International Journal of Advanced Biotechnology and Research(IJBR)
ISSN 0976-2612, Online ISSN 2278–599X,
Vol5, Issue3, 2014, pp313-324
http://www.bipublication.com

Parasitic Study of *Labeo bata* (Hamilton, 1822) in Selected Districts of West Bengal, India

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[Received-29/04/2014, Accepted-05/07/2014]

ABSTRACT

The study was carried to find the prevalence of different parasites in *Labeo bata* with respect to different months, seasons and length groups. The parasites were isolated and identified from fish samples collected from three selected districts of West Bengal namely South 24 Parganas, North 24 Parganas and Burdwan. The investigation was made on *Labeo bata*, such way that the selected districts having more potential fishery resources, easy to collect samples and easy transportation of collected samples to laboratory. Approximately 720 fishes were observed in between April, 2012 to March, 2013. During the study period the isolated parasites were *Myxobolus* sp., *Thelohanellus* sp., *Trichodina* sp., *Dactylogyrus* sp., *Gyrodactylus* sp., *Argulus* sp., *Lernea* sp., *Chilodonella* sp., *Cosia* sp., Nematodes and unidentified Crustaceans. The winter season was found to be the most vulnerable period to get parasitic infestation. During this period the water qualities get deteriorated and the fishes were in stressed condition which favours the parasites to infest.The prevalence of *Myxobolus* sp. and *Thelohanellus* sp. were highest in winter and spring seasons. Prevalence *of Trichodina* sp. was more in winter whereas prevalence of *Dactylogyrus* and *Gyrodactylus* sp. were highest in rainy season. *Costia* sp. was recorded only in winter with the prevalence of 1.66%. It was also found that 20-25cm length group fishes were more infested with parasites compared to 10-15 cm and 15-20 cm length groups.

Key Words: Parasites, prevalence, PFI, seasons, length groups, *Labeo bata*

I. INTRODUCTION

Aquaculture is the fastest growing food producing sector with an annual growth rate of over 6%. In India freshwater aquaculture has made notable progress in recent years, and contributed about 3/4th of the total fish production in the country. The projected additional demand of fish in India by 2020 is about 3.21 million tonnes out of which about 90% is expected to be met from the freshwater sources comprising Indian Major Carps (IMC, 52%) and other freshwater fishes including minor carps (38%). The genus *Labeo* exhibits intensive species diversification and constitutes commercially important carps with nutritional benefits for mankind. Out of 31 species of *Labeo* only few have been domesticated for culture. *Labeo rohita* is being widely cultivated throughout the country and accounts for a great bulk of the production, while other *Labeo* species have a great potential in terms of biodiversity as well as consumer preferences. Among these, *Labeo bata* (Hamilton) is one of the most important species of inland fisheries of India. The species is basically a benthopelagic and potamodromous in nature and widely cultured in the country considering commercial and economical importance. It is known for its unique taste among other carps.

West Bengal has 37% of the pond resources in India, of which 70% are utilised for fish culture producing around 1-3 million tonnes of fish per year [1]. About 64% of farmers are practiced with a semi-intensive or intensive type of aquaculture. This intensification is mainly in terms of very high stocking density with input of external feed. However there are no water exchange or planned feeding schedule, regular health management as well as water quality monitoring. Since the fishes are stocked at a very high density this can leads to stress on the fishes leads to the development of diseases. Among the infectious diseases parasitic diseases accounts around 19.40% in aquaculture production system. It is also reported that the parasitic infestations are playing a major role in disease occurrences (78%) in Indian freshwater aquaculture [2]. The results corroborate the observations of [3], who reported that ectoparasitic diseases are the main problem in freshwater fish farms of Andhra Pradesh, India which caused an annual loss of US$ 1 million. Further, the freshwater fish farmers of Andhra Pradesh and West Bengal were estimated to facing about 21% and 26% of production loss due to diseases, poor farm management practices and impaired growth [4, 5]. Though the taxonomy of fish parasites had been done by a number of workers but the report on prevalence is found to be scanty. So the present study was conducted to unearth the prevalence of parasites, severity of infestation, frequency with respect to different months, seasons and length groups in *Labeo bata.*

II. MATERIAL AND METHODS

The present study was carried out for a period of 12 months from April, 2012 to March, 2013. The samples were collected from different localities of 3 district namely Garia, Bantala, Bamanghata, Gangajuara of South 24 Parganas District, Naihati of North 24 Parganas District, Memari of Burdwan District of West Bengal. The samples were collected on a regular basis once in every month. In each sampling about 60 fishes were collected in live condition. The fishes were brought to the laboratory in live condition with water filled buckets and the total lengths, body weight of fishes were taken. The vital organs like skin, intestine, kidney and gills were examined for the presence of different parasites described [6]. External parasites from body surface, fin and gills were removed by scrapping the slime with a sharp scalpel. It was mixed with a drop of physiological saline (0.85% NaCl) and was spread on a clean dry glass slide with coverslip on top of it. The gill arches were removed and macerated on slides and examined under a compound binocular microscope. In case of monogeneans the gills were removed into petridishes containing physiological saline and gently scrapped to dislodge monogeneans. After that the monogeneans were placed on clear slides with a fine pipette with a drop of water and covered with cover slip. For endoparasites fishes were dissected out ventrally by a sharp scalpel to observe parasites inside buccal cavity, stomach and intestine. The whole gut was removed in a watch glass containing physiological saline and was cleaned several times with tap water to free it from any unwanted materials. Small worms were searched initially with the help of magnifying glass by scrapping out mucus [7]. Phenotypic characterization of all protozoans, monogeneans, digeneans and nematode parasites were studied as described by the reported method [8]. Photomicrographs were taken using a Motic BA400 phase contrast microscope with in-built digital camera.

