

CHAPTER-4

DISCUSSION

Graphics of the fish species

The present investigation exposes the comprehensive account of the systematic of the two test species *Danio dangila* and *Puntius chola* hitherto remained unattended from the drainages of Nagaland. Variations in some morphometric, meristic and morphological characters have been observed in the species, *Danio dangila* and *Puntius chola* from earlier worker (Talwar and Jhingran, 1991) and are purported below.

Danio dangila

Morphometrics:

BD 7.60 – 6.60 (male) and 8.20 – 4.85 (female) in relation to SL (*versus* 3.2 – 3.7 Talwar and Jhingran (TG), 1991); SnL 5.00 – 4.00 (male) and 5.00 – 3.20 (female) in relation to HL (*versus* 3.3 – 4.3 TG); ED 3.33 – 4.00 (male) and 3.33 – 4.00 (female) in relation to HL (*versus* 2.5 – 3.7 TG).

Meristic:

D ii 8 (male) D ii 10 (female) (*versus* D ii 9-11 Talwar and Jhingran (TG), 1991); P iv 9 both male and female (*versus* P i 11-12 TG); A iii 13 (male) A iii 14 (female) (*versus* A ii-iii 12-15 TG).

General characteristics

Danio dangila possess attractive body coloration in live condition. The fish species is rather small in size, easily adapted to aquarium life and display majestic movements. These characteristics put *Danio dangila* as classified ornamental fish. Similarly Dey *et.al*, (2002), also placed *Danio dangila* as classified ornamental fish in the global market.

Puntius chola

Morphometrics:

BD 7.50 – 6.88 (male) and 7.00 – 7.00 (female) in relation to SL (versus 2.8 - 3.1 Talwar and Jhingran, 1991).

Meristic:

D iii 9 (female) (versus D iii 8 Talwar and Jhingran, 1991. (TG); P iii 13 (male) P iii 12 (female) (versus P i 14 TG); V ii 7 (female) (versus V i 8 TG); A ii 6 (male) A iii 6 (female) (versus A ii 5 TG).

General characteristics

Because of beautiful colour pattern on the body, orange red eyes and deep-black blotch near base of caudal fin, *Puntius chola* is put under classified ornamental fish, which is also in accordance with Dey *et.al*, (2002).

Behavioural perspectives

Danio dangila

Ingestive behaviour of the test species have been precisely investigated in the aquaria. Normally, *Danio dangila* is a surface feeder but it is well competent to feed both at column as well as bottom level when food is supplied in the aquaria.

The males of *Danio dangila* are not territorial and do not display aggressiveness towards other males, as reported in daniids (Sarmah, 2002). Courtship behaviour or courtship dance was found in the test species as was reported in *Brachydanio rerio* (Guthrie and Mutz, 1993), *Danio aequipinnatus* (Kharbuli *et.al*, 2004) and *Puntius chola* (Vincent and Thomas, 2008). The male initiates the motivation for courtship by poking the female. The female remains indifferent while the male entices the female during spawning and this is in accordance with the view of Leigh (1977) and Fischer (1980) in small sea basses of the genus *Thyoplectrus* of Caribbean coral reefs.

Puntius chola

Ingestive behaviour of the test species have been precisely investigated in the aquaria. The feeding activities commence with the fish swiftly gulping the food elements making an angle of 70°. Normally, *Puntius chola* is a column feeder but after acclimatization, it was seen to execute at the surface level.

Courtship behaviour or courtship dance was found in the test species as was in conformity with the findings of Vincent and Thomas, (2008). Similar observations were also made by Gathrie and Muntaz, (1993) in *Brachydanio rerio*. Before the actual courtship display, the male and female of *Puntius chola* exhibit restlessness and frequently moving at the base of the aquaria. Both male and female exhibits swimming movements in pairs, circling and pushing the female on the abdomen during courtship. The male initiates the motivation for courtship and in the process nudges the female with the snout and pushes the female upwards and then bends down and brings its genital pore in proximity with the female's genital pore enticing and interlocking the female with the pelvic and anal fin.

Bionomics profile

Danio dangila

The present study portrayed that, the basic food of *Danio dangila* was of animal origin, such as aquatic insects, earthworm, tadpole, mosquito larva and planktons, showing variation in their percentage of consumption during different seasons. Besides this, the study further revealed that, the secondary food of the test species comprises of decaying plant matters and algae which were found to occur in maximum percentage throughout the year whereas mud and sand are found to be incidental food.

