INTRODUCTION

Fish has appeared during the Ordovician period (about 350 million years ago), but maximum development appeared during the Devonian period. The bony fish group been the most successful group of fishes in terms of number of species and length of evolutionary history. Over 20,000 species have been found and are living today where as cartilagenous are less than 600. Bony fish occupies the wide variety of aquatic niches, from freezing arctic lakes to hot springs and from fresh through brackish and marine water. They also found in the shallow water of river systems to depths of over 9000 meters in the ocean. There is almost no aquatic environment from an underground stream to swamp or desert oasis, which is not utilised by some or other bony fish.

Fish is one of the most important source of natural proteins to the people. An abundant and chief supply of the fish through aquaculture will help to solve the problem of unbalanced diet of the people. Aquaculture has a substantial history, although its origin is mystery. In India, fish culture system was developed thousands of years ago. Susreta made ecological classification of fishes in 600 B.C. Kautilya mentioned in his Arthasastra about fish culture in tanks and reservoirs in 300 BC. King Ashoka declared edible fishes as protected species during their spawning period in 246 BC. King Someswara III, son of the King
Vikramaditya VI had immense knowledge of herbivorous, carnivorous and detritivorous feeding habits of different fish species and also the usage and recycling of wastes in 1126 - 1138 AD. During 1875, Bloch published a book "Auslandiche fische", and recorded many Indian marine species. Russell described 200 species of fishes, in 1803. Hamilton made a description of 269 species of fishes from the Ganges and its tributaries in 1828 - 1849. Cuvier and Francis Day (1875 - 1889) provided notable information on the Indian fishes in "Fishes of India, and Fauna of British India".

Important event took place in the history of fishes in India with the enactment of Indian fisheries Act 1897, and declaration of Exclusive Economic Zone (EEZ) in the sea upto 200 nautical miles in 1976. The Indian fisheries act delegated some responsibilities of development, management and conservation of fishery resources to the states as,

1. To increase production for per capita consumption and per capita income by which national income will be higher.

2. Ornamental fishes

3. Sports and game purposes like culture of trout and Mahasheers.


5. Earning foreign exchange

7. Create employment opportunity.
8. Controlling parasites like Mosquito larvae by larvicidal fishes.

Tropical environment, higher primary productivity, excellent growth performing stocks indicate good potential in Indian waters. Fishery resources of India are highly diversified in nature including high-altitude subtemperate streams, rivers, lakes, reservoirs and ponds to subtropical and tropical water bodies. Inland fishery resources are supported by five major river systems with myriads of streams and canals of 3.12 million square Km and total length of 1.7 lakh Km. Reservoir constructed on these rivers have 2.05 million ha. area with combined storage capacity of 16.247 cubic Km.

Today, aquaculture in India accounts for over 15 million metric tons of aquatic products harvested each year and hence it ranks seventh among the fish producing countries of the world. Top seven fish producing countries of the world along with their production in million tonnes are, China (15), Japan (8.46), Peru (6.84), Chile (6.50), Russia (5.61), America (5.6) and India (4.17).

During last decade (1985-1995), India witnessed a rapid growth in the fisheries sector with an increase in fish production from 2.876 to 4.949 million mts, achieving an approximate average annual growth rate of 5.4% . The sector employs about
5.96 million fishermen and supports a large workforce engaged in fisheries and related activities.

Fish flesh is rich in protein (15-25%) and less fat (1.5%), calcium, vitamin A, B and D content which is suitable for human diet. It contains lysine and sulphur containing amino acids which complements the cereal based diet. Marine fish is a good source of iodine. As fish contains high polyunsaturated fatty acids specially 'Omega 3', an important component in lowering blood cholesterol levels and also effective in lowering blood pressure and preventing cardio-vascular and renal diseases in human beings. These reasons are encouraging to consume fish and other aquatic organisms.

Thus, fishes have occupied a significant position in socio-economic fabrics of countries as nutritious food, income source and employment opportunities. Of the 21723 fish species known to science, over 40% are living in freshwater and majority of them are inhabiting in tropics. The Indian fish fauna is an assemblage of about 2500 species depicting diverse characteristics, out of which 930 belonging to 326 genera, inhabiting in inland waters. Scientific understanding of the fish species with respect to their morphological, biological and adaptive characters along with their natural distribution, it is imperative to back up their optimum exploitation.

The natural aquatic ecosystem of India has been subjected to a considerable stress, the adverse effects of which
are being manifested in fish populations. A need has therefore arisen to conserve the vast and diverse fish genetic resources for their efficient utilization. Conservation of fish genetic resources of any region requires a knowledge of the available resources and salient biological features pertaining with the reproduction. Tropical freshwater fish exhibits great diversity in morphological, physiological and ecological attributes, and provide excellent system for the evaluation of life history pattern. The main goal of reproduction remains the transfer of the information stored in the parent genomes to the next generation.