2.1 Determination of parasitic frequency index (PFI, %)

The Parasitic Frequency Index (PFI) was calculated by taking the percentage of the number of hosts infected by an individual parasite species against the total number of hosts examined in a particular area under investigation. The frequency index were further classified into rare (0.1 – 9.9%), occasional (10-29.9%), common (30 – 69.9%) and abundant (70-100%) as described [9].

$$\text{Prevalence}(\%) = \frac{\text{Total number of infected fishes}}{\text{Total number of fish host examined}} \times 100$$

In order to assigning numerical qualitative value of severity grade of infections, surface infestation and disease syndrome, the generalize scheme was followed [10].

III. RESULTS AND DISCUSSION

3.1 Prevalence of different parasites in *Labeo bata*

Monthly distribution of parasites in *Labeo bata* is presented in **Table- 1** and **Figure- 1**. During the study period, total number of 10 ectoparasites species i.e., 2 Myxozoan (*Myxobolus* sp., *Thelohanellus* sp.); 4 protozoan (*Trichodina* sp., *Chilodonella* sp., *Ichthyobodo* sp., *Vorticella* sp.), 2 monogenean (*Gyrodactylus* sp. and *Dactylogyrus* sp.) and 2 crustacean (*Argulus* sp. and *Ergasilu* sp.) and 1 endoparasite species i.e. nematode (*Goezia* sp.) were identified from fish samples. The PFI of *Myxobolus* sp. (**Figure-2, 3**) were found to be varied from 5% to 41.66% throughout the year. The highest prevalence was found in the month of February (PFI, 41.66%) and the condition was 'abundant' whereas the lowest was in May (PFI, 5%) with the condition 'rare'. There was no *Myxobolus* found from the month of March to September (PFI, 0%). These present findings are revealed by the report that the probable cause of higher infestations of *Myxobolus* sp. in February could be due to the presence of oligochaetes, as they need an intermediate host to complete their life cycle [11]. Moreover, the oligochaetes are bottom dweller which results the more infestation in case of bottom feeding fish such as *Labeo bata* which acts as an intermediate host to complete the life cycle [12]. The variation in the prevalence of *Myxobolus* sp. in other months may be due to unfavourable environmental conditions such as reduced water level, and comparatively low oxygen content associated with high water temperature. In case of *Thelohanellus* sp. (**Figure-4, 5**) the highest prevalence was found in the month of March (PFI, 75%) whereas in the month of December (PFI, 13.33%) and January (PFI, 15%) it was comparatively low. These findings may be due to low temperature of winter months [13, 14].

The PFI of *Trichodina* sp. (**Figure-6, 7**) were found to be highest (PFI, 70%) in the month of August and lowest (PFI, 16.66%) in February and March. In the case of *Chilodonella* sp. (**Figure-8, 9**) the prevalence was highest (PFI, 33.33%) in February and lowest in January (PFI, 8.33%). *Ichthyobodo* sp. (**Figure-10, 11**) was found only in 3 months of the year namely January, February and March (PFI, 5%, 25% and 16.66% respectively). These variations could be due to stocking density, water depth, temperature, physicochemical parameters and management practice maintained in the ponds. High stocking density increases the chance of ectoparasite transmission from fish to fish easily. It is revealed by the report on availability of host for the ectoparasitic infection increases with the increasing stocking density [15].

Vorticella sp. (**Figure- 12**) were found only in the month of April, June and September and their PFI values were 10%, 20% and 18.33% respectively. These variations may be due to the factors namely age and seasons as these factors are basically related with the physiological and ecological conditions of the host and parasites [16]. *Gyrodactylus* sp. (**Figure-13, 14**) was found in four months of the year namely July, August, September and October. They gave the condition termed as 'occasional' with the highest prevalence (PFI, 16.66%) in the month of September. But the *Dactylogyrus* sp. (**Figure-15, 16**) was found in the months of February, July, August and October. In this case the highest prevalence (PFI, 16.66%) was found in the month of August with the same condition of *Gyrodactylus* sp. The 'rare' condition of *Gyrodactylus* and *Dactylogyrus* sp. were found in the months of July with the lowest PFI. These variations are revealed by the report on prevalence and intensity of gill ciliate and monogeneans that found to increase in polluted environments relating to the host susceptibility [17, 18].

Prevalence of Nematodes (**Figure- 17, 18**) was found to be varied from 10% to 30% throughout the year. The highest prevalence with the condition called 'common' was found in the month of November (PFI, 30%). The lowest PFI (PFI, 10%) values for the nematodes were found in the month of August with the condition of 'occasional'. These findings could be revealed by the report that the stress and poor water quality during winter months leading to the various parasitic infestations [19]. Moreover it is stated that water temperature is often a critical environmental parameter for parasites of fishes, with effects upon parasite survival, growth, time of transmission, distribution and host hormone cycle [20].

Argulus sp. (**Figure-19**) was found only in the month of October (PFI, 20%) and its condition was 'occasional'. These findings are different in *Labeo rohita* as described [14]. These differences may be due to place of sample collection, no of fishes observed and size of host fishes. *Ergasilus* sp. was found only in September (PFI, 11.66%) and March (PFI, 10%) with the condition 'occasional'. These variations may be due to unavailability of host since they are host specific parasites. Apart from these the chemical characteristics of water may also have an important effect on parasites of fishes. Low Alkalinity reduces the buffering capacity of water and badly affects the pond ecosystem that in turn cause stress to the fish and become more susceptible [21]. Statistical analysis revealed that there was no significant difference ($P > 0.05$, df=11) in monthly PFI values. But there was a significant difference ($P < 0.05$, df=10) existed among PFI values of parasites. (**Table- 2**)

