CHAPTER I

INTRODUCTION
The brilliant colours, bizarre shapes and curious habits of tropical fishes are well known, and throughout the tropics, freshwater fishes are of immense importance as a food source for human beings. Wide distribution of fishes has also resulted into the production of a variety of different kinds of adaptive modifications in order to meet with the stresses of the physical, chemical and the biotic environment. The indigenous adaptations displayed in anatomy, physiology and behaviour of these animals lead to the familiar conclusion that each evolved to suit the life in its particular corner of the world. Fishes also manage to persist in a particular geographical region which depends on the suitability of ecological conditions for all stages of life history, since fishes are very mobile creatures, searching out different habitats to suit the particular requirements of the eggs, the young fish, juveniles or adults. Their social requirements too, change as many fishes living in shoals when young, but in pairs or solitarily when adults. Thus, the composition of the fish communities, the group of interacting population within a particular habitat, may be changing continually (Lowe-McConnell, 1975).

Studies have shown that in certain places, communities of fish are very stable throughout the year and from-year to year and probably long periods of time, while in other places community membership is changing radically all the time, often with seasonal regularity. Some fish species are “eurytopic”, that is to say that they can withstand a great range of environmental conditions such as changing temperatures or salinity, or they can eat diverse type of food, while other species are “stenotopic”, tolerating only a very narrow range of environmental conditions.

Fishes excel, as a source of commerce and recreation. They form a rich source of food, and are cultured both intensively and extensively to give the best values of their raising. Today, protein deficiency is the world’s most serious human malnutritional problem, and perhaps 30 million underdeveloped countries (WHO report).
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40% of the world’s population suffers from protein deficiency. For the development of fishery resources, it is necessary to understand their population dynamics i.e., how fast they grow and reproduce, the size and age at which they spawn; their mortality rates and its causes, on what they prey upon along with other biological processes.

(What is a well known fact that the knowledge on fish biology particularly on morphometry, length-weight relationship, condition factor, reproduction, food and feeding habit etc., is of utmost importance not only to fill up the lacuna of our present day academic knowledge but, also in the utility of the knowledge in increasing the technological efficiencies of the fishery entrepreneurs for evolving judicious pisciculture management.)

The general concept of length-weight relationship is that the weight of fish varies as the cube of its length. But as the specific gravity and shape or body outline of the fish is subjected to changes, the cube law need not always hold good (Rounsefell and Everhart, 1953). Nevertheless, most workers have failed to report statistical significance of the departures from cubic relationship that they had recorded in such studies.

Determination of proper sizes of fish to harvest for maximum sustained yield is directly related to fish weight. The increment in fish weight is usually considered to follow the hypothetical cube law. Length-weight relationship of fish varies depending upon the condition of life in the environment. The variations in this relationship provide a measure of condition of the fish and the suitability of its environment.

Studies related to length-weight relationship is also important for understanding the population dynamics and proper management of the resources. The information also helps in selecting suitable species of faster growth rate for culture and assessment of the duration of culture period for the attainment of marketable size of the animal.
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It is useful to have seasonal length-weight and also the length-weight relationship of different size groups. This will help to estimate the general well being of different sizes of the fish. Weights of various parts of fish often required for biological studies, e.g., weight of alimentary tract (gut weight) for estimation of feeding intensity, gonads for selective fecundity etc. The analysis of length-weight data describes mathematically the relationship between length and weight, primarily so that one may be converted into the other. The other purpose is to measure variation from the expected weight for length of individual fish or relevant groups of individuals as indication of fatness, general “well being”, gonad development, etc., (Le Cren, 1951). The study of length-weight relationship also helps in setting up yield equations (Beverton and Holt, 1957; Ricker, 1958), in estimating the numbers of fish landed, and in comparing populations in time and space (Pandey and Datta Munshi, 1974). The deviations from the general cube law governing the length-weight relationships have been utilized by fishery biologists in determining the condition or general well being of the fish. These variations from the basic law are measured by a unit, the condition factor (also known as ponderal index, K-factor or coefficient of condition) and serves as an useful index of the nutritional and biological cycle of the species (Jhingran, 1972). Thus, condition factor is another way of expressing the relationship between length and weight of a particular fish. The condition factor was determined with the objective of expressing the condition of the fish in numerical terms i.e., degree of well-being, relative robustness, fatness etc.