The reproductive success of a fish depends on the resources, and where and when spawning takes place. The reproductive cycle consist of two distinct parts, spawning and gametogenesis. Spawning comprises the sequence of events of maturation (oocyte maturation, ovulation and the formation of sperm), and also require specific stimuli such as flooding or rainfall or probably many other triggers. Gametogenesis is the formation of gametes, it varies from species to species and also depend upon the environmental conditions.

Most of the teleost reproduce sexually (external fertilization). It is impersonal lengthy courtship behaviour and proceeds for mating and involves a series of interrelated movement. The overall reproductive strategies of fish species, is a complex of reproductive trails, including age at first maturation, and fecundity.
Three main types of strategies have been recognized viz.
(i) species with a short annual spawning period - They are usually
fecund fish, and spawning generally occurs once a year.
(ii) Multiple spawner with a long annual reproductive period -
The egg ripe in batches and laid either at intervals throughout
breeding season or a seasonally.
(iii) Small brood spawners - Fish with parental care tend to have
smaller broods than fish which leaves their eggs unguarded.
Mouthbrooders have the smallest batches of eggs.

Present study has been designed to study the edible fish
_Nemacheilus moreh_ from Mula - Mutha river system in northern
western ghats, Pune in Maharashtra state, situated between 17°54"
and 19°21" N latitude and 73°24" to 75°14" E longitude in western
India. The river system is contributed by several streams
originating along the crest of sahyadries (Western Ghats) and
finally drains to Krishna river system about 200 Km to South east
of Pune. Besides natural water sources, there are other water
reservoirs i.e. dams, lakes, ponds and impoundments, providing
major water surface area (15532 hectors), suitable for fish
production. Tilak and Tiwari (1976) surveyed fish fauna of whole
district and recorded 120 species of fishes. The area under water
which can be exploited throughout the year is 12,263 hектores,
while the area under water which can be utilized for fish production
is 2139 hектres. The total fish production from this resource is

12
1992-93  1160 tonnes
1992-93  2200 tonnes
1993-94  2200 tonnes
1994-95  2640 tonnes
1995-96  1600 tonnes
1996-97  3890 tonnes
1997-98  3490 tonnes
1998-99  1320 tonnes

These resource supports a wide range of indigenous and few exotic fish species. In general 66 species comprising 38 genera and 18 families have been reported (Kharat et al., 2001) from river system. Of these, the several fishes are at endangered stage and may go extinct in near future, which may be the source for the biodiversity study of the fish fauna.

During past few years, there has been vast expansion in the knowledge of the teleost reproductive biology, especially morphology and physiology. The regulatory process of reproduction is carried out by hormones secreted from endocrine gland which act on target organs to induce predictable responses. The study of hormones has a background of the last 40 years, but unfortunately pattern of hormone production and function in fish is not yet completely clarified.

Studies on the reproductive biology of fishes of Indian sub-continent have been carried out by a number of researchers,
(Ramkrishniah 1992, Sharma et al., 1996; Gupta, 1974; Usha and Nair 1994; Shrestha, 1980; Padmaja et al., 1997; Sriramchandramurthy 1979; Reddy and Rao 1992; Gupta, 1975; Piska and Waghray 1989; Bisht 1974; Siddiqui et al., 1974; etc. but no attention was so far is paid to the Homalopterid fish, Nemacheilus moreh.

*Nemacheilus moreh*, is a small fish plays vital role in torrential ecosystem and contribute immense importance in fish biodiversity. Though it is not productive and economically important, it is pretty common in river Mutha and tribal people, and the "Katkari" catch them on commercial point of view. *N. moreh* are known to have the potential to withstand extreme ecological conditions. It is therefore, worth, to consider such study. Hence, the present study is undertaken to observe the process of gametogenesis, seasonal cyclicity, endocrine control, especially role of pituitary gland in reproduction and other biological factors. It may also provide a basic knowledge on biology and reproductive behaviour of hill stream fish, and hence encouraging to work on the group of fishes and other wild variety of hill stream teleost.