3.2 Occurrence of parasites in different seasons

Occurrence of parasites in different seasons is given in **Table- 3** and **Figure-20**. The total study period was divided into four seasons; i.e. summer (April - June); rainy season (July-September) or monsoon; winter (October-January) and spring (February- March). Though the distributions of myxosporean were found throughout the year, the distinct seasonal variations were found to be associated with their occurrence. For the *Myxobolus* sp. highest PFI was found in winter (PFI, 41.66%) and lowest in summer (PFI, 15.83%). In the winter season they gave the 'common' condition whereas in case of other seasons it was 'occasional'. The present findings are supported by earlier workers [11] who stated that myxozoan are highest during winter season. The probable factor for highest prevalence in winter may be due to low environmental temperature which leads to the low metabolic activity of fish ultimately making the fishes more susceptible to parasitic infestation. On the other hand, *Thelohanellus* sp. was not reported during summer and monsoon seasons. The highest PFI (PFI, 37.5%) of *Thelohanellus* sp. were in spring with the 'common' condition whereas lowest PFI (PFI, 9.44%) were found in winter. It is may be due to the external factors, which directly influenced the parasite fauna of fish. These factors include age, diet and abundance of fish, independence of number of parasitic fauna within the fish [22].

The prevalence of *Trichodina* sp. were found to be highest (PFI, 43.88%) in winter season with the 'common' condition whereas, in spring it was 'occasional' (PFI, 18.33%). *Ichthyobodo* sp. were also found in winter (PFI, 1.66%) and spring (PFI, 20.83%) seasons. These findings are supported by many studies suggesting that *Trichodina* sp. and *Ichthyobodo* sp. are common in cyprinids in freshwater cultured ponds. The stated infestations in winter season can be revealed by the findings that the ectoparasitic infestations are heavy during winter due to several biological factors of the host (fry and fingerlings of cyprinids) as well as the water quality parameters [23]. The prevalence of *Chilodonella* sp. was recorded highest (PFI, 16.66%) in spring with the condition 'occasional' whereas the lowest (PFI, 2.77%) was found in winter with the condition 'rare'. But, *Vorticella* sp. were reported only in smmer (PFI, 15%) and monsoon seasons (PFI, 6.11%).

In the monsoon season the prevalence of *Dactylogyrus* sp. (PFI 7.77%) and *Gyrodactylus* sp. were found to be highest (PFI 10.55%) with the condition termed as 'occasional'. In the winter season the prevalence was low for both the species. Moreover, in the case of *Gyrodactylus* sp, there were no reports in summer and spring seasons. These findings are found to be reverse compared to the earlier reports [24]. The reason for variations may be due to the water quality characteristics which influences and determines the parasite fauna.

The prevalence of nematode were highest (PFI, 33.88%) in winter season with the condition ‘common’, whereas lowest was recorded in spring season (PFI, 9.16%). These results are found to be reversed with the earlier report stated that the growth, maturation and egg productions of nematode are greatest during warm season [20]. These differentiations may be attributed to the differences in environmental conditions, fish species, and the differences in the degree of water pollution as well as number of examined samples.

The prevalence of *Ergasilus* sp. were found to be lowest (PFI, 3.88%) in monsoon whereas, in case of spring season it was highest (PFI, 5%) with the condition ‘rare’ in both the cases. The condition for *Argulus* sp. was also ‘rare’ (PFI, 6.66%) with their presence only in winter season. These seasonal variations are probably due to water temperature which influences the parasitic reproduction as stated by earlier workers [25, 26]. Moreover it was also stated that *Argulus* sp, can live throughout the winter season as an inactive juvenile stage, or as an adult on fish [27, 28].

Statistical analysis showed that PFI values were not significantly differ ($P > 0.05$, df=3) among the seasons. But there was significant difference ($P < 0.05$, df=10) in PFI values among the parasites. There was no significant difference ($P > 0.05$, df=10) in PFI values among the *Trichodina* sp., *Myxobolus* sp., *Nematode* sp., *Thelohanellus* sp. and *Chilodonella* sp. but there was a significant difference ($P<0.05$, df=10) existed among PFI values of *Ichthyobodo* sp., *Vorticella* sp., *Dactylogyrus* sp., *Gyrodactylus* sp., *Ergasilus* sp. and *Argulus* sp. Similarly there was no significant difference ($P > 0.05$, df=10) in PFI values among the *Myxobolus* sp. and rest of all other parasites. (**Table- 4**)

3.3 Prevalence of parasites in different length groups of *Labeo bata*

The distribution of parasites in different length groups of *Labeo bata* is stated in **Table- 5** and **Figure-21**. *Myxobolus* sp. and *Thelohanelus* sp. showed highest prevalence (PFI, 40% and 14.28% respectively) in 20-25 cm length group of fish. Similarly PFI of *Trichodina* sp, *Vorticella* sp. and *Ichthyoboda* sp. were highest (PFI, 42.85%, 8.57% and 9.75% respectively) in 20-25 cm length groups. These results are revealed by the report stated that increase in abundance of parasite with host size. The lowest prevalence of *Myxobolus* sp. and *Thelohanellus* sp. (PFI, 10.57% and 7.85% respectively) were reported in 10-15 cm length groups; whereas *Trichodina* sp. and *Ichthyoboda* sp. showed lowest prevalence (PFI, 30.88% and 4.53% respectively) in 15-20 cm group. In case of *Vorticella* sp lowest prevalence (PFI, 2.43%) was found in 5-10 cm length groups. These findings were supported by earlier worker who reported that fishes of medium length groups were more infested which was similar with the results obtained in the present study [29]. The prevalence of the *Chilodonella* sp. showed highest (PFI, 9.75%) in 5-10 cm and lowest (PFI, 4.53%) in 10-15 cm. Similarly *Dactylogyrus* sp. and *Gyrodactylus* sp. showed the highest prevalence (PFI, 4.87% and 6.09% respectively) in 5-10 cm group but lowest (PFI 3.02% and 2.20% respectively) in 10-15 cm length groups. These variations may be due to lack of oxygen in culture system as reported by earlier worker [22]. Nematodes showed highest prevalence (PFI 20%) in 20-25 cm but lowest (PFI, 14.70%) in 15-20 cm group and the occurrences were ‘occasional’. It was found that prevalence increased as length decreased from 15-20 cm to 5-10 cm. These variations could be due to physiological condition of fish, influences of biotic and abiotic factors in the culture system. From the earlier report it can also be revealed that the food habit of fish may alter the parasitic prevalence in the fishes [30]. In case of *Argulus* sp., the highest prevalence (PFI, 2.94%) was found in 15-20 cm whereas lowest (PFI, 0.60%) in 5-10 cm group of fishes. The prevalence of *Ergasilus* sp. was found to be highest (PFI, 2.85%) in 20-25 cm and lowest (PFI, 1.83%) in 15-20 cm length groups. These variations were may be due to water quality changes in the culture system as stated by former workers [31].