The overall victual spectrum was almost similar in both male and female species. The gut content of the test species was found to vary in different seasons with the availability of the food items. The most intensive feeding takes place during the season, when the food consisting mostly of

the young aquatic insects or other food of animal origin were found abundant. This was found to be relevant in the present test species. Therefore, changes in the supply of food and the seasonal rhythm of feeding were connected with the availability of feed itself throughout the year. Similar observations on food and feeding habit of fishes was also reported by Galis *et.al*, (1993).

The relative gut length (RLG) is closely related to the food habit (Das, 1958). The length of the gut varies not only with the food habit but also in relation to size and age of the species (Sinha and Moitra, 1975 a, 1975 b and Sinha, 1972). Low and high RLG indices purport for the carnivores and herbivores respectively with an intermediate value prevailing for the omnivores. This is for the fact that, long intestine of the herbivores helps in the digestion and absorption of the vegetable matters than the carnivores whose diet is easily assimilated consisting of animal matter.

The present findings revealed specific changes in RLG of the species. It showed every 5.0 mm increment in body length from sub adult to adult. In females at maximum size range of 75 – 80 mm, the RLG was 0.747 whereas in males at size range of 75 – 80 mm, the RLG was only 0.679, indicating that, males of the test species are more carnivorous than the females. Comparative analysis between male and female of *Danio dangila* revealed that, the males have shorter alimentary canal than the females. Fluctuation in the RLG may also be attributed to the condition of food supply, the amount of indigestible matter and age of individual fish irrespective of its body size (Kapoor *et.al*, 1975) which were in accordance with the present empirical investigation.

The hepato somatic index (HSI), considered as an exponent of feeding intensity showed direct relationship with size range in the test species. The present study showed that, HSI changes in relation to food supply and seasonal rhythm in food consumption through adaptive change in the abiotic condition. However, during breeding season, the HSI in the

female of the test species showed decreasing trend than the overall HSI. This was attributed to the development of gonads during spawning season, which occupy the major space of the abdominal cavity. Similar observation on HSI in relation to food supply and seasonal rhythm in food consumption was also made by (Jhingran, 1961). Therefore, it can be inferred that the intensity of feeding shows a downward trend in the approach of the maturation phase and ingestion improve only when the spawning period was over.

The gill rakers of fishes are variously modified according to feeding habits of the fish (Das and Moitra. 1956, 1963). The structure of the gill raker is closely related to the feeding behaviour of the fish. The number and structure of the gill rakers can vary considerably, from a few small hard structures in predatory fishes to a complex network of numerous rakers in planktophagic fishes (Nikolsky, 1963). The gill raker configuration basically revealed carnivorous pattern both in structure and number of the test species. The gill rakers were short, stumpy and blunt and also were longer in the central part of both the limb.

Puntius chola

Based on the recorded variation in the type of food consumed, *Puntius chola* may reasonably be classified as marginal euryphagic feeder. Euryphagism has evolved as an adaptation to unstable supply of food. (Nikolsky, 1963). Changes in the food spectrum were observed in the same population of the test species throughout the year. However, no differences between male and female *Puntius chola* in their food spectra were observed.

The present study portrayed that, the basic food of *Puntius chola* was algae showing variation in their percentage of consumption during different seasons. Besides this, the study further revealed that, the secondary food of the test species comprises of decaying plant matters, aquatic insects and debris. Dasgupta, (2004) also found predominance of plant matter in the gut contents of *Colisa fasciata*. Certain unidentified food items were also

present which were classified as incidental food. The overall victual spectra were almost similar in both male and female species. The gut content of the test species revealed that, the percentage of occurrence of algae was the highest. The most intensive feeding takes place during the months, when the food consisting mostly of algae and related food are found in abundance. Therefore, changes in the supply of food and the seasonal rhythm of feeding are connected with the condition of the fish itself throughout the year.

The present study portrayed that, for every 5.0 mm increment in body length, changes in RLG was recorded. Comparative analysis between male and female of *Puntius chola* revealed that, the males have a shorter alimentary canal than the females. In males at maximum size range of 80 – 85 mm, RLG was 1.728. Whereas, in females at size range of 80 – 85 mm the RLG was 2.365 thus, indicating that, females of the test species were more algaephagus than the males. Fluctuation in the RLG may also be attributed to the condition of food supply, the amount of indigestible matter and age of individual fish irrespective of its body size (Kapoor *et.al*, 1975). This was in accordance with the present empirical investigation.