Maturity can be defined as cyclic morphological changes which the male and female undergo to attain full growth and ripeness (Qasim, 1973). Fishes have a very diversified reproductive behaviour. The time of onset of maturity also varies considerably among different species.
Generally, the attainment of maturity is related to acquisition of a particular size by the individual and, as a general rule, the slower the growth rate of the fish, the later the onset of sexual maturity and vice-versa. The maturity studies provide a number of useful information such as the maturity of the stock and related cyclic changes in the gonads, exact breeding time, frequency of spawning and sex-ratio which can be successfully used for management of the fishery.

The sequence of changes in maturity stage during the year is of considerable importance in building a thorough knowledge of the general biology of an exploited stock. From these studies a variety of inferences could be drawn, such as the rate of regeneration of stocks and determination of ecological factors which led to synchronization of breeding activity. Similarly, information on such related aspects as fecundity, size at first maturity, etc. are also pertinent and all these aspects should be taken into consideration for successful aquaculture programme.

The knowledge of the number of eggs produced by fishes is of great value in pisciculture, as it would determine the amount of rearing facilities required and the extent to which various kinds of equipment will be needed. According to Corbin (1948 and 1952), the number of eggs produced by the fish must be known, if survival is to be estimated. The data pertaining to fecundity are also useful in determining the density dependent factor affecting population size (Simpson, 1951) and for separating different fish stocks from the same population (Farren, 1938). For several centuries, the attention of naturalists as well as fishery scientists has been drawn to the number of eggs in the roes of female fish. Fish fecundity has been studied not only as one aspect of natural history, but also in association with studies of population dynamics, racial characteristics, production and stock recruitment problem (Bagenal, 1978;
Habib, 1979). Yet another utility of the fish fecundity is in fish culture for proper planning of the hatchery and nursery operations. The number and size of the brood stock to be maintained for achieving a certain set target of fish seed production also calls for a knowledge of the fecundity of the species in question (Varghese, 1973).

Food plays one of the most vital roles in the life history of fishes by way of controlling their growth, fecundity and migration. Studies on food and feeding habits of fish also help to determine the niche in the ecosystem, the preferred food items and also reveal the food spectrum overlapping with that of co-existing fishes (Basudha and Vishwanath, 1999; Yeon et al., 1999). Nikolsky (1963) realized the importance of food study and stated that a deterioration in food resources might lead to reduced food consumption resulting in deceleration of growth rate, emaciation, delayed sexual maturity, changes in food spectrum, reduction in fish stock and an increase in the range of morphological variability of the fish species.

The diverse nature of dietary habits of different species of fishes is always reflected in the morphological adaptations of the alimentary canal of the concerned fish. Histological study of the alimentary canal of fishes helps to trace out the structural modifications of the gut depending upon the food and feeding habits of the fish. Scanning Electron Microscopic (SEM) studies of this carnivorous fish *N. nandus* provide extensive information on the surface ultrastructural organisation and mucosal modification of the digestive tract in relation to food and feeding habits of the fish.

Fishes are also known to change the food habits, as they grow, accompanied by correlative changes in the digestive systems (Al-Hussaini, 1949; Ahsan-ul Islam, 1951; Kapoor, 1953; Das and Moitra, 1956). Another remarkable feature regarding the fish feeding is its seasonal
variation in selection of food and intensity of feeding. The former is linked with the availability of the food in the biotope.

Extensive researches on freshwater fishes in India, generally centres around the biology of only those species which are being used to stock dams and lakes rather on natural fish communities. In India, generally the important culturable fishes are the Indian major carps, such as Catla catla, Labeo rohita, and Cirrhinus mrigala and the exotic carps viz., Cyprinus carpio, Ctenopharyngodon idella and Hypophthalmichthys molitrix. Extensive research works are also there on wide variety of game fishes. Apart from these there exist a large number of endemic fishes which needs good research. Due to culture of Indian major carps, pollution, different types of diseases especially Epizootic Ulcerative Syndrome, faulty fish culture practices, over exploitation, filling up of aquatic ecosystems for industrialization and construction of houses, introduction of exotic fish species etc.; culture of these endemic fishes are being neglected and gradually they are being catagorised as ‘vulnerable’, ‘threatened’, ‘endangered’ fish species. If proper attention is not given such fishes are likely to become extinct in near future. The studied fish Nandus nandus is one such endemic fish of the New Alluvial Zone of West Bengal that was once considered a commercially important fish due to its taste and nutritional values and also fetched good price. But now its number is decreasing and it is rarely available in the market due to the above mentioned adverse factors. IUCN has enlisted mottled Nandus nandus in their red list of threatened fishes of Bangladesh as a vulnerable taxa (IUCN, 2000). In India, particularly in West Bengal this fish is considered to be a critically endangered fish (Das and De, 2002). Also, as mentioned earlier our knowledge on the biology of other indigenous and game fishes are much more relevant than the endemic fishes including Nandus nandus as evidenced from the review of
literature.

