CHAPTER 8 - FOOD AND FEEDING BIOLOGY

8.1. INTRODUCTION

In natural condition, fish can regulate their feed intake from wide varieties of natural food to fulfill their nutritional requirement. Irregular availability of natural food for culture of ornamental fish under captivity is the main bottleneck. Standardization of optimal nutritional requirement and feed supplement for different stages of ornamental fishes will very important database for development of diet required for maturation and successful breeding and culture of ornamental fishes under captivity. Nutrition, in terms of food is the essential requisites for all living beings for all energy to perform its biological processes such as growth, development, reproduction and other metabolic activities. Al-Hussaini, 1947 observed numbers of species of fish from the Red Sea and classified the fish on the basis of their food preferences into four groups as i) plankton feeders ii) herbivorous, iii) omnivores and iv) carnivores. Ganapati and Chacko, 1950, classified the fish as i) surface feeders, ii) column feeders and iii) bottom feeders. All these classifications of fish are arbitrary as the feeding habits of fish are varies according to age, sex, localityor season. The success of good scientific research and fish farming largely depends on the knowledge of their food and feeding habits (Begum *et al*., 2008; Sarkar and Deepak, 2009). Study on food and feeding habits of fish have numerous importance in fish biological studies (Singh *et al*., 2013). Al-Hussaini, 1949 is the pioneer to work out the relative length of alimentary canal of a large number of fish in relation to food and feeding habits. The relationship between alimentary canal and

feeding habits was studied for many fishes by different authors viz. Mishra *et al*., 2013; Chakraborty *et al*., 2016; Dey *et al*., 2016 and Khongngain *et al*., 2017 etc. Determination of relative gut length and effect of different live and artificial feed on growth, captive maturation and breeding *C. nobilis* have not been studied deeply. Only some data available on the natural feeding habit of *C. nobilis* (McCleland, 1845; IUCN Bangladesh, 2000; Rossman, 2008).

8.2. MATERIALS AND METHODS

Study of feeding biology were consist of: i) morphology of facial, alimentary canal and other associated structures, ii) study of natural feeding habit, iii) Proximate composition of different food items, iv) feeding intensity of matured fish, v) relative length of the gut and vi) FCR.

8.2.1. Study of natural food and feeding habit:

To know the natural feeding habit of a particular fish gut content analysis is very important. After collecting the fish from natural habitat gut was dissected from 50 specimens and preserved in 10% formaldehyde solution for further testing. Gut content analysis has been performed following the percentage of occurrence method by Hynes, 1950. This method is based on the count of particular food item in gut. The formula used:

Percentage by number, $\% O_i = \frac{N_i}{N_t} x\ 100$

Where: % O_i is the percentage of particular food item in gut; N_i is number of that particular food item in gut and N_t is number of total food items in gut.

8.2.2. Gastro-somatic Index (GaSI):

For determination of the food and feeding habits of the fish species GaSI, gut content, mouth size and shape were studied as per standard methods. After measuring the total length, mouth to anus length and weight of specimen, the alimentary canal was dissect out and preserved in 10% formalin for microscopic examination of food items. Length of intestine was measured for comparison with total length of fish. The weight of gut was taken and the feeding intensity was measured by calculating the GaSI.

$$\text{GaSI} = \frac{\text{Weight of gut (gm)}}{\text{Total weight of fish (gm)}} \text{x}100$$

8.2.3. Relative Length of Gut:

Relative Length of Gut (RLG) value has been measured by the formula of Al-Hussaini, 1949. The RLG values calculated have then been grouped in response to different size classes to know any change of RLG value in respect to size.

$$\text{RLG} = \frac{\text{Total length of gut (mm)}}{\text{Total body length (mm)}}$$

The relationship between total length and the length of intestine and total length was calculated by the formula-

$$Y = a + bX$$

Where, Y = Intestine length (IL), X = Total length (TL), 'a' is the interception on the ordinate and 'b' is the regression co-efficient.