In breeding season, the HSI in the female of the test species showed more or less decreasing trend than the overall HSI. The low feeding behaviour during breeding season in the present test species was therefore, attributed to the development of gonads during spawning season, which occupy the major space of the abdominal cavity (Jhingran, 1961). Thus it can be inferred that the intensity of feeding shows a downward trend in the approach of the maturation phase and ingestion improve only when the spawning period is over.

The gill rakers of *Puntius chola* were short, straight and pointed. The gill rakers are longer in the central part of both the limb. The gill raker configuration basically revealed omnivores pattern both in structure and number of the test species. Similarly, Das and Moitra (1963) also reported

that gill rakers of fishes are variously modified according to feeding habit of the fish.

Length-weight relationship

Danio dangila

In the present study the value of regression co-efficient (n) for male was found 2.103 and for female 2.055, thus the value of 'n' was slightly lower in case of female population, but in mixed population it showed a value of 2.114. The results indicated that, the values of 'n' in all the cases were less than 3, and therefore it deviated from the cube law. The divergence from the cube law may be due to certain environmental factors and general condition such as, appetite and gonadal contents of fish. The growth in weight of fish, in general, is directly proportional to the cube of its length, but sometimes values of the relationship may deviate from the cube law, either due to environmental factors or condition of fish (Le Cren, 1951; Solanki *et.al*, 2004). Pervin and Mortuza (2008) cited that, the length-weight relationship is very important for proper exploitation and management of fish species population. The economic value of fish depends upon its length weight relationship.

The correlation coefficient (r) between log-length and log-weight were 0.979 for males, 0.977 for females and 0.959 for mixed population. As was evident from 't' test' the coefficients of correlation were highly significant in all cases (5% probability) and the body weight positively and significantly correlated with the length. Similar observations were also made by Subba and Ghosh, (2000) and Pawar and Mane, (2006) in case of *Glyptothorax telchitta* and *Glossogobius giuris* respectively.

The ponderal index or coefficient of condition is an index of well being of the fishes. In the present study Le Cren's relative condition factor (Kn) was estimated separately for mixed, male and female population. The value of Le Cren's relative condition factor attributes to be more reliable index for the well being study of the fish. The data of present study

purported that, the well-being of the fish was comparatively better exhibited in female population than the male population.

Puntius chola

In *Puntius chola*, the value of regression co-efficient (n) for male was found 2.506 and for female 2.271, thus the value of 'n' was slightly lower in case of female population, and in mixed population it showed a value of 2.112. The results indicated that, the values of 'n' in all the cases were less than 3, and therefore it deviated from the cube law. The divergence from the cube law may be due to certain environmental factors and general condition such as, appetite and gonadal contents of fish. Similar observation was also made in case of *Danio dangila* where the values of 'n' were found to deviate from the cube law (Angami and Ahmed, 2010).

The correlation coefficient (r) between log-length and log-weight were 0.979 for males, 0.980 for females and 0.977 for mixed population. As was evident from 't' test' the coefficients of correlation were highly significant in all cases (5% probability) and the body weight positively and significantly correlated with the length. Similar observations were also made by Subba and Ghosh, (2000) and Pawar and Mane, (2006) in case of *Glyptothorax telchitta* and *Glossogobius giuris* respectively.

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same sample varied considerably. Similarly, Vijay and Dhana (1981) determined the numerical relationships between length and weight along with condition indices for wild and cultured *Clarias batrachus* and Gökhan *et.al*, (2007) reported on some commercial fish species from the North Aegean Sea.

Reproductive biology

Danio dangila

The present work gave a comprehensive treatise on the reproductive biology of *Danio dangila*. All the parameters within the ambit of reproductive biology of fish have been successfully covered and documented in the present study. The innovative exposition on the sexual dimorphism, size at first maturity, spawning habitat were significant.

The studied test species were sexually dimorphic and the in-vitro characteristics elucidated will immensely help in field collection and identification of male and female species.

