GENERAL INTRODUCTION
The study of somatic and organ condition of fishes constitutes an important aspect of their biology. Information on somatic condition (obtained through condition factor or ponderal index) is widely used to understand relative robustness or heaviness of fish. Recent years have seen a surge of interest in evaluating the physiological or nutritional state which is responsible for changes in the mass of body (expressed by somatic condition), weight of internal organs (indicated by organ condition) and also the chemical makeup and nutritional quality of fish. The biochemical composition of fish is so profoundly influenced by factors of both extrinsic and intrinsic origin that a simple deviation of the mass of an individual from average mass for a given length do not reveal the underlying changes (Mustafa, 1979 and Shams, 1980). While giving a review of seasonal and environmental influences on various attributes of the flesh of Atlantic cod (Gadus morhua) Love (1975) discussed the demerits of using weight : length ratio to gain an accurate idea of the health and standard of living of the fish. From the exhaustive review of Love (1980) it is clear that over a certain period a fish deprived of food and exposed to man-made and natural vagaries may not lose weight due to replacement of nutrients like protein and fat by water. The condition factor and length-weight exponent fail to bear witness to this physiological emergency prevailing in the fish body, a condition which lowers the food value of
flesh. Disadvantage of length-weight approach also lies in its masking of true dynamics of condition of fish in the event of large gonads and more gut contents which contribute substantially to the total weight of fish. To exclude the effects of these factors Mustafa (1979) and Mustafa and Zofair (1983) used 'fillet condition factor' (fillet weight, g \times 1000/cube of fillet length, cm) rather than condition factor of the intact fish (body weight, g \times 100/cube of total length, cm). The situation warrants the need of finding out some sensitive and reliable tools which can truly depict the condition and living status of fish. Several workers determined the weight of internal organs of fishes in relation to starvation, ration size, dietary quality, etc. A resume of these studies has been given by Love (1970, 1980). Differences in the nature of response of the various organs were discerned. Liver has emerged as the most dynamic visceral organ of the body. Its weight fluctuates with small-scale changes in the aforementioned factors. This organ is an important site for the accumulation of glycogen and fat. Fluctuations in weight are linked with changes in the amounts of the reserves. Several authors have sought to explain the short-term changes related to daily food intake (Heidinger and Crawford, 1977), food storage (Bulow et al., 1978), sexual maturation (Love, 1980). Besides, Tyler and Dunn (1976) working on winter flounder,
Pseudopleuronectes americanus, and Jensen (1979: pollock, Pollachius vireng) demonstrated liver-somatic index as a fairly good measure of condition. Of all the parameters of the liver, the most reliable indicator of condition is the RNA/DNA ratio. Bulow (1971) tested the sensitivity of RNA/DNA ratio in different organs and tissues of the body and suggested the use of liver for this ratio technique. Mustafa and Mittal (1982a) examined comparatively the liver and brain weight and nucleic acid response of catfish Clarias batrachus to food deprivation; the lability of liver and stability of brain were clearly evident.

Some biochemical constituents have proved to be still more sensitive than gravimetrically derived indices of somatic and organ condition. Nikolsky (1965) proposed coefficient of fat content (weight of 'internal' fat expressed as a percentage of total weight of fish) to indicate fish's living condition. The term 'internal' fat was used to denote the fat which accumulates in the viscera. This 'fat depot' is easy to remove and makes the evaluation of fat coefficient practically feasible. The available evidence shows that the amount of visceral fat is very closely related to intensity of feeding, and the changes in the coefficient of fat content fairly reflect variations in total fat content of the fish. There are, however, differences in the fat distribution in
the body of fishes. Not all fishes store fat in the body
cavity. Application of Nikolsky's (1963) fat coefficient
is thus of limited applicability. In sharks and gadoids
fat accumulates chiefly in the liver; in gadoids and
percoids very little quantity of fat occurs in the flesh,
whereas in cyclostoms and eels, flesh is an important site
of fat deposition. There is hardly any fat on the intestine
in gadoids. Indeed, majority of fishes store fat around the
intestines. A typical example is that of roach. Prozorovskaia
(1952) went to the extent of suggesting a scale of fat deposition
on the intestines of caspian roach. Caulton and Bursell (1977)
also considered fat indices as correlates of condition. More
recently, Mustafa and Jafri (1981) working on *Heteropneustes
fossilis* gave a lucid and succinct account of the strong
relationship between fat and biological condition. The same
authors have also reported the changes in glycogen concentration
as indicative of condition of fish and derived glycogen-condition
exponent to emphasize the strength of progression. Use of
protein content as an index of condition in cod, *Gadus morhua*
has been advocated by Love (1962) based on the fact that
fish growth is largely a function of protein biosynthesis.
Nucleic acids are increasingly employed these days for
assessing the well-being of fishes.

