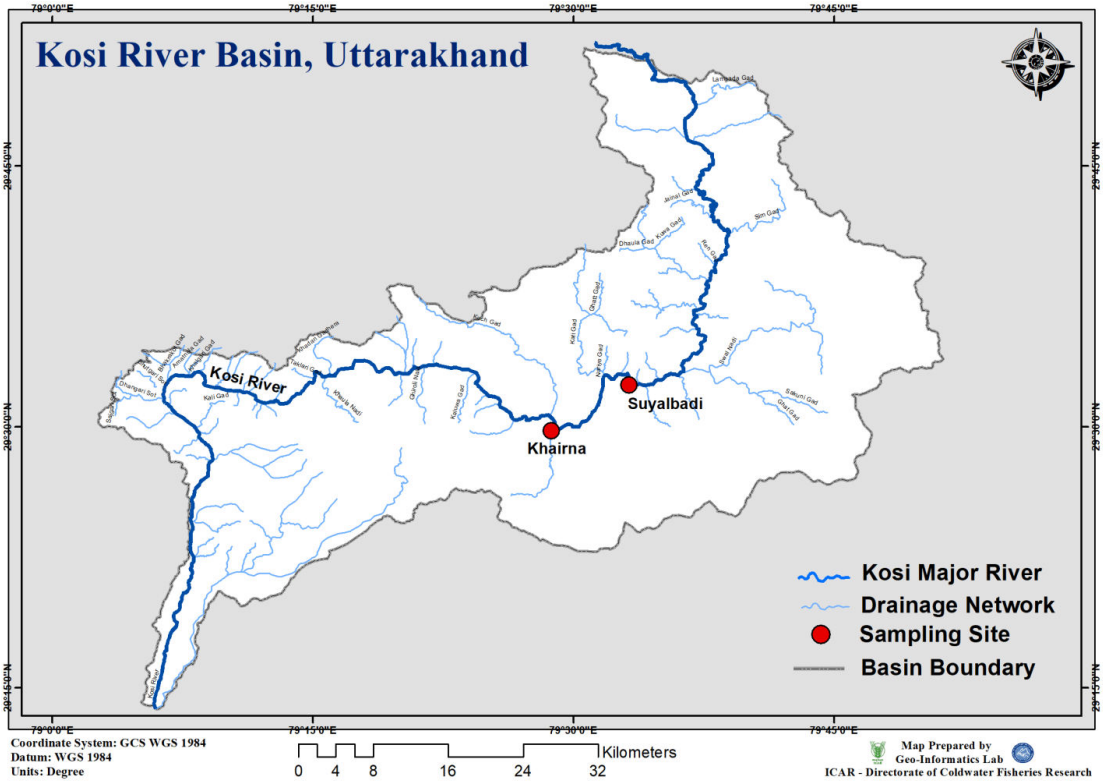

Fig.1: location map of sampling station of Kosi river of Kumaon Himalaya.

Results and Discussion

Qualitative analysis:

The finding of present study reveals that the food item of *Garra gotyla gotyla* can be categorized into five groups namely-- Bacillareophyceae; Chlorophyceae; Cyanophyceae; sand; and mud and miscellaneous items. A total 10 taxa of Bacillareophyceae, 8 taxa of Chlorophyceae and 3 taxa of Cyanophyceae were recorded and enlisted (Table 1). Throughout the year, Bacillareophyceae and Chlorophycae constituted the main food items, of which Bacillareophyceae was the most preferable food. Ganapati and Chacko (1950) classified fishes as bottom feeder, column feeder, and surface feeder. Das and Moitra (1955) further classified fishes according to their food preference as herbivorous, carnivorous and omnivorous. The result of the present study indicates that *Garra gotyla gotyla* is bottom feeder, phytoplanktyvorous fish. Nikolsky (1999) reported it as Plankty herbivorous fish and Gaur *et al.* (2013) specify it as herbivorous fish in south eastern Rajasthan. Algae as dominant food item of herbivorous fish was observed in *Barillius vagra* (Bahuguna *et al.,* 1984), *Garra mullya* (Anthony, 1985), *Accrossocheilus hexagonolepis* (Das and Goswami, 1997), *Garra lamta* (Kanwal and Pathani, 2012), *Garra gotyla gotyla* (*Gaur et al.*, 2013*),* *Labeo rohita* (Ravindranathan, 2003; Maheswari, 2015), *Cyprinus carpio* (Manon and Hossain, 2011), *Barilius vagra* (Gandotra *et al.,* 2007) and *Garra rufa* (Ozdilek and Ekmekei, 2016). Tekle-Giorgis *et al.* (2016) examined the diet composition of *Garra quadrimaculata* as fish eggs, phytoplankton, macrophytes, insect and detritus from lake Hawassa, Ethiopia.