Statistical analysis revealed that PFI values differ significantly (P< 0.05, df=3) among the length groups as well as parasites. There was no significant difference (P> 0.05, df=10) in PFI values of parasites between the *Trichodina* sp. and *Myxobolus* sp. but there was a significant difference (P< 0.05, df=10) between *Trichodina* sp. and Nematode; and rest of all parasites. Similarly there was no significant difference (P> 0.05, df=10) between *Myxobolus* sp. and Nematode but there was a significant difference (P<0.05, df=10) between *Myxobolus* sp. and *Thelohanellus* sp.; and also the rest of all other parasites. There was no significant difference (P> 0.05, df=10) in PFI values among the Nematode, *Thelohanellus* sp., *Chilodonella* sp. and *Ichthyobodo* sp. but there was a significant difference (P< 0.05, df=10) among the Nematode, *Vorticella* sp, *Gyrodactylus* sp., *Dactylogyrus* sp., *Argulus* sp. and *Ergasilus* sp. Similarly there was no significant difference (P> 0.05, df=10) among the *Thelohanellus* sp., *Chilodenella* sp., *Ichthyobodo* sp., *Vorticella* sp., *Gyrodactylus* sp., *Dactylogyrus* sp., *Argulus* sp. and *Ergasilus* sp. (**Table- 6**)

IV. CONCLUSION

The present study focuses about the conclusion that the *Labeo bata* is vulnerable to different parasites such as *Myxobolus* sp., *Thelohanellus* sp., *Trichodina* sp., *Gyrodactylus* sp., *Dactylogyrus* sp., Nematodes, *Argulus* sp., *Lernea* sp., *Chilodonella* sp. and unidentified crustaceans. The parasites multiply rapidly under favourable conditions and cause economic loss by affecting the health status of fishes causing high mortality. Among the different seasons the winter is the most vulnerable period to get parasitic infestation. During this period the water qualities get deteriorated and the fishes are in stressed condition which favours the parasites to infest. Some parasites are found more during the summer season which favours their reproduction due to the availability of their intermediate hosts. In the monsoon season the temperature fluctuates which also favours growth of some parasites. These parasites were found mostly on gills and skin of the fishes. The small and medium size fishes were found to be more vulnerable due to their poor immunity power and wide spread surface area respectively, which favours more colonization of parasites. Therefore, the successful economic benefit from aquaculture practices can get by maintaining proper health of the fishes. Water quality should be maintained during winter which can prevent parasite infestation to a greater extent. Establishment of strong quarantine system can prevent the entry of exotic parasites. To improve the fish's own resistance during the winter a good feed to be fed to increase the immunity of the fishes.

ACKNOWLEDGEMENTS

The authors are thankful to Indian Council of Agricultural Research, Delhi, India for their financial support to conduct the experiment.

Author’s contributions

The authors equally contributed for this research work and preparing the paper. All authors read and approved the final manuscript.

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Table--1: Prevalence of parasites (PFI, %) in *Labeo bata*, in different months

Month	*Myxobolus* sp.		*Thelohanellus* sp.		*Trichodina* sp.		*Vorticella* sp.		*Ichthyobodo* sp.		*Chilodonella* sp.		*Dactylogyrus* sp.		*Gyrodactylus* sp.		*Nematode* sp.		*Argulus* sp.		*Ergasilus* sp.	
	I	PFI (%)	I	PFI (%)	I	PFI (%)	I	PFI (%)	I	PFI (%)	I	PFI (%)	I	PFI (%)	I	PFI (%)	I	PFI (%)	I	PFI (%)	I	PFI (%)
April	16	26.66^{b}	0	0	16	26.66^{b}	6	10^{b}	0	0	0	0	0	0	0	0	16	26.66b	0	0	0	0
May	3	5^{a}	0	0	24	40^{c}	0	0	0	0	9	15^{b}	0	0	0	0	0	0	0	0	0	0
June	0	0	0	0	12	20^{b}	12	20^{b}	0	0	6	10^{b}	0	0	0	0	0	0	0	0	0	0
July	0	0	0	0	15	25^{b}	0	0	0	0	0	0	4	6.66^{a}	3	5^{a}	11	18.33^{b}	0	0	0	0
August	0	0	0	0	42	70^{d}	0	0	0	0	0	0	10	16.66^{b}	6	10^{b}	6	10^{b}	0	0	0	0
September	0	0	0	0	21	35^{c}	11	18.33^{b}	0	0	0	0	0	0	10	16.66^{b}	12	20^{b}	0	0	7	11.66^{b}
October	18	30^{c}	0	0	15	25^{b}	0	0	0	0	0	0	3	5^{a}	6	10^{b}	12	20^{b}	12	20^{b}	0	0
November	15	25^{b}	0	0	24	40^{c}	0	0	0	0	0	0	0	0	0	0	18	30^{c}	0	0	0	0
December	20	33.33^{c}	8	13.33^{b}	22	36.66^{c}	0	0	0	0	0	0	0	0	0	0	15	25^{b}	0	0	0	
January	22	36.66^{c}	9	15^{b}	20	33.33^{c}	0	0	3	5^{a}	5	8.33^{b}	0	0	0	0	16	26.66^{b}	0	0	0	0
February	25	41.66^{c}	0	0	10	16.66^{b}	0	0	15	25^{b}	20	33.33^{c}	9	15^{b}	0	0	11	18.33^{b}	0	0	0	0
March	0	0	45	75^{d}	10	16.66^{b}	0	0	10	16.66^{b}	0	0	0	0	0	0	0	0	0	0	6	10^{b}