Usually the study of limnological parameters deal with various aspects of the ecological strata and function of freshwater environments. Here the study area is a wetland locally called "beel" in West Bengal which includes a dynamic system involving a continuous interaction between organisms and physico-chemical conditions of water. To keep the water body conducive for fish growth, the physico-chemical parameters like temperature, transparency, dissolved oxygen, pH, carbon dioxide, alkalinity and nutrient elements like nitrogen, phosphorous and organic carbon were monitored regularly in the present study. The ecology of wetlands is highly diversified satisfying the basic requirements of the fish species which may provide the ideal spawning ground, suitable shelter and bountiful food to graze upon. (Refer to page 33)

The present study reveals that the fish prefers an optimal environmental condition for its growth and reproduction. It was also noted that any adverse change in environmental condition causes stress on the fish; if such a change increases arithmetically, the stress on fish may increase geometrically. Therefore, both biological parameters and ecological parameters influence the fish population.

Considering the significant position of this fish *Nandus nandus* among other economically important freshwater fishes in India, there is a basic necessity to have a profound knowledge on the general biology of this fish as well as its relationship with ecological parameters. Therefore the present study on the biology and ecology of *N. nandus* was considered worthwhile and attempts to unravel the biological and ecological aspects of the fish from the New Alluvial Zone of West Bengal.
Diagnostic Characters of *Nandus nandus*

*Nandus nandus* is a critically endangered fish of West Bengal. It is also known as the Gangetic leaf fish. It is a predatory fish and mainly piscivorous. It has a compressed, oblong body. It attains a length of 20.0 cm. The head is relatively large and compressed. The mouth is terminal, very protractile and the cleft of the mouth is very wide extending to below posterior border of eyes or slightly beyond. The eyes are present in the anterior part of the head; they are lateral in position; large in size and are not visible from below ventral surface; the diameter of the eye is 5-6 times in head length. Lips are thin. Jaws are sub-equal and the lower jaw is longer. Villiform teeth are present on jaws, palate and on tongue. The dorsal fin is inserted above pectoral base and has 12-14 spines and 11-13 rays; the spinous portion of dorsal is longer than soft portion. Anal fin has three spines and 7-9 rays. The caudal fin is square shaped or slightly rounded.

Depth of the body is greater than the length of the head. The caudal peduncle is well formed but narrow. Lateral line is interrupted at about 36th scale; 46-59 scales are present in lateral line.

Colour of the fish in life is greenish-brown with brassy reflections; vertically marbled with three broad patchy blotches; a dusky blotch is present on caudal fin base; some narrow dark bands are seen to radiate from eye. Fins are greenish in colour; yellowish narrow bands of spots across soft portions of dorsal, anal and caudal fins are present.
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Synonyms and Geographical Distribution of *Nandus nandus* (Hamilton)

1822 *Coius nandus* Hamilton, *Fish. Ganges*, pp. 96, 370, pl. 30, fig. 32; type locality: Gangetic provinces.


1875 *Nandus marmoratus* Day, *Fish. India*, p. 129, pl. 32, fig.1.


1834 *Bendula hamiltonnii* Gray, *Ill. Ind. Zool.*, 2, pl. 88, fig. 3 (from Hamilton's Ms. drawings).

1937 *Nandus nandus* Shaw and Shebbeare, *J. Asiat. Soc. Beng.*, 3, p. 115, fig. 120; type locality: N. Bengal.


*Distribution*: India, Nepal, Pakistan, Bangladesh, Burma, Thailand and Malaya. Inhabits fresh and brackish waters. The species is common in ditches, rivers, ponds, *beels*, bheries, tanks and inundated fields.

*Vernacular names*

| Assamese | Gadguddi, Badvaadei, Gedgedi |
| Bengali  | Bheda, Nadosh, Meni, Latha   |
| Bihari   | Vaadhul, Dhebari             |
| English  | Mottled Nandus               |
| Malayalam| Mootahree                    |
| Punjabi  | Khota, Gadha, Chambal        |
| Oriya    | Bodisi, Gossiporah           |
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Telegu       Septi
Malayalam   Mootahree

Taxonomic Status of the Fish (after Berg, 1940)

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