Quantitative analysis:

During the present study, the Bacillareophyceae were found dominantly (38.25%) followed by Chlorophyceae (31.99%); sand, mud and detritus (14.82%); Miscellaneous (13%) and Cyanophyceae (1.7%) in the gut content of *Garra*

Table 1: Qualitative and Quantitative analysis of food and feeding habit of *Garra gotyla gotyla* in captive freshwater environment

Qualitative and quantitative analysis of food and feeding habit of *Garra gotyla gotyla* in freshwater condition													
Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Mean**
Bacillariophyceae	**38.9**	**39.66**	**37.59**	**38.91**	**47.14**	**37.51**	**31.9**	**39.3**	**35.67**	**37.73**	**38.46**	**36.23**	**38.25**
Achnanthes Sp.	8.31	7.79	9.21	2.13	3.62	4.48	8.91	2.16	4.13	6.8	9.2	7.13	6.1558333
Amphora Sp.	0	1.62	2.17	3.82	1.11	0	2.11	0	2.38	1.72	4.36	1.23	1.71
Cymbella Sp.	7.1	8.5	11.2	12.6	12.2	11.32	14.76	13	13.7	13.2	13.8	13.5	12.073333
Pinnularia Sp.	0	5.2	0	0	4.8	8.79	8.73	14.11	8.26	0	3.66	0	4.4625
Diatom Sp.	25.71	23.65	22.23	22.36	20.71	23.92	20	22.43	23.16	21.13	21.46	22.22	22.415
Fragilaria Sp.	8.1	7.3	6.2	9.8	7.41	8.61	8.69	12.3	9.86	9.92	8.91	9.26	8.8633333
Navicula Sp.	18.11	14.98	15.84	13.15	15.36	12.98	9.65	9.11	11.76	14.44	9.24	10.24	12.905
Nitzschia Sp.	9.8	7.21	8.47	14.42	9.31	8.77	13.33	7.91	8.82	6.32	9.32	9.98	9.4716667
Synedra Sp.	13.33	15.36	14.65	15.34	14.23	11.56	7.28	9.32	10.68	12.97	11.79	14.36	12.5725
Tabellaria	9.54	8.39	10.03	6.38	11.25	9.57	6.54	9.66	7.25	13.5	8.26	12.08	9.3708333
Chlorophyceae	**35.62**	**34.37**	**31.79**	**27.81**	**29.63**	**30.36**	**33.33**	**27**	**30.56**	**32.58**	**31.87**	**39**	**31.993333**
Chlorococcum Sp.	5.36	4.21	3.12	7.6	0	2.3	0	0	2.8	4.4	3.6	7.8	3.4325
Chlorella Sp.	16.34	18.79	17.11	14.52	21.49	16.86	20.22	19.16	16.97	16.3	17.04	8.18	16.915
Oedogonium Sp.	14.46	13.11	14.82	16.33	10.81	15.23	14.36	12.11	13.71	13.68	14.76	14.11	13.9575
Pediastrum Sp.	8.32	9.64	9.13	8.11	7.69	7.31	7.26	9.82	11.62	9.93	9.97	11.32	9.1766667
Hydrodictyon Sp.	12.56	11	13.33	10.46	15.32	16.14	11.46	12.31	10.71	12.67	13.3	12.02	12.606667
Spirogyra Sp.	14.14	12.46	14.21	14.36	13.32	12.13	16.21	15.48	16.53	18.12	13.22	14.46	14.553333
Scendesmus Sp.	16.46	15.32	16.81	15.31	17.14	15.32	17.82	13.36	13.13	13.78	15.76	16.55	15.563333
Ulothrix Sp.	12.36	15.47	11.47	13.31	14.23	14.71	12.67	17.76	15.53	11.12	12.35	15.56	13.878333
Cyanophyceae	**1.4**	**2.3**	**3.5**	**1.2**	**4.3**	**2.7**	**0**	**0**	**0**	**2.1**	**1.7**	**1.2**	**1.7**
Anabaena	20	0	15	32	19	16	0	0	0	37	14	24	14.75
Oscillatoria	35	60	48	28	21	34	0	0	0	27	45	46	28.666667
Anacystis	45	40	37	50	60	50	0	0	0	36	41	30	32.416667
Sand and Mud	**14.3**	**11.72**	**14.36**	**19.82**	**12.56**	**11.23**	**18.36**	**18.63**	**14.54**	**12.92**	**18.11**	**11.36**	**14.825833**
Miscellaneous	**10.08**	**11.95**	**12.75**	**12.26**	**6.37**	**18.2**	**16.41**	**15.07**	**19.23**	**14.67**	**9.86**	**10.21**	**13.088333**