Table-- 2: ANOVA for prevalence of parasites (PFI, %) in *Labeo bata*, in different months

Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value*	*F crit*
Parasites	10436.75	10	1043.675	7.668032	3.34355E-09	1.91782714
Month	895.4203	11	81.40184	0.598071	0.826891045	1.876731984
Error	14971.8	110	136.1072			
Total	26303.96	131				

Table-- 3: Prevalence of parasites (PFI, %) in *Labeo bata*, in different seasons

Seasons	No of Fish examined	*Myxobolus* sp.		*Thelohanellus* sp.		*Trichodina* sp.		*Vorticella* sp.		*Ichthyobodo* sp.		*Chilodonella* sp.		*Dactylogyrus* sp.		*Gyrodactylus* sp.		*Nematode* sp.		*Argulus* sp.		*Ergasilus* sp.	
		I	PFI (%)	I	PFI (%)	I	PFI (%)	I	PFI (%)	I	PFI (%)	I	PFI (%)	I	PFI (%)	I	PFI (%)	I	PFI (%)	I	PFI (%)	I	PFI (%)
Summer	120	19	15.83^{b}	0	0	52	43.33^{c}	18	15^{b}	0	0	15	12.50^{b}	0	0	0	0	16	13.33^{b}	0	0	0	0
Monsoon	180	0	0	0	0	78	43.33^{c}	11	6.11^{a}	0	0	0	0	14	7.77^{a}	19	10.55^{b}	29	16.11^{b}	0	0	7	3.88^{a}
Winter	180	75	41.66^{c}	17	9.44^{a}	79	43.88^{c}	0	0	3	1.66^{a}	5	2.77^{a}	3	1.66^{a}	6	3.33^{a}	61	33.88^{c}	12	6.66^{a}	0	0
Spring	120	25	20.83^{b}	45	37.5^{c}	22	18.33^{b}	0	0	25	20.83^{b}	20	16.66^{b}	9	7.50^{a}	0	0	11	9.16^{a}	0	0	6	5^{a}

Table-- 4: ANOVA for prevalence of parasites (PFI, %) in *Labeo bata*, in different seasons

Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value*	*F crit*
Season	207.2092977	3	69.06976591	0.632003518	0.600127422	2.922277191
Parasites	4593.36765	10	459.336765	4.20303222	0.00106376	2.164579917
Error	3278.609877	30	109.2869959			
Total	8079.186825	43				

Table-- 5: Prevalence of parasites (PFI, %) in *Labeo bata*, in different length groups

Length groups (cm)	No of fish examined	*Myxobolus sp.*		*Thelohanellus* sp.		*Trichodina* sp.		*Vorticella* sp.		*Ichthyobodo* sp.		*Chilodonella* sp.		*Dactylogyrus* sp.		*Gyrodactylus* sp.		*Nematode* sp.		*Argulus* sp.		*Ergasilus* sp.	
		I	PFI (%)	I	PFI (%)	I	PFI (%)	I	PFI (%)	I	PFI (%)	I	PFI (%)	I	PFI (%)	I	PFI (%)	I	PFI (%)	I	PFI (%)	I	PFI (%)
5-10	82	22	26.82^{b}	7	8.53^{a}	29	35.36^{c}	2	2.43^{a}	8	9.75^{a}	8	9.75^{a}	4	4.87^{a}	5	6.09^{a}	14	17.07^{b}	1	1.21^{a}	0	0
10-15	331	35	10.57^{b}	26	7.85^{a}	103	31.11^{c}	14	4.22^{a}	9	2.71^{a}	15	4.53^{a}	10	3.02^{a}	12	3.62^{a}	56	16.91^{b}	2	0.60^{a}	7	2.11^{a}
15-20	272	48	17.64^{b}	24	8.82^{a}	84	30.88^{c}	10	3.67^{a}	7	2.57^{a}	14	5.14^{a}	12	4.41^{a}	6	2.20^{a}	40	14.70^{b}	8	2.94^{a}	5	1.83^{a}
20-25	35	14	40^{c}	5	14.28^{b}	15	42.85^{c}	3	8.57^{a}	4	11.42^{b}	3	8.57^{a}	0	0	2	5.71^{a}	7	20^{b}	1	2.85^{a}	1	2.85^{a}

Table-- 6: ANOVA for Prevalence of parasites (PFI, %) in *Labeo bata*, in different length groups

Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value*	*F crit*
Length groups	272.507425	3	90.83580833	5.618105703	0.003524792	2.922277191
Parasites	4511.310341	10	451.1310341	27.90201223	1.6972E-12	2.164579917
Error	485.05215	30	16.168405			
Total	5268.869916	43				