8.2.4. Food preference and dietary intervention in growth:

For food preference study the fish was given Tubifex, Daphnia, Mosquito larvae, Artemia and dry feed for 5 days @ 2% of body weight and noticed the acceptance. Growth study was conducted with 5 different types of feed: Tubifex, Daphnia, Mosquito larvae, Artemia and dry feed (Commercial dry food by Finsters with 24% crude protein and 4% lipid). Feed was given @ 2.5% body weight at twice a day (morning 10 AM and evening 5.30 PM) for 90 days. Each experiment was done n duplicate and 6 numbers of fish (Average size length 45-60 mm and 2-3.5 g weight) give in each tank (**Figure 34**). At that time water temperature varies between 24-28^{o}C. Un-utilised feed collected daily and dried to calculate the actual feed intake by the fish. The growth of the fish was calculated in terms of length and weight gained by the fish. The FCR values calculated in different types of feed given to the fish.

Figure 34. Experimental setup for dietary intervention

(See colour photo in Plate No. VIII, Fig. 22)

8.3. RESULT

8.3.1. Facial and alimentary canal morphology:

The alimentary canal of the fish is comprises two main parts:

A) Buccopharynx comprising mouth, buccal cavity, pharynx

B) Gut includes oesophagus, moderately long intestine and undifferentiated rectum

A) Buccopharynx

Terminal mouth position with little protruding. The mouth is bounded by thin upper and lower lips (**Figure 35**). The mouth opens into laterally compressed buccopharyngeal cavity. In *C. nobilis* there are three pairs of well developed gill arches (**Figure 36**). The first gill arch modified into vascularised labarynth organ. Each gill arch comprises of double row of gill rakers on its concave aspects and gill filaments on convex side. The mouth gape 0.3mm of adult size (Ranges between 72-100mm).

Figure 35. Mouth position of *C. nobilis*

(See colour photo in Plate No. VIII, Fig. 23)

Figure 36. Structure of gill of *C. nobilis*

(See colour photo in Plate No. VIII, Fig. 24)

B) Gut

Pharynx leads into oesophagus. The oesophagus is very short in length and leads into the intestine. Intestine is characterised by short, thick walled and straight (**Figure 37**). The anterior part of the intestine was slightly swollen forming an intestinal bulb behind the oesophagus.

Figure 37. Structure of alimentary canal of the fish

(See colour photo in Plate No. IX, Fig. 25)

8.3.2. Gut content analysis:

With a thorough microscopic examination of the gut contents of the fish of different size groups during April to June indicates the presence of various food items

which are classified into five broad classes namely Zooplankton, micro worms, tiny Crustacean, insect larvae and Unidentified Species. Results of gut content following percentage of occurrence method have been presented in **figure 38**. Study reveals that tiny crustacean, zooplankton and followed by insect larvae have higher rate of occurrence in gut so it can be concluded that these may be their food preference in natural habitat.

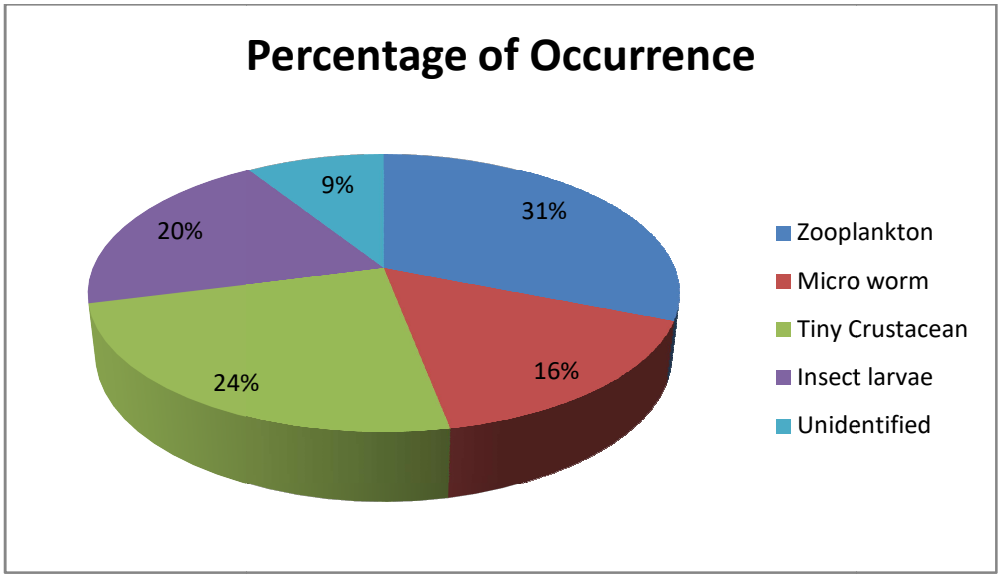

Figure 38. Percentage of occurrence of different food items in gut

(See colour photo in Plate No. IX, Fig. 26)