gotyla gotyla (Fig. 2). The diversity of phytoplankton species recorded in present study was higher than the previous study on same genera by Gaur *et al.* (2013) whereas Gandotra *et al.* (2018) have not classified the algae into genera in their study.

Bacillareophyceae:

Maximum contribution were recorded in the month of May (47.14%) and minimum in the month of July (31.9%). The most dominant species found in the gut content was *Diatom* sp. *(*22.4%), followed by *Navicula* sp. (12.9%), *Synedra* sp. (12.57%), *Cymbella* sp. (12.07%), etc. while least available species was *Amphora* sp. (1.71%). In the present study Bacillareophyceae were recorded as main preference food. Teferi *et al.* (2000) observed that Bacillareophyceae is highly digestible than other plankton group. Mondal *et al.*

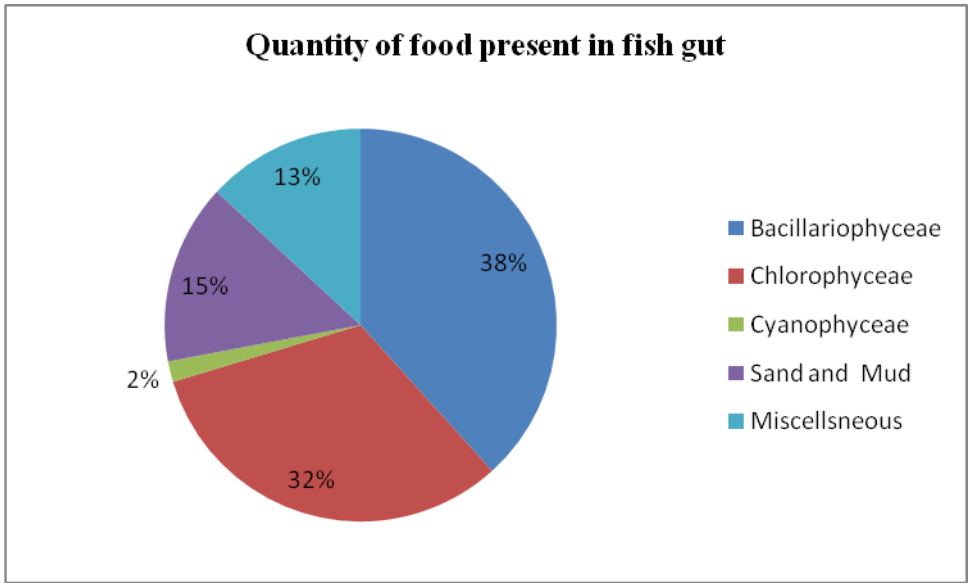

Fig. 2: Mean percentage occurrence of food items in gut content of *Garra gotyla gotyla.*

(2005) in *Puntius gonionotus*, Kanwal and Pathani (2012) in *Garra lamta* and Wagaw (2021) in *Oreochromis niloticus* also recorded Bacillareophyceae as a dominant food.