The study will also provide a deeper insight into morphohistology and cell types of pituitary gland, role of GTH cells in development of gonads and other biological studies.
Pituitary gland

The Morphology and histology of piscine pituitary has been reported from time, to time but much less is reported as compared to mammals, birds, reptiles and amphibians (Pickford and ATZ, 1957). The morphology and histology of the fish pituitary has attracted an attention of workers (Herring, 1908, 1913; Tinley 1911; Stendell 1914 de Beer 1926; Mathews 1936, 1939, Charrier 1937; Bell 1938; Scruggs 1939; 1951; Kerr 1942 a, b, 1948, ATZ 1953; Olivereau, 1954; Sathyansen 1958, 1960a,b, Sundaraj, 1959; Robertson and Wexler 1962a, b). The study of the histophysiology of the gland inspite of its importance is still at infancy. The teleost pituitary has many structural and histological features peculiar to itself. Thorough knowledge of this gland has always been a hurdle in understanding the reproductive physiology of fish. After more than 100 years of research only 30,000 known species have been studied through the microanatomy of the pituitary has been studied using more recent histological and histochemical techniques. The existing disagreement on the function of various cell types is namely due to the lack of the appropriate experimental techniques to know the function of the cells which is attempted systematically; (Ball and Baker, 1969). Morphological characteristics, especially those concerning with the active phases of different cell types, have not been examined in detail in the past (Boddinglus, 1975).
In the present study, pituitary histology and morphology of the freshwater Homalopterid teleost, *Nemacheilus moreh* is described using Mallory's triple staining (MTS) techniques. Identification of gonadotrophs has been made in relation to changes in gonads. Description of various cell types has also been made.

**Correlation of pituitary with gonads**

Another approach of the interpretation of the functional cytology of the pituitary is to correlate with different active phases of pituitary in cyclical activities. e.g. Reproductive cycles, determined by the cyclic release of gonadotropic hormones by hormone secreting cells.

Like other vertibrates, gonadotrophs in the teleost pituitary control reproductive activities. The pituitary-gonad interrelationship has been variously assayed by hypophysectomy (Mathews, 1939), injection of pituitary extracts (Houssay, 1930. 1931, Cardeso, 1934). Experiments on the induction of spawning by pituitary extracts in Indian species have been attempted by (Khan, 1938) with appreciable degree of success (Alikunhi and Choudhary, 1957, and Ramaswamy, 1958). It has also been experimentally demonstrated that, environmental factors are not directly responsible, either collectively or individually, making the breeders spawn, Ganapti and Alikundi (1949) and Mookerjee (1945) stated that the endocrine mechanism is responsible for
Gonads of *N. moreh*.
ovulation, while environmental factors probably mediate through the pituitary.

Reports on the correlative changes of the pituitary and gonads are available only in isolated instances (Brestchnerider and deWit, 1947; Scruggs (1951); Stolk (1950). It has been observed that, though pituitary-gonad relationship in fishes has been demonstrated, functional relationship is yet to be established (Hoar 1955). The pattern of reproduction of tropical and subtropical inland water fishes is little known. Present study is an attempt to correlate the functional mechanism of the pituitary and gonad in fish, N. moreh.

**Gonads**

The study on gonadal maturation in teleost occurring in temperate regions of the world and inhabiting in hill streams, meagerly considered for such studies. Hence, studies on such species are therefore important to undertake for investigation as they may contribute towards the understanding the role and importance of hill stream teleost.

**Testes**

Several important contributions on the cyclic changes in testis are available (Craig Bennett 1931; James 1946; Ghosh and Kar 1952; Sathyanesan, 1959; Khanna and Pant 1966; Hyder 1970; and Sanwal and Khanna 1972). It is well known that, the teleost inhabit in different ecological conditions exhibit great diversity of their reproductive behaviour. So far, only a few reports
are available on the seasonal cycles in the testes of hill stream fishes, Shrestha and Khanna (1978) and Padmaja et al. (1997).

**Ovary**

Most of the studies on reproductive biology of teleost have been described through development of gonad in terms of stage of maturity of ovums (Kesteven, 1960; Nikolsky, 1963) and of gonadosomatic index (LeCren, 1951, Craig, 1974).

Spawning in teleost during a particular phase of the reproductive cycle represents a spawning behaviour. Some species are annually breeder, some breeds at regular intervals throughout the year. It implies that a knowledge of reproductive cycle of a species is essential for designing experimental working. Although studies on teleostean gonads have been attempted by various workers since the middle of 20th century (Zuckeman, 1962), the cyclic histological changes in gonads have only been examined in a few dozen species (De Vlaming, 1972).

One of the objective of the present study, is to describe histological changes in the ovary during development on the microscopic scale of maturity stages as defined by Kesteven (1960).

**Gonadosomatic index**

The reproductive cycle in fishes also involves changes in weight and weight of gonads. Measurements of total weight and weight of gonad is usually correlated and reported in terms of the gonadosomatic index (GSI). The term was firstly
introduced by Meien (1927) and since then GSI has been used in study of reproductive behaviour of a species as an indicator of gonad development. Increase in GSI during the period of gonad maturation is mainly due to the deposition of large amounts of proteins and lipids directly from ingested food during the active feeding season (Larson, 1974 and Zahnd, 1959).

**Fecundity**

Fecundity can be defined as the number of ova laid by a fish during the spawning season, it is species specific. Number of eggs depends on the size and age of the fish. The fecundity has been studied by several investigators. Siddiqui (1977); Marcus and Kusemiju (1984); Piska and Waghray (1989) and Treasurer (1981), and have reported that, the knowledge of the fecundity is useful in fishery development and management.