The morphological size differences in between the sexes were significant in the present test OFS. The males are slightly smaller than the female which thus confirms the observations of Kurian and Inasu, (1997), Pal *et.al*, (2003) and Thomas *et.al*, (2003). Usually the female are found to be larger than male of the same age group (Tessy and Inasu, 1997). In case of *Danio dangila* also the femals are found to be larger than male species. Males of *Danio dangila* have reddish tinge colour fins whereas the tip of the anal fin was found to be reddish. The females have yellowish tinge colour fins and whitish yellow anal fin tip.

The sex ratio of *Danio dangila* varies considerably from one population to another and from year to year in the same population which support the proposition of Nikolsky (1963). However, sparse male population over female in nature is a significant feature, which may perhaps have relevance to low natural population of the species. This contradicts with the findings of higher male sex ratio than female in case of *Colisa*

fasciata from the flood plain wetland of Ganga river basin as reported by Mitra *et.al*, (2007).

The individual relates the onset of maturity to the attainment of a particular size. Sexual maturity is also related to the abundance of food supply. Considerable variation exists among different populations of the same species, and also within the limits of a single population (Noikolsky, 1963) and was also evident in the present study. The male and female *Danio dangila* attain its sexual maturity at 4.5 cm in total length which is species specific since Mitra *et.al*, (2007) reported that, females of *Colisa fasciata* reaches its maturity at 5.7 cm in total length.

Danio dangila is a seasonal breeder and it breeds once in a year and exhibits rhythmic changes in the structure of the ovary in different seasons. Seven stages of ovarian cycle have been identified in the test species studied. Whereas, only four stages in the ovarian cycle of some Indian fresh water fishes including *Rasbora (Parluciosoma daniconius)* were reported by Raizada, (1971).

Fecundity is an important tool to understand the reproductive capacity of a fish species. It is a basic means of regulating the rate of reproduction to changing environmental condition. Regression analysis depicts a positive correlation between fecundity and ovary weight but negative correlation between fecundity and total length and total weight, which was a significant feature and forms a record in this OFS. Nikolsky, (1963) reported that, the individual fecundity is increased by fractional spawning which was also recorded in the present test species. Borkotoki and Dey, (2002) reported a high degree of positive correlation between fecundity and gonad weight in *Parluciosoma daniconius* indicating a significant relationship between fecundity and gonad weight.

Although fecundity is considered a phylogenetic character of a fish, it also depends upon various environmental parameters, which the fish had to face in different stages of its life history. Mahapatra *et.al*, (2004) reported that, fecundity was more dependent on body length when compared to body

weight and ovary weight in *Brachydanio rario*. The fecundity aspects of population dynamics, racial characteristics and fishery management practices appear relevant for the present OFS in their mass culture and breeding, and this was also opined by Agarwal, (1996).

Nutrition and environment influence the gonadal development of a fish. Under optimum condition the gonads begin to grow rapidly and there is also an accompanying increase in the total weight of the fish. The relationship is direct and represented by the GSI. Unlike high GSI index in total spawner (Sarmah, 2002), the test species, a protracted spawner showed an ascending trend in the GSI. This indicated ovary maturation and decline for spawning. In the spent or resting female the lowest GSI was recorded. However, recovery in GSI values indicated by nominal increase of the index was observed which culminates to a new breeding cycle. Borkotoki and Dey, (2002) observed that, the GSI trend in five different size range of *Parluciosoma daniconius* showed increasing GSI with increase in total length. The GSI trend in the test species indicates a spike in the month of May. Unlike pronounced abdomen bulging of matured female in IMC and other fishes, *Danio dangila* exhibited marginal swelling of abdomen. And this feature is more discernable in medium sized fishes.

The breeding season of *Danio dangila* spans from May to mid June, with highest amplitude of spawning in the month of May synchronizing with the onset of monsoon which was also reported by Mustafa *et.al*, (1980) in other fish species. The optimal environmental conditions under which the test species breed successfully in nature have been ascertained during the field studies.

Puntius chola

The present contribution forms a comprehensive treatise on the reproductive biology of *Puntius chola*, hitherto remained unreported from NER. Similar to *Danio dangila*, all the parameters within the ambit of reproductive biology of fish have been successfully covered and completed in the present study.