8.3.3. Feed preference and growth study:

As the fish is naturally larvae eaters so it is observed that the fish preferred to take live feed especially Daphnia, mosquito larvae, artemia larvae and small tubifex. The proximate analysis of Daphnia, mosquito larvae, artemia larvae and tubifex were done (**Table 60**). The feed preference study of the fish conclude that the feed preference sequence of the fish is Mosquito larvae, Daphnia > Live Tubifex > Artemia larvae > Live Blood worm > Dry feed (**Figure 39**). From the experimental data on growth of the fish

with these types of food items, it is observed that the fish grow maximum with tubifex diet (0.73g and 27mm) (**Table 61**).

Table 60. Proximate composition of live fish food organisms

Diet	Tubifex	Daphnia	Mosquito larvae	Artemia nauplii
Moisture (%)	85.12	92.18	86.25	2.84
Ash (%)	5.42	15.22	10.20	7.52
Crude Protein (%)	58.48	42.78	71.52	62.80
Crude Lipid (%)	12.03	4.16	15.08	18.28

a. Daphnia

b. Mosquito larvae

c. Artemia larvae

d. Tubifex

e. Dry feed

Figure 39 (a-e). Different types of food items

(See colour photo in Plate No. IX, Fig. 27)

Table 61. Somatic growth of *C. nobilis* with different food items

Feed types	Avg. Weight gain (g)	Avg. Length gain (mm)
Mosquito larvae	0.68	24

Daphnia	0.61	18
Tubifex	0.73	27
Artemia	0.52	16
Dry feed	0.39	10

The fish only take feed @ 1.5-2% of total body weight. But the amount of feed intake increase up to 2.5% just after the breeding. The FCR is about 1.63 in the adult fish with daphnia and tubifex diet (**Table 62**).

Table 62: Variation of FCR of *C. nobilis* with different food items

Feed Applied	FCR
Mosquito larvae	1.59
Daphnia	1.63
Tubifex	1.63
Artemia	1.26
Dry feed	0.78

8.3.4. Relative Length of Gut (RLG):

The alimentary canal is short in length and the Relative Gut Length is about 0.56-2.18 depending on size group of 25-98mm (**Table 63 and Figure 40**). The RLG value of the fish implies that it is carnivorous in nature.

Table 63: Changes of Relative gut length with the total length of *C. nobilis*

Length range (mm)	No. of fish examined	Average values of RLG
22-47	10	0.96
48-55	5	1.28
56-69	8	1.81
70-100	9	2.18