Chlorophyceae:

It was second dominant group found in the gut content of *Garra gotyla gotyla*. The maximum quantity was recorded in December (39%) and minimum in August (27%). The most dominant sp. of Chlorophycae found in gut content was *Chlorella* sp. (16.91%) followed by *Scendesmus* sp. (15.56%), *Spirogyra* (14.55%),) etc. while the least available species was *Chlorococcum* sp. (3.43%). Kanwal and Pathani (2012) recorded *Spirogyra* sp. as dominant Chlorophyceae in *Garra lamta*.

Cyanophyceae:

The least available group in gut content was Cyanophyceae. Only three taxa were recorded namely *Anabaena* sp., *Oscillatoria* sp. and *Anacystis* sp. The maximum quantity was recorded in May (4.3%) while during July, August and September no taxa were recorded. Out of these *Oscillatoria* sp. (28.66%) was found maximum while *Anabaena* sp. (14.75%) was found in low abundance. In freshwater ecosystem Cyanophyceae were generally found in less quantity.

Sand and Mud:

The percentage of this group was 14.82% in total gut content. The maximum percentage was recorded in April (19.82%) followed by August (18.63%) and July (18.36%) while minimum was observed in June (11.23%). Low density of plankton forced fishes to feed on sand, mud and detritus. Similar study was reported by Engdaw *et al.* (2013) from *Nile tilapia*.

Miscellaneous:

Miscellaneous is unidentified detritus matter present in gut with an average of 13%. The maximum percentage of it was recorded in September (19.23%) while minimum in May (6.37%). High presence of sand, mud, and detritus along with miscellaneous item in gut content establishes *Garra gotyla gotyla* as detrivorous and bottom feeder.

Feeding intensity in relation to gonadal maturity:

Feeding intensity has been categorized into five groups namely- full, ¾ full, ½ full, ¼ full and empty (Table 2). The feeding intensity of mature fishes was recorded very poor during peak spawning months of July, August and September. Maximum number of empty stomach has been recorded in peak breeding season (September) while in other stage of maturity after breeding,

Table 2: Monthly variation in the feeding intensity of *Garra gotyla gotyla* in relation to gonadal maturity

Month	Full No. (%)	¾ Full No. (%)	½ Full No. (%)	¼ Full No. (%)	Empty No. (%)	Total specimen	Gonadal Maturity status
January 2019	3 (17.64)	6 (35.29)	4 (23.52)	4 (23.52)	0	17	Immature
February 2019	5 (29.41)	4 (23.52)	3 (17.64)	2 (11.76)	3 (17.64)	17	Immature + Early maturing
March 2019	7 (33.33)	5 (23.80)	6 (28.57)	2 (9.52)	1 (4.76)	21	Early maturing
April 2019	5 (38.46)	4 (30.76)	2 (15.38)	2 (15.38)	0	13	Early maturing + late maturing
May 2019	5 (45.45)	2 (18.18)	0	4 (36.36)	0	11	Late maturing + Early mature
June 2019	2 (25)	1 (12.5)	1 (12.5)	3 (37.5)	1 (12.5)	8	Early mature
July 2019	0	2 (18.18)	3 (27.27)	4 (36.36)	2 (18.18)	11	Late mature
August 2019	0	0	1 (20)	3 (60)	1 (20)	5	Ripe
September 2019	0	0	1 (11.11)	3 (27.27)	5 (55.55)	9	Ripe + spent
October 2019	3 (15.78)	5 (26.31)	5 (26.31)	3 (15.78)	3 (15.78)	19	Spent
November 2019	4 (26.66)	3 (20)	5 (33.33)	4 (26.66)	0	15	Resting
December 2019	6 (37.5)	5 (31.25)	2 (12.5)	2 (12.5)	1 (6.25)	16	Resting

fish feeds as per requirement. Feeding can never discontinued due to demand of energy for various activity including swimming, search of food and morphological and gonadal maturation, so the fishes with ¾ full guts and ½ full guts recorded almost throughout the year. The preference for food and availability of various food items in river fluctuate feeding intensity of fish (Pathani and Das, 1979). Non-availability of food, quality of available food in water and maturation of gonads influenced the feeding intensity of fishes (Kariman, 2009; Sadguru, 2017). The maximum number of full gut was observed in the month of May (45.45%) while empty during July, Aug and September months. Other coldwater fishes such as-- *Schizothorax* sp., *Barillius* sp., and *Garra* sp. breed in the monsoon season, and due to the increase in population by new recruitment, the availability of food items is drastically reduced. Similar result was observed by Kanwal and