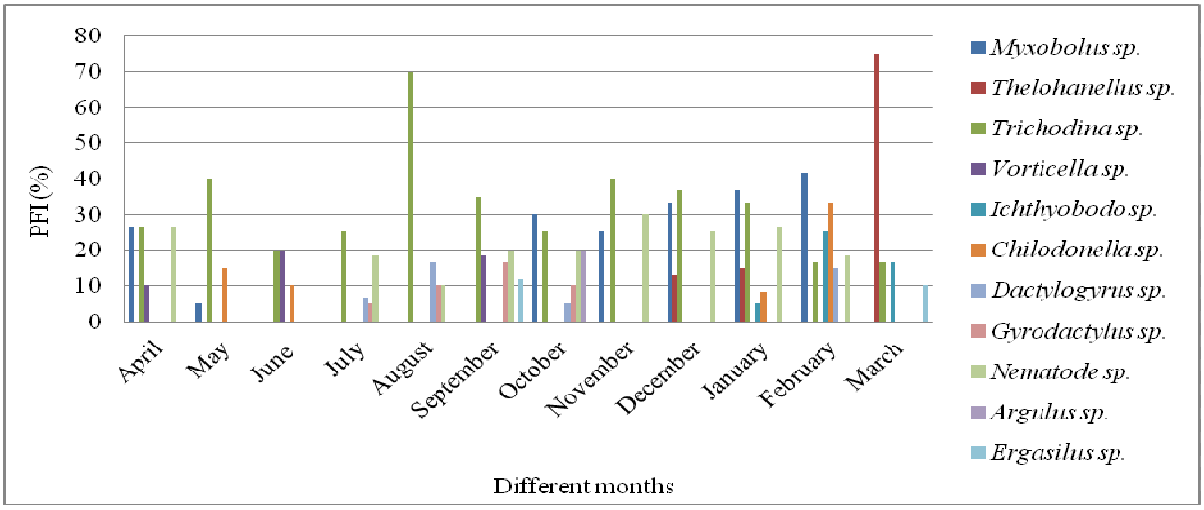

Figure- 1. Prevalence of parasites (PFI, %) in *Labeo bata*, in different months

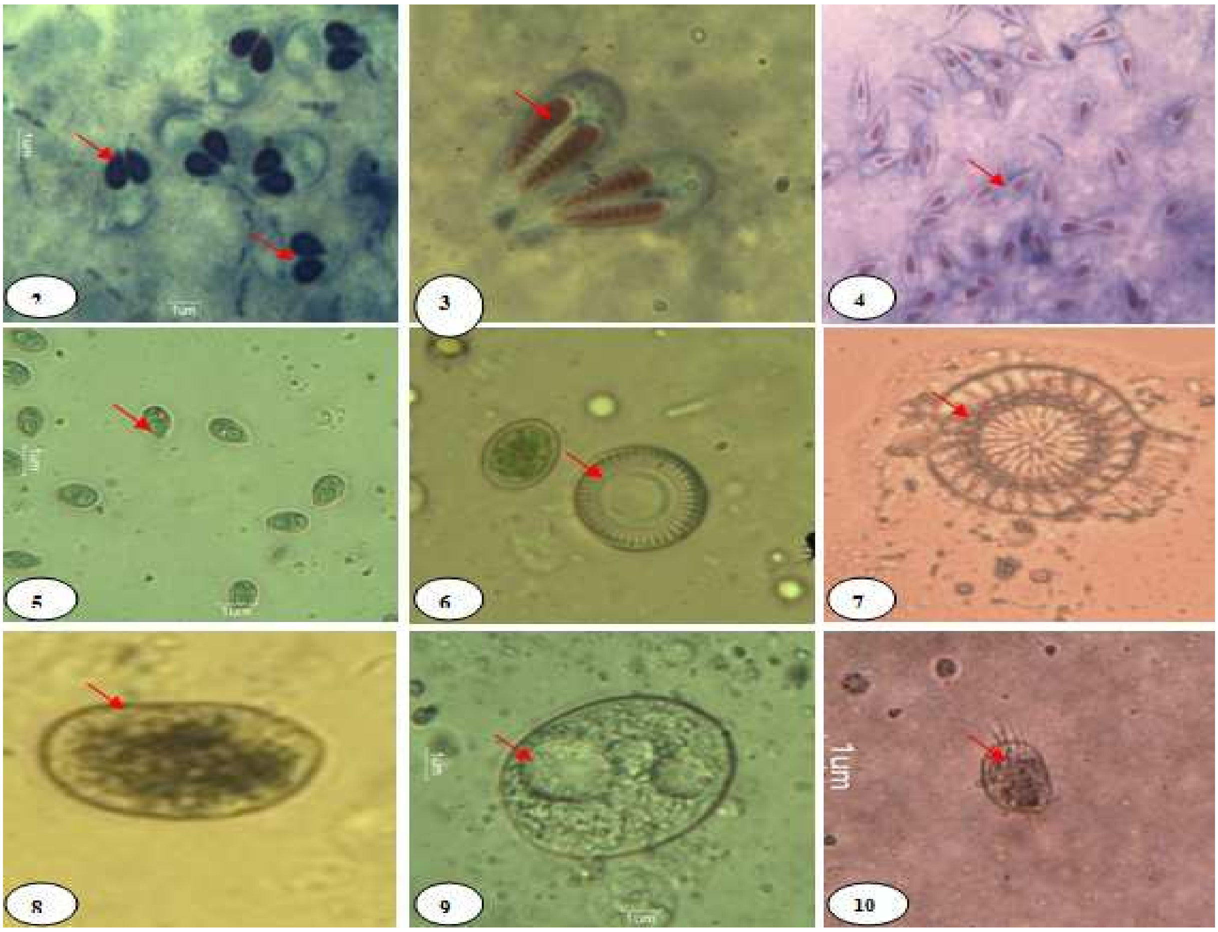

Figure-2. Myxobolus sp. (arrow) with distinct polar capsules (arrow) present in the gills of Labeo bata (Giemsa stained, 1000x).