The studied test species was sexually dimorphic and the in-vitro characteristics elucidated will immensely help in field collection and identification of male and female. The morphological size differences in between the sexes were significant in the present test species. The males were larger than the female in the present test fish which contradict with the findings of Thomas *et.al*, (2003) in some freshwater salmonids. Presence of rough dorsal side of pectoral fin, a common feature in male Indian Major Carp (Dey and Roy, 1991) was not discernable in this species. Further, *Puntius chola* does not exhibit rough pelvic fin and was also opined by Pal *et.al*, (2003).

The sex ratio of *Puntius chola* varies considerably from one population to another and from year to year in the same population which support the proposition of Nikolsky (1963). However, sparse male population over female in nature is a significant feature, which may perhaps have relevance to low natural population of the species.

According to Wootton (1982), the difference in sexual maturity is due to variations in genetic resources and environmental conditions of the fish habitat. The male *Puntius chola* matured much earlier than the female in the present test fish species. Considerable variation exist among different populations of the same species, and also within the limits of a single population (Nikolsky, 1963) was also observed.

In the present investigation, on the basis of the ova diameter study, seven maturity stages were determined in *Puntius chola* as was reported by (Kesteven, 1960).

Regression analysis depicts a positive correlation between F and OW, TL and TW, which was significant and forms a record in this Species. The individual fecundity was increased by fractional spawning. Although fecundity is considered a phylogenetic character of a fish, it also depends upon various environmental parameters, which the fish had to face in different stages of its life history. Bahuguna *et.al*, (2010) observed fecundity in *Barilius bendelisis* and commented that, fecundity increases

with increase in all body parameters. The fecundity aspects of population dynamics, racial characteristics and fishery management practices (Agarwal, 1996) appeared relevant for the present fish species also in its mass culture and breeding.

Nutrition and environment conditions influence the gonadal development of a fish. Under optimum condition the gonads grows rapidly which also increases the total weight of the fish. The relationship is direct and represented by the GSI. Unlike high GSI index of in total spawner (Sarmah, 2002), the test species, which spawns twice in a year, exhibited two mean GSI above 17% just before spawning which is in accordance with the findings of Thomas *et.al*, (2003). As observed in *Danio dangila*, the ascending trend in the GSI was indicative of ovary maturation and decline for spawning. The lowest GSI was recorded in the spent or resting female. However, recovery in GSI values was indicated by increase of the index, which culminates to a new breeding cycle. The GSI trend in the test species indicated an initial spike in the month of May with a lull phase in June, which than recovered with the second spike in the month of September. *Puntius chola* exhibited marginal swelling of abdomen. This feature is more discernable in medium sized fishes. The GSI of the first breeding period showed a maximum peak during the month of May and the GSI of the second breeding period showed a maximum peak in the month of September. The occurrence of different sizes of fries in nature indicated prolonged breeding period. Thus, the breeding period may be described as primary phase of prolonged breeding season. After this spawning phase, few brooders remain unspawned and enter in the quiescent period. On the approach of favourable environmental conditions, they spawned during September.

According to Jhingran (1983), most of the freshwater fishes in Indian sub-continent breed during monsoon season. In this context the present study revealed that, *Puntius chola* has two breeding season, once in the month of May and another in the month of September with inactive

period of spawning during October-April and June-August. During these two breeding season majority of the brooders were found to be ready to breed, as evident from the GSI and occurrence of large number of ripe fishes in the natural as well as in the stocking pond. The spawning grounds of *Puntius chola* was characterized by the occurrence of gravels, mud and sand in the shallow water at a depth not more than 4-4.8 feet, where typically very low water current occurs. Thus it belongs to “lithophil spawner” category (Nikolsky, 1963).

Laboratory propagation

Danio dangila

The present study forms the model for the development of the technology of captive breeding of endemic ornamental fish species of NER using synthetic hormone. The in-house breeding technology of *Danio dangila* has been successfully achieved.

Malady free, bright coloured with good finage and fast growing specimen were considered as an important criteria for the selection of brood stock. The selection of breeding stock from the wild becomes considerably easier than the cultivated strain to avoid inbreeding of the species (Kelly, 1987). In the present investigation mean ova diameter (MOD) of the brooders was found to be a favourable indicator for spawning and maturity of the species which can be correlated with the findings of Shashi and Sengupta (2002). The study further revealed that, the MOD of the effective brooder should lie between 0.95 – 1.05 mm prior to inducing. Saha *et.al*, (2009) reported that, the maximum mean diameter of ova of *Amblypharyngodon mola* was 1.82 mm obtain during March to August with a peak mean value in June.