**Length-weight Relationship and Relative Condition factor**

Length-weight relationship studies in fishes is being carried out with a view to establish the relationship between length and weight of a species which enable to major the growth rate, (Beverton and Holf, 1957). It also helps to measure the variations of the expected weight due to changes in surrounding environment related to life cycle of all fishes (LeCren, 1951). Relationship between length and weight of the fish has numerous practical applications in fishery biology. Weight of a fish is a unit function of growth and vary with the cube of length (Brody, 1945; Lagler, 1952; and Brown, 1957). Length weight relationship of *N. moreh*
collected from Mutha river has been studied and discussed in
detailed in the present study.

**Kn value**

The study on the relative condition factor (Kn) can be
used to compare the promptness of a fish to the relative
environmental factors. It also helps a fish culturist to compare the
weight of fish against a calculated weight, to determine whether
the fishes are in better or poor condition. The relative condition
factor can also be used to compare the general well being, fitness
or the state of development (Thomas, 1969 and LeCren, 1951)
and recommended a study on relative condition factor (Kn) in
preference with the ponderal index (K), will be highly influenced
by many environmental factors. *N. moreh* is not only the important
as food fish but it also draw attention on its diversified occurence.

**Length-frequency studies**

In the length frequency studies, knowledge of age and
growth of fish is an important prerequisite to understand the
dynamics of fish population. In fishery, studies on growth is one
of basic variables determining the exploitable growth of a stock
and yield through fishing (Beverton and Holt, 1957). The
knowledge of growth is not only essential to determine the growth
in fishes in different seasons, but also to know the year classes for
fishing. The practical application of age and growth studies in
fishes deals with the following problems (Lagler, 1956) (i) At what
age does a fish attain sexual maturity? How long it must be held to reach breeding age? How soon will a fresh stock of young produces? (ii) At what age will a given species reach catchable size? Important for fisheries regulation. (iii) Determination of the age may help to discover environmental unsuitabilities (iv) A comparison of the rate of fish growth in different water bodies may partly identify good or bad environmental conditions. (v) Age and growth studies may also show suitability of the stock used as a follow up measure (vi) Continuing studies of age and growth in particular water bodies will show the normal fluctuations from year to year and also over period of years.

Determination of age and growth rate of fish is one of the prime pre-requisites for the proper management and conservation fishery. It also helps in finding out the distribution of different year classes, month by month and determining the average size of the fish in the first few years of the life.

Age and growth can be determined by the following methods:

1. Peterson's length frequency method
2. Age determination through hard parts such as scales, otoliths, bones, spines and
3. Tagging or known age method.

Determination of age of tropical fishes by examining growth rings on hard parts such as scales, otoliths etc. is not always feasible. Since the tropical waters do not show well marked wide
variations in temperature, the growth rings on the hard parts do not faithfully reflect the actual growth patterns. Hence, in length frequency polygon method is adopted to determine the age and growth pattern of tropical fishes. The method is most effectively applicable to a fish population which has a short and well synchronised spawning season. The length frequency method is based on the expectation that when data for a sample of the entire population is plotted, there must be a clumping of fish of successive age to the given lengths. This method of length frequency was adopted by several workers (Al-Hakim et al., 1981; Menezis, 1980; Okera, 1974; Ketchen, 1972; Reddy and Baburao, 1993 ;).

**Sex ratio**

Sex ratio indicates the proportion of male to female in a population. In nature, the ratio is expected to be 1:1. The study on sex ratio throws light on aspects such as sex availability and segregation of sexes according to breeding behaviour. It also helps to know whether differential fishing exists (Kumthekar, 1988). A knowledge of sex-ratio in fish population is essential in the fishery management. It is essential to derive means of ensuring a proportional fishing of the two sexes (Pillay, 1954). A knowledge of the sex composition in catches also helps in understanding whether differential fishing exists between male and female and if so it is possible to bring it on the fishable stock (Surendra and Neelkanthan, 1981). Gon and Ben-Tuvia (1983); Sukuraman
(1978); Usha and Nair (1994); Sharma et al. (1996); Piska et al. (1991) and Bhatnagar (1972).

**Food and feeding habits**

Fishes have become adapted to a wide variety of food. Some of them feed exclusively on plant (herbivorous), other feed on animal (carnivorous) while a large number of species are omnivorous, derives their requirements both from animals and plants.

It is generally agreed that fishes are either herbivorous, omnivorous or carnivorous, but most of them are highly adaptable in their feeding habits, and utilize the readily available food. The feeding intensity of the fish varies with the season and is related with maturity, spawning and the availability of food items (Bahuguna and Sing, 1981).