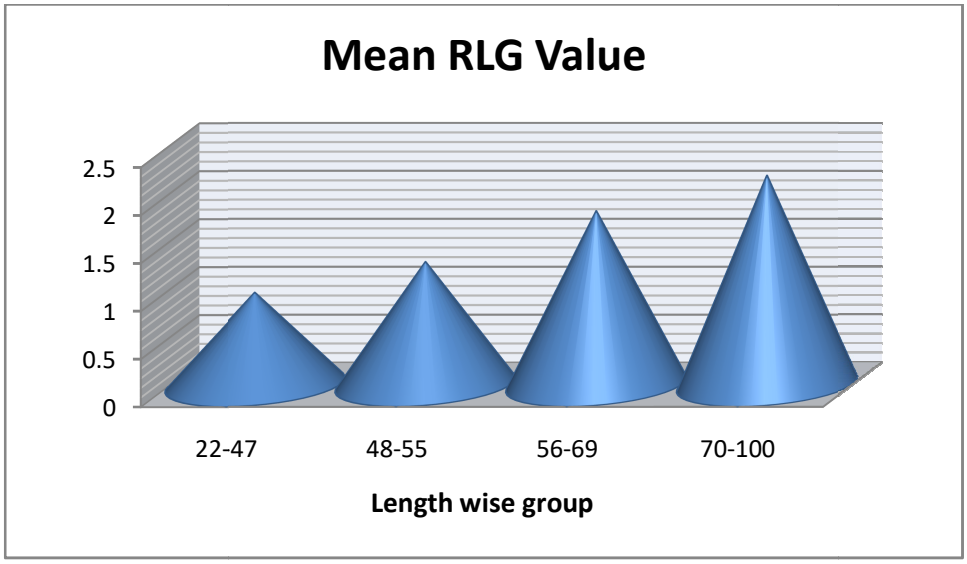

Figure 40. Length group wise average RLG values in *C. nobilis*

8.3.5. Relationship between total length and intestinal length:

The length of intestine (IL) plotted against the total length of fish (TL) is shown in **figure 41** which reveals that the length of intestine increases in proportion to the total length of fish. The equation for regression line is:

IL= -0.147 + 0.766 TL.

The coefficient of correlation 'r' is calculated to be 0.985 (**Table 64**). The above relationship is worked out on 100 specimens for the fishes belonging to length range from 25 mm to 100 mm.

Table 64. Descriptive Statistics of length of intestine (IL) and the total length of fish (TL) of *C. nobilis*

	Sample size (N)	Range	Mean	R	R Square	Calculated 't' value	Significance
TL (mm)	**100**	**25-100**	**57.73**	**0.958[a]**	**0.918**	**3.13**	**S**
IL (mm)	**100**	**17-42**	**31.13**				

S= Significantly different at 1% level.