Minor variation in the physico-chemical parameters of the brooder tank does not affect the survivability of the brooders of the test species investigated. When the physico-chemical conditions in the brooders tank were compared to the condition recorded in the wild, a significant variation

was observed. However, these variations did not adversely affect the rearing of the brooders. It may, therefore, be ascertained that, the combination of factors in the brooders tank as a whole contributes to successful rearing of present OFS brooders.

Nutrition is another important factor and there was a distinct variation in the preference level of different feed. As *Danio dangila* feeds exclusively on living organisms, the feeds were disinfected prior to application to avoid contamination or outbreak of disease.

The spawning was achieved in captivity by induced breeding through hypophysation in various teleost fish in India and abroad (Turner, 1993 and Anna Mercy *et.al*, 2003). The failure of spawning after administration of gonadotropin in many species is due to the dopamine inhibitor activity (Nandeesh *et.al*, 1991).

In contrast to reports of partial spawning in *Botia dorio* (Das, 2004), induced breeding with ovaprim was successful in *Danio dangila*. This may be due to the salmon gonadotropin releasing hormone (sGnRH) and domaperidone—a dopamine inhibitor substance in the ovaprim. Significantly, male reaches oozing state one month earlier than the functional maturity of the female. This is in confirmity with the observation of Sukumaran *et.al*, (1984) in *H. molithrix* and *C. idella*.

The males of *Danio dangila* are not territorial and do not display aggressiveness towards other males, as reported in daniids (Sarmah, 2002). Courtship behaviour or courtship dance was found in the test species as was reported in *Brachydanio rerio* (Guthric and Mutz, 1993), *Danio aequipinnatus* (Kharbuli *et.al*, 2004), and *Puntius chola* (Vincent and Thomas, 2008). Turner, (1993) and Anna Mercy *et.al*, (2003) reported that, cyprinid fishes in general, exhibit some common patterns in their courtship and reproductive behavior. The male initiates the motivation for courtship by poking the female. The female remains indifferent while the male entices the female during spawning (Leigh, 1977 and Fischer, 1980).

A total of 12 sets were induced out of which 11 sets spawned successfully with a success rate of 91.67%. The negative response of one set was identified as inappropriate hormone administration. The test species was a seasonal spawner and after the courtship display, releases eggs in batches. The experimental result showed that, the eggs released in the first batch were 100% fertilized, which declines proportionately in subsequent batches. The success of fertilization in *Danio dangila* was found directly proportional to the matured stage of eggs in the ovarian cycle. First batch ova were found in sixth stage of maturity ensuing 100% fertilization. But, in subsequent batches the ova are mostly found in their fourth and fifth stages mingled with limited number of ova at sixth stage of maturity. Unlike other fishes, this trend which forms a unique feature in *Danio dangila* results in descending trend of fertilization in subsequent batches.

Puntius chola

As indicated in *Danio dangila*, the captive breeding of *Puntius chola* using synthetic hormone will thus form a model technology for induce breeding of other indigenous ornamental fish species of NER region. The present study revealed that, the MOD of the effective brooder should lie between 1.0–1.5 mm prior to extragenous administration of synthetic hormone.

The survivability of the test brooders were not adversely affected for rearing upon some minor variation in the physico-chemical parameters of the brooders tank. *Puntius chola* feeds on planktons. The planktonic feeds were disinfected prior to its application to avoid contamination or outbreak of disease.

In contrast to reports of partial spawning in *Botia dorio* (Das, 2004), induced breeding with hormone, ovaprim was successful in *Puntius chola*. Significantly, male reaches oozing state one month earlier than the functional maturity of the female which is in confirmity with the findings of Sukumaran *et.al*, (1984) in *H. molithrix* and *C. idella*.

In the present investigation 'Ovaprim' was found successful for inducing *Puntius chola* in laboratory conditions. The domaperidone potentiate the action of Gonadotropin by inhibiting the dopamine in the fish (Nandeesh *et.al*, 1991). The response of *Puntius chola* to higher doses of ovaprim during the study could be related to the high dopamine activity in this test species. *Puntius chola* does not respond actively to single dose of ovaprim, but two split doses gave better results. This could be due to the self-potentiating action of releasing hormone when given in split doses.