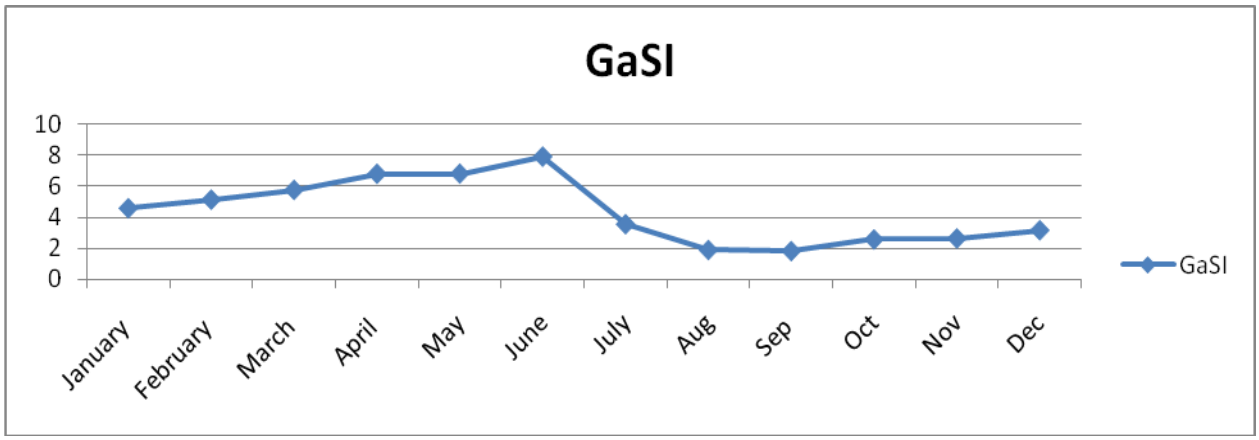

Fig. 3: Monthly variation in gastrosomatic index of *G. gotyla gotyla*.

Pathani, (2012). Seasonal changes in food and feeding habit of other fishes were studied by Dutta (1991) in *Rasbora rasbora* and Soni and Ujjainia, (2017) in *Labeo rohita*. Poor feeding during spawning season was also recorded in *Barilius vagra* (Gandotra *et al.*, 2007) and *Tor tor* (Sharma, 1988), *Mystus tengara* (Gupta and Banerjee, 2014), *Cyprinus carpio var. specularis* (Menon and Hossain, 2011) and *Gudusia chapra* (Mondal and Kaviraj, 2010). The maximum feeding intensity during summer coincides with sufficient food abundance and store energy for upcoming breeding season (Serajuddin *et al*., 1998). High percentage of empty gut during spawning season may be due to mature gonads reside in major portion of peritoneal cavity and make feeding difficult (Serajuddin *et al.*, 1998).

Gastrosomatic index (GaSI):

During the present study, mean GaSI value (Fig. 3) has been found between 1.85 and 7.92. The monthly mean GaSI value has been recorded highest during June (7.92) while lowest during September (1.85). GaSI value decreased from July month gradually till September and then again rise from October and onwards. The results indicate lowest GaSI coincide with peak spawning season. The possible reason is that fish save their energy for gonadal development and spawning. After breeding performance the GaSI value increased October onwards to compensate the loss of energy. Similar findings were observed by Soni and Ujjainia (2017) in *Labeo rohita*, Gupta and Banergee (2014) in *Mystus tangara*, Kumar *et al.* (2015) in *Catla* and Sarkar and Deepak (2009) in *Chitala chitala*. Gastrosomatic index has determined the feeding intensity (Dasgupta, 2002). During the month of September, the minimum GaSI was recorded with maximum empty gut. From October onwards percentage of empty gut decreased with increasing GaSI. Gandotra and Rizwan (2018) observed the GaSI of *Garra gotyla gotyla* in decreasing pattern with increasing in size and highest GaSI recorded (12.32) in summer while lowest (8.80) in winter month. GaSI of *Garra gotyla gotyla* was 6.53-8.13 (Kaundal *et al.*, 2013). GaSI of *Barilius bendelisis* (5.32-8.60), *Crossocheilus latius latius* (3.17-8.69) and *Schizothorax richardsonii* (5.43-10.25) recorded by Kaundal *et al.* (2013).