Figure-3. Myxobolus sp. with distinct polar capsules having visible coils (arrow) present in the gills Labeo bata (Unstained, 1000x).

Figure-4. Heavy infestation of Thelohanellus sp. (arrow) in the gills of Labeo bata (Giemsa stained, 200x).

Figure-5. Thelohanellus sp. (arrow) with distinct polar capsule (arrow) present in the gills of Labeo bata (Unstained, 200x).

Figure-6. Trichodina sp. (arrow) present in the body of Labeo bata (Wet mount, 200x).

Figure-7. Magnified view of Trichodina sp. (arrow) with distinct ridges (arrow) present in the gills of Labeo bata (Wet mount, 400x).

Figure-8. Chilodonella sp. with clear cytoplasmic matter (arrow) present on the gills of Labeo bata (Wet mount, 200x).

Figure-9. Magnified view of Chilodonella sp. with distinct nucleus (blue arrow) and cytoplasmic matter (black arrow) present on the body of Labeo bata (Wet mount, 400x).

Figure-10. Ichthyobodo sp. (Costia) with distinct polar flagella (arrow) present on the gills of Labeo bata (Wet mount,200x).

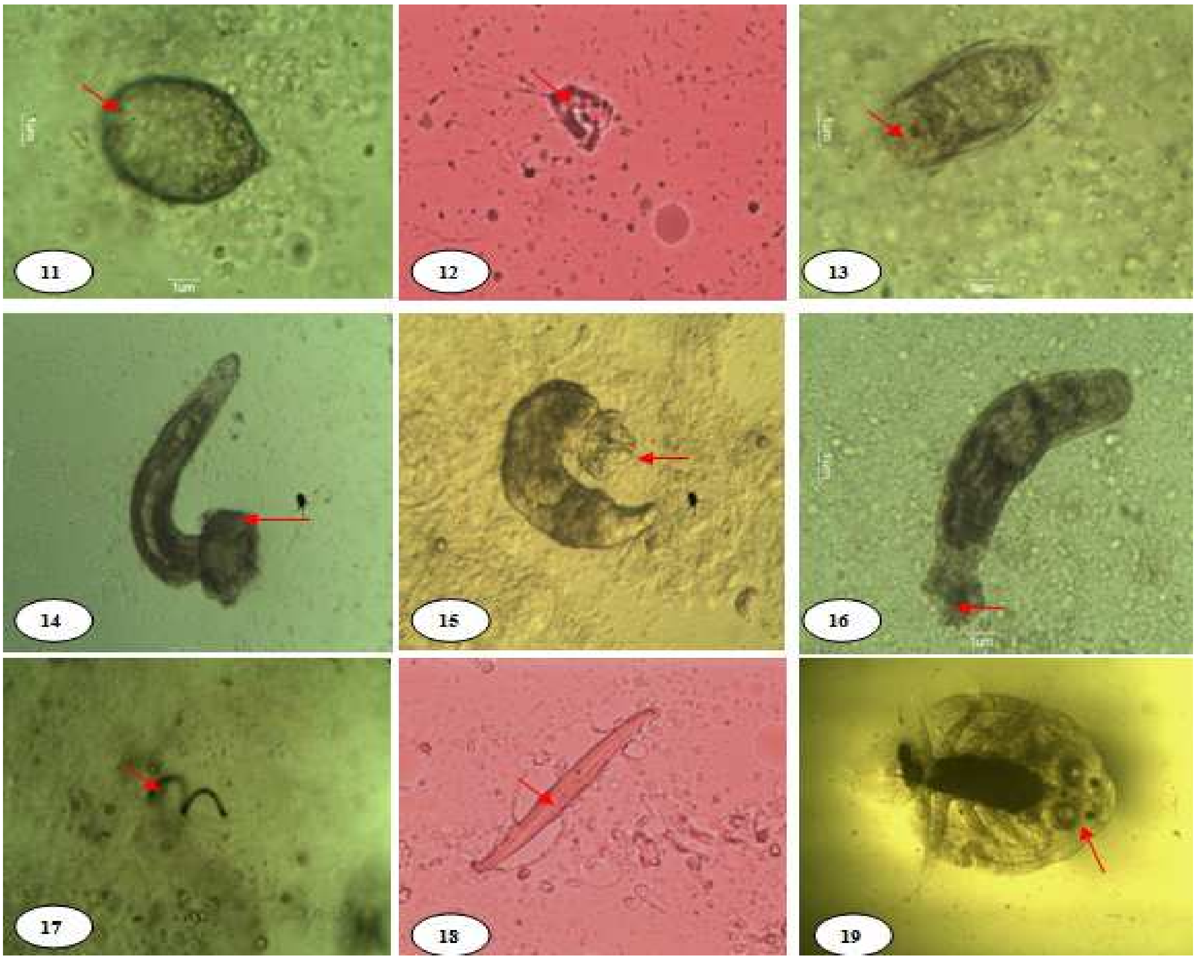

Figure-11. Magnified view of Ichthyobodo sp. (Costia) (arrow) present on the gills of Labeo bata (Wet mount, 400x)

Figure-12. Vorticella sp. with distinct stalk (arrow) on the gills of Labeo bata (Wet mount, 200x)

Figure-13. Gyrodactylus sp. with distinct eye spot (arrow) present on the skin of Labeo bata (Wet mount, 200x)

Figure-14. Gyrodactylus sp. with distinct organs of the body (arrow) attached to the body of Labeo bata (Wet mount, 200x)

Figure-15. Dactylogyrus sp. with distinct lobes (arrow) present in the gills of Labeo bata (Wet mount, 200x)