Work presented here in the form of thesis is based on
freshwater species of carps (*Catla catla, Labeo rohita,*)
Cirrhina mrigala and Puntius stigma), catfish (Heteropneustes fossilis) and murrel (Channa punctatus). The first part of the thesis (Chapters I, II) presents information on somatic and organ condition of teleosts. For study of somatic condition of major carps, the data were processed statistically to establish the relation between length and weight of the body with special reference to change in mass/unit length of fishes. Other parameters examined were condition factor (ponderal index) and relative condition factor to substantiate the length-weight exponents. For investigations of organ condition, heart, liver and brain were selected. Growth pattern of these organs with increase in length and weight of the body was compared with a view to understand the degree of stability or variability of vital organs and to suggest the most dynamic organ for determining the relative well being of the fish (condition) either gravimetrically or through biochemical changes. Liver was found most suitable. Earlier, Bulow (1971) also examined liver, stomach, intestine and muscle and highlighted the sensitivity and hence suitability of liver for study concerning fish condition.

Next part of the thesis (Chapter III) gives a comprehensive account of the relations of fillet condition factor of Heteropneustes fossilis to specific gravity, RNA and DNA. The suggested regression models serve to emphasize the use of nucleic acids in evaluating the health and
robustness of fish. The protein and nucleic acid study was further extended to *Catla catla*, *Labeo rohita* and *Cirrhina mrigala* (Chapter IV); seasonal turnover of these macromolecules was thoroughly investigated at various stages of life of the fishes so that a greater ingenuity is brought to bear in application of molecular biology for interpretation of fish condition. The work assumes special importance since:

1) it brings to light the sequence of nucleic acid changes which are an exception to the more generalized concepts,

2) little information exists on seasonal changes in nucleic acids (Satomi and Ishida, 1976; Satomi and Tanaka, 1978a; Love, 1980; Bulow et al., 1981) compared to considerable number of publications on changes in other chemical constituents related to season (Noguchi and Bito, 1953; Dambergs, 1964; Jangaard et al., 1967a,b; Khawaja and Jafri, 1968, 1970; Dawson and Grimm, 1980; Shreni, 1980; Eliaasen and Valn, 1982).

Realizing the importance of fish nutrition in aquaculture, possibility of using homoeopathic extracts as feed mixes was considered (Chapter V). Results obtained on *Heteropneustes fossilis* were quite encouraging. The homoeopathic additives (Calcarea phosphorica, Natrum muriaticum and Lycopodium) were effective in enhancing the appetite and nutritional efficacy of impoverished diet in the form of raw buffalo meat of poor quality. It may also be added that the work opens a new avenue in the application of homoeopathy in fisheries and
holds out promise for future developments. Gonadal steroids were also tested on *Heteropneustes fossilis* for understanding their possible influence on growth and condition. The problem of steroidal-treatment of fish has been reviewed by Donaldson *et al.* (1979) and Higgs *et al.* (1982). Suppressing or stimulating effects of androgens and estrogens on growth of several species of teleosts, especially salmonids have been documented. The present work (vide Chapters VI, VII, VIII) carried out on *Heteropneustes fossilis* reports: effects of a homoeopathically prepared glandular extract (*Testes 3X*) and natural ovarian steroids obtained from the same species on growth and food utilization, and the response of liver-somatic index, RNA and DNA to exogenous steroidal preparations (*Testoviron* and *Ovacyclin*). Besides elaborating the practical utility of steroids in increasing fish yield, the data adds to the available information vis-a-vis the physiological pathways in the body. Little has been done on steroid metabolism in fishes (*Emmersen and Emmersen, 1976; Emmersen *et al.*, 1979; Lone and Matty, 1980a, 1981a).