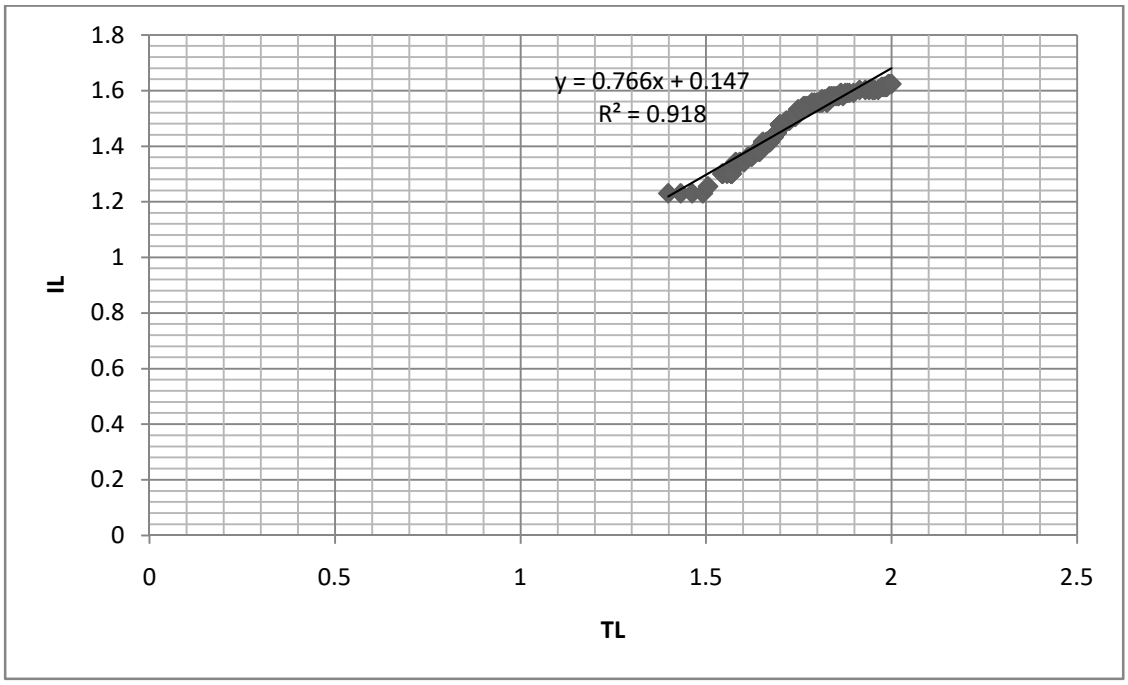

Figure 41. Total length and Intestine length relationship

8.3.6. Gastrosomatic Index:

The Gastrosomatic Index (GaSI) of the fish has been observed to become highest in winter which is about 2.30 and become very low in monsoon time which is near about 1.68 (**Table 65**). Month wise trend of GaSI of the fish is displayed by scattered diagram (**Figure 42**) which shows that at the month of March, April and May the GaSI is higher than other times of the year. Then May onwards the GaSI tending lower and again from October it shows higher growth. In the month of August it reach the lowest point of GaSI.

Table 65: Seasonal changes in Gastrosomatic Index of *C. nobilis*

Seasons	No. of Fish examined	Average GaSI
Pre-monsoon (April to June)	9	2.12
Monsoon (July to September)	10	1.68
Post-Monsoon (October-December)	6	1.96
Winter (January to March)	7	2.30

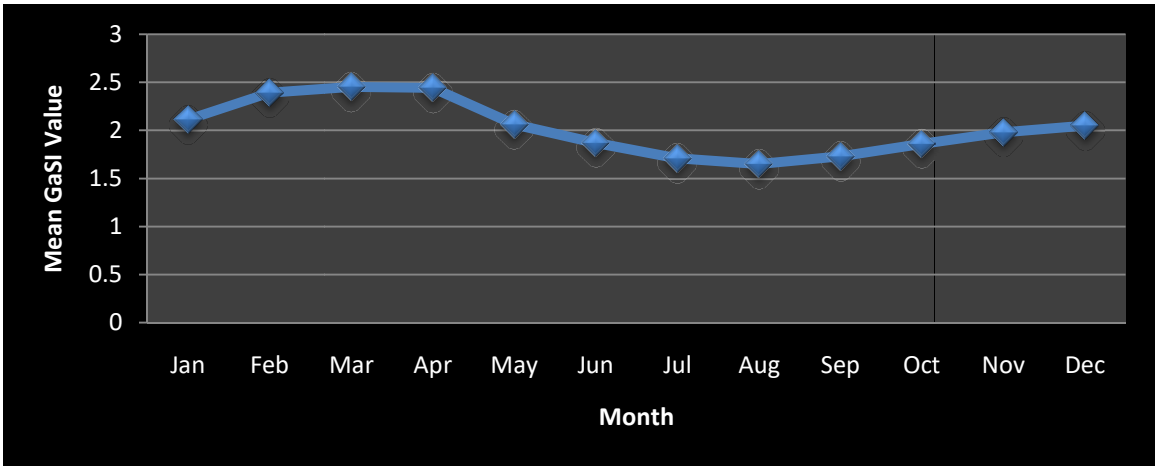

Figure 42. Month wise GaSI trend of *C. nobilis*

8.4. DISCUSSION

The mouth position varies with the feeding behaviour of fish. In *C. nobilis* pipe shaped mouth bounded with thin upper and lower lip and lower lip is little upturned and longer than the upper one. There are three pairs of well developed gill arches with minute but closely packed filamentous gill rackers. Zooplankton with 31% and tiny crutacean with 27% has been observed as the most abundant group in the gut content of the *C. nobilis*. Rossman, 2008 also observed crustacean, micro worms and zooplankton occurrence in the gut of the fish. A gradual increase in RLG was noticed among the fish of different size groups from 22-100 mm which varies from 0.96-2.18. Al-Hussaini, 1947 classified the fish depending on RLG values as - carnivorous (0.5-2.4), omnivorous (1.3-4.3) and herbivorous (3.7-6.0) fishes. The mean monthly values of Gastro-Somatic-Index (GaSI) have been observed to become high during March to May with the peak being in March. Then it started to drop down from May onwards. The lowest value was observed in the month of November. Then it gradually started to increase from December onwards and reach the peak again in the month of April. The lower values along with the decreasing trend of GaSI observed from May to October, depicting the poor feeding intensity of the fish which is correspondence with their breeding periodicity.