Figure-16. Dactylogyrus sp. with distinct marginal hooks (arrow) present in the gills of Labeo bata (Wet mount, 200x)

Figure-17. Capillaria sp. (Nematode) (arrow) present in intestine of Labeo bata (Unstained, 400x)

Figure-18. Goezia sp. (Nematode) isolated from intestine of Labeo bata (Unstained, 1000x)

Figure-19. Argulus sp. with distinct features (eye spots suckers) (arrows) present on the body surface of the Labeo bata (Wet mount, 40x)

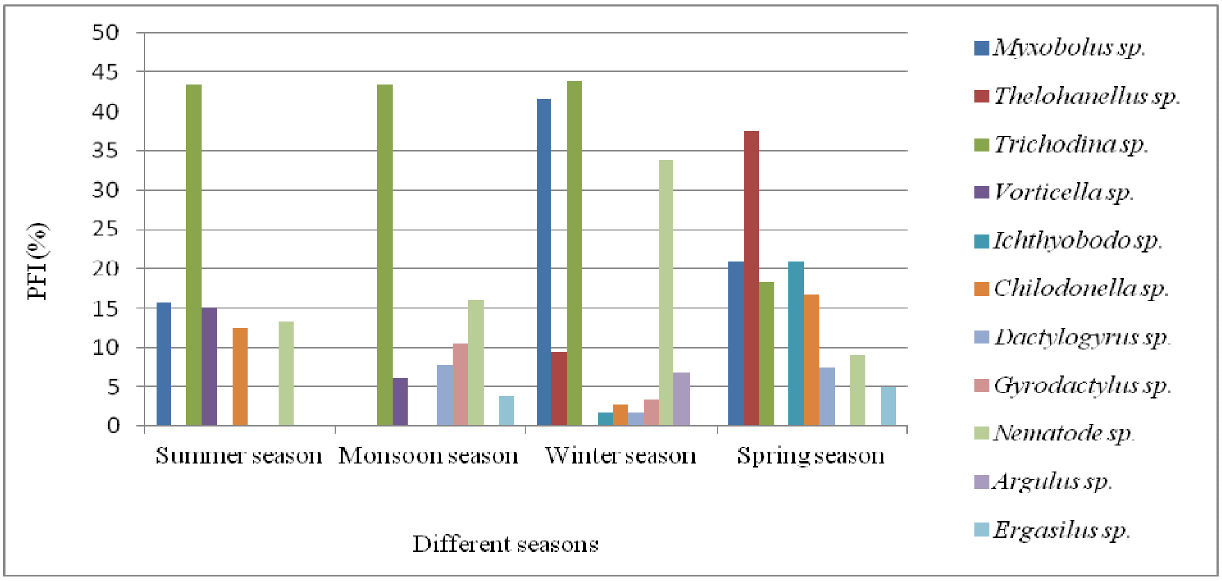

Figure-20. Prevalence of parasites (PFI, %) in *Labeo bata*, in different seasons

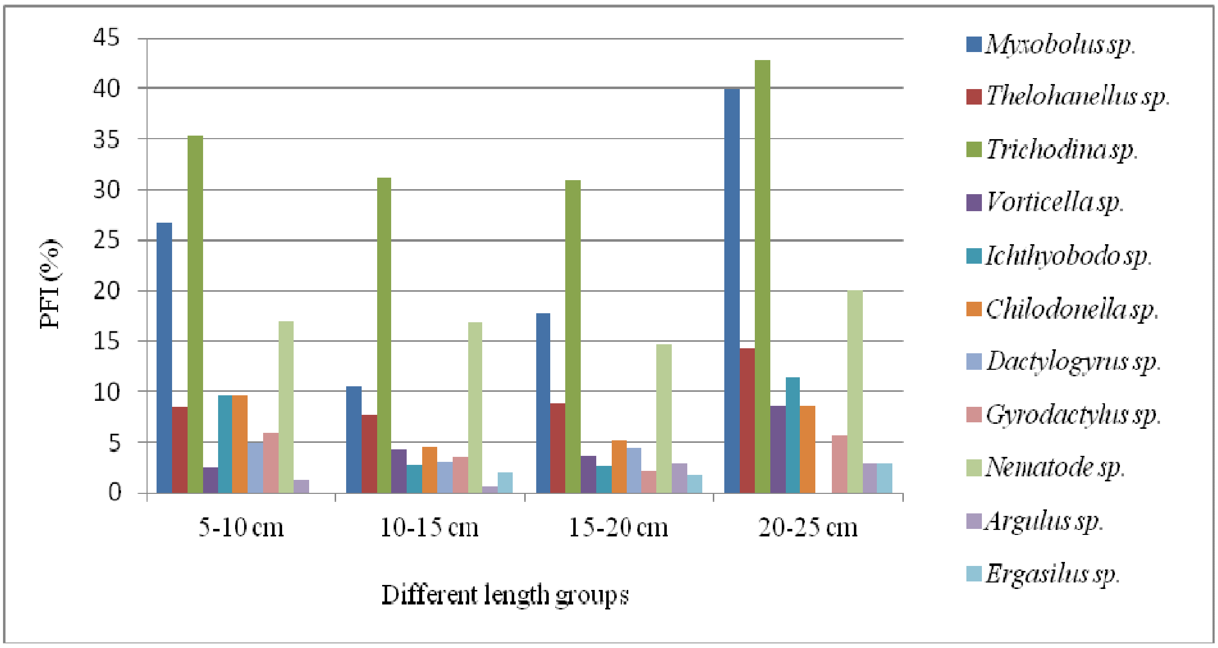

Figure-21. Prevalence of parasites (PFI, %) in *Labeo bata*, in different length groups