Relative length of Gut (RLG):

Observed values of RLG varied between 3.27 (3.8-6.8 cm) to 4.49 (16.2- 18.2 cm) with an average of 3.82 (Fig. 4). Value of RLG is depicting that *Garra gotyla gotyla* is herbivorous fish. Relative length of gut and ventral position of sucking mouth confer this genus as algae eating, bottom dweller (Kanwal and Pathani, 2012). Relative gut length determines feeding habit (Serajjuddin and Mustafa, 1994). RLG value of *Garra gotyla gotyla* recorded increase with increasing body length. Alhussaini (1947)

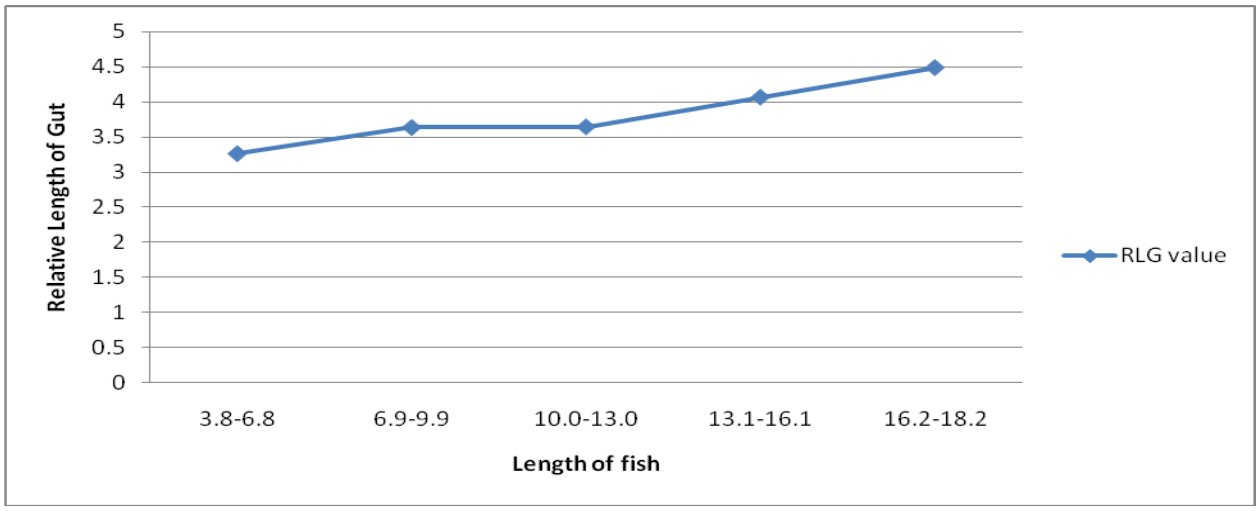

Fig. 4: Variation in Relative length of Gut (RLG) of *G. gotyla gotyla.*

categorized fishes into three category according to their feeding nature namely-- herbivorous (RLG value= 3.7-6), omnivorous (1.3-4.3), and carnivorous (0.5-2.4). Gupta and Banerjee, (2014) reported *Mystus tangara* as carnivorous fish with mean RLG of 0.90. Sadguru (2017) observed the mean RLG value of *Channa punctatus, Channa straitus* and *Channa gachua* as 0.77, 0.81 and 0.67, respectively. Kaundel *et al.* (2013) reported *Garra gotyla gotyla* and *Crossocheilus latius latius* as herbivorous fish with RLG value 4.73-6.27 and 3.49-4.09, respectively. RLG of hill stream fish *Barilius bendelisis* was recorded between 0.78-0.90 and in *Schizothorax richarsonii* 1.56-3.01 (Kaundal *et al.*, 2013).

Conclusion

The present study on food and feeding habits revealed that the *Garra gotyla gotyla* in *in-situ* environment is bottom feeder and phytoplanktyvorous. Ecological conditions play main role in developing the food and feeding habits of the species. The food contents and feeding intensity in different seasons give insight of feeding behavior, which will lead to great role in formulating a diet of the species and developing a protocol for seed production, rearing and brood banking of the species for culture and conservation.

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