Courtship behaviour or courtship dance was reported in some ornamental fish species viz, *Brachydanio rerio* (Guthric and Mutz, 1993), *Danio aequipinnatus* (Kharbuli *et.al*, 2004). The male initiates the motivation for courtship by poking the female. *Puntius chola* was found to exhibit swimming movements in pairs and circling. Vincent and Thomas (2008) reported that, the sequence of behavioural patterns in *Puntius chola* is well organized and characterized by several circling movements around the female during courtship activity. After the courtship display the female releases eggs in batches.

A total of 12 sets were induced out of which 10 sets spawned successfully with a success rate of 83.33 %. The negative response of two set was identified as inappropriate hormone administration. The success of fertilization in *Puntius chola* was found directly proportional to the maturity stage of eggs in the ovarian cycle. Fertilization rate was recorded between 70 to 95 % at ambient water temperature ranged from 20 - 26.5 °c. The lower fertilization rate could be attributed to the comparatively poor quality of the eggs and milt produced by the brood stock reared in laboratory conditions.

Embryonic and larval development

Danio dangila

The pigmentation in the yolk and non sticky eggs are the chief diagnostic characters of the eggs of *Danio dangila*. The quality of sexual

product (yolk amount) and environmental conditions such as temperature, dissolved oxygen etc were found significant which is in accordance with the findings of Blaxter, (1969). Swain, (2008) reported that, the period of incubation differs according to the water temperature, under ideal water temperature condition (26-28⁰ c) the hatching period of gold fish was three days. However in the present study, the incubation period was 36 hours at 20–26.5 ⁰c water temperature. Thus, it is apperant from the present study that, the period of incubation differs in different fish species and therefore, does not dependent on the ambient water temperature.

The present findings also confirm the view of Balon, (1975) that even in the same species, which live in different water bodies among wild and domesticated races, early ontogenetic differences were evident. Several workers, (Blaxter, 1969; Suzuki and Hibiya, 1984 and Unal *et.al*, 2000) reported that, chromatophores in newly hatched free larva are absent. However, in *Danio dangila* at 29.45 hrs after hatching chromatophores were distinctly recorded. Further star shaped chromatophores were observed to aggregate at perspective band sites.

Presence of some cement organs for attachment to substratum as reported in some cyprinids, like carp and bream (Nikolsky, 1963; Blaxter, 1969 and Balon, 1975) was evident in the present test species as well. Pre-hatching latency observed in daniids for a brief period (Harrington, 1947) was also observed in *Danio dangila*. This may be attributed to its lotic habitat.

Puntius chola

The eggs of *Puntius chola* are non adhesive and non demersal with grey or black pigmentation on the yolk. The incubation period was 26 hours at 22–27⁰ c water temperature. However, Swain, (2008) reported that, the period of incubation differs according to the water temperature, under ideal water temperature condition (26-28⁰ c) the hatching period of gold fish was three days.

The present findings also confirm the view of Balon (1975) that even in the same species which live in different water bodies among wild and domesticated races early ontogenetic differences are evident. As observed in *Danio dangila* the chromatophores are distinctly recorded in *Puntius chola* at 26.35 hrs after hatching. More over, the chromatophores were also observed to aggregate at perspective band sites of the newly hatched larva.

Presence of some cement organs for attachment to substratum as reported in some cyprinids, like carp and bream (Nikolsky, 1963; Blaxter, 1969 and Balon, 1975) was evident in the present test species. Pre-hatching latency observed in daniids for a brief period (Harrington, 1947) was conspicuously absent in *Puntius chola*. This may be attributed to its lentic habitat.

Laboratory rearing of fry

Danio dangila

The success of rising of hatchlings up to the marketable size has been achieved in the present study. The most crucial and sensitive stage in the life of a fish is during early larval stages. The large-scale mortality of spawn may occur due to appreciable differences in the physico-chemical conditions of water, lack of requisite amount of choice food and predatory nature of fish. Hence, the rate of survival at these stages depends on the maintenance of optimum water quality, availability of sufficient amount of right kind of food and a predator free environment.

Approximately, 90% survivability of fry of *Danio dangila* in glass aquaria has been achieved in the present study. Whereas Pal *et al.*, (2003) reported about high mortality in laboratory rearing of fries. Swain *et.al.*, (2008) reported on successful larval rearing of *Ompok pabda* at CIFA, Kalyani centre, leading towards commercialization.

The fries of *Danio dangila* were carnivorous and prefer infusorians rather than egg yolk suspension and other pelleted food. Survivability of the fries was found correlated with the availability of choice food and the

feeding schedule. The larvae soon changes its food habit to live crustacean larva and other zooplanktons from twenty fifth day onward after hatching, confirming similar observations in sea bass larva (Parazo *et.al*, 1998).

Puntius chola

The successful raising of hatchlings up to the marketable size of the species has been achieved in the present study.

Early larval stages are the most critical and sensitive stage in the life of a fish. The rate of survival at different stages depends on the maintenance of optimum water quality, availability of sufficient amount of right kind of food and a predator free environment.

Almost, 95% survivability of fries of *Puntius chola* in glass aquaria has been achieved in the present study. Larval rearing of some ornamental fish species endemic to North East India was also reported by CIFA, Bhubaneswar centre (Swain *et.al*, 2008).

The fries of *Puntius chola* were omnivorous but reject egg yolk suspension and other pelleted food. As in *Danio dangila* the Survivability of the fry was also found to be correlated with the availability of choice food and the feeding schedule. The early fry feeds on cultured infusorians, egg yolk and planktons but it soon accepts the formulated and manufactured feed from thirtyth day onward after hatching.

Fish malady and restraints

Danio dangila

Danio dangila was most susceptible to fungal attack caused by *Saprolegnia spp*, which manifest in the body as well as the eyes. The infection develops secondarily in areas, which were bruised by rough handling or mechanical injury. Jhingran, (1991) also reported the secondary fungal infection of fishes. Heavy fungal infection leads to ulceration or exfoliation of the skin followed by haemorrhage and blindness. Next to fungal disease, *Danio dangila* was prone to bacterial disease, tail and fin rot

followed by ulceration. Overcrowding in the stocking tank could be the causative factor for the outbreak of bacterial disease and was also reported by Schaperclaus (1986). General prophylaxis measures opined by various authors (Hora and Pillay, 1962; Gopalakrishnan, 1963; Schaperclaus, 1986; Singh and Sreedharan, 2002 and Mishra and Das, 2005) were found to be relevant in the present test species. But to be precise, the present investigation recommended that, the disease specific prophylaxis measure was more effective and desirable for control of malady of *Danio dangila*.

Treatment through antibiotics like chloromycetin, tetracycline, oxytetracycline etc. at prescribed doses yield good results in the test species as, also reported by some workers (Schaperclaus, 1986; Varghese, 1988; Swain, 2008). However, some modifications of doses were required to fetch better result. Body fungus treated by dip treatment @ 1mg/litre Km_nO_4 solution was found effective (Hora and Pillay, 1962 and Swain, 2008).

“Salt treatment”, a very popular among the aquarists for its cheap, easily available and non-toxic proportion was found effective for treatment of *Myxosporidian* and moderately effective in fungal disease. Malachite green @ 5 mg/litre water when spread 2–3 drops in nursery tank before spawning and hatching phase showed good result against fungal attack, which was also reported by (Srivastava, 1987).

Puntius chola

The occurrence and magnitude of various fish diseases are closely related to the sanitary conditions prevalent in the water and also the condition and general health of the fishes themselves. *Puntius chola* was also found most susceptible to fungal attack caused by *Saprolegnia spp*, which manifest in the body as well as the eyes. This fungal infection develops secondarily in areas, which were bruised by rough handling or mechanical injury (Jhingran, 1991). Next to fungal disease, *Puntius chola* was also prone to bacterial disease, tail and fin rot followed by ulceration. Overcrowding in the stocking tank probably leads to outbreak of bacterial disease (Schaperclaus, 1986). General prophylaxis measures opined by

different authors (Hora and Pillay, 1962; Gopalakrishnan, 1963; Schaperclous, 1986; Swain, 2008 and Mishra and Das, 2005) were found to be relevant in the present test species.

Treatment through antibiotics like Chloromycetin, tetracycline, oxytetracycline etc. at prescribed doses as given by various authors (Schaperclous, 1986; Varghese, 1988; Singh, 2002; Singh and Sreedharan, 2002) yield good results in the present test species.