To understand the detrimental effects of environmental deterioration on ichthyofauna, study envisaging the possible changes in liver condition and nucleic acids of *Puntius stigma* exposed to DDT was designed. DDT is widely used as an effective insecticide, especially in agriculture and vector control programs. By way of surface run-off it enters the
aquatic environment and there are reports of mass mortalities of organisms caused by DDT poisoning. Stability of the pesticide in the medium and body tissues exaggerates the problem. Unfortunately, despite considerable work on DDT-toxicity to fishes (Hatch, 1957; Cope, 1961; King, 1962; Holden, 1962; Allison et al., 1963, 1964; Breidenbach and Lichtenberg, 1963; Johnson, 1963; Burdick et al., 1964; Guerrier et al., 1967; Macek, 1968; Hopkins et al., 1969; Johnson and Pecor, 1969; Willford et al., 1969; Atchison and Johnson, 1975; Jarvinen et al., 1977; Stauffer, 1979) knowledge of biochemical and physiological alterations induced in the body is too fragmentary. The last Chapter(IX) of the thesis tends to fill this vacuum.

Main emphasis of the present work is on liver condition and nucleic acid concentrations of the hepatic tissue.

RNA and DNA were selected because of their pivotal position in protein biosynthesis, metabolism and hence growth of fish. These macromolecules are a key to the changes that occur at cellular level and manifest in a wide variety ways. 'Growth pulses' so characteristic of life history stages of fishes reflect the underlying pattern of protein and nucleic acid turnovers. Notable contributions in the field are reviewed here: DNA concentration in different regions of body musculature and its change in
relation to season were studied in North Sea cod (*Gadus callarias*) by Love (1958). Creelman and Tomlinson (1959) noted changes in RNA and DNA concentrations in different tissues of sockeye salmon, *Oncorhynchus nerka*, at different stages of spawning migration. Seasonally based data on red and white muscles of *Plecoglossus altivelis* and *Anguilla japonica* have been published by Satomi and Ishida (1976) and Satomi and Tanaka (1978a) respectively. Bulow *et al.* (1981) outlined results of their study on seasonal fluctuations in RNA–DNA ratios in bluegill (*Lepomis macrochirus*), and correlated the data with feeding, reproduction, energy storage and condition of life of the fish. The sequence of nucleic acid changes in relation to growth or nutritional status of teleostean fishes has been detailed by Bouche *et al.* (1970), Bulow (1970, 1971, 1974), Luquet and Durand (1970), Satomi and Nose (1971), Satomi (1972), Haines (1973), Bulow *et al.* (1978) and Satomi and Tanaka (1978a,b). Observations on larval fish nucleic acids are also available in the published record. Zeitoun *et al.* (1977) presented information on the turnover of DNA, RNA, protein and free amino acids during ontogenesis of rainbow trout, *Salmo gairdneri*. Buckley (1979a) analysed the nucleic acids of the larvae of winter flounder (*Pseudopleuronectes americanus*) and discussed the utility of RNA–DNA ratio in diagnosis of starving condition. The same author (1979b) also demonstrated the relationship
between RNA-DNA ratio, prey density and growth rate in Atlantic cod (Gadus morhua) larvae. Changes in RNA, DNA and protein contents in Pseudopleuronectes americanus during ontogenesis and in relation to food deprivation were also examined (Buckley, 1980). Recently, Haque (1984) has expressed some new ideas on the nucleic acid dynamics in fry of major carp Cirrhina mrigala supplied artificially formulated diet.

Interest in nucleic acid study on freshwater fishes of India is growing. Jafri and Mustafa (1976) recorded the differences in RNA and DNA concentrations in the dark and white muscles of carp Barbus stigma. Dynamics of RNA and DNA turnover in the two muscle types was thoroughly investigated in catfish Mystus vittatus (Mustafa and Jafri, 1976), and major carps, Catla catla, Labeo rohita and Labeo bata (Mustafa, 1977a). Pattern of RNA and protein variations in murrel Channa punctatus as related to age and growth was documented by Mustafa and Jafri (1977). Quantitative differences in RNA and DNA concentrations in red and white muscles, trunk and tail regions of musculature of teleosts have also been outlined by Mustafa (1978a; Heteropneustes fossilis) and Mustafa and Jafri (1978; Channa punctatus). Mustafa (1979) expressed the relationship between RNA and protein biosynthesis, and that between each of these macromolecules with fillet condition factor in
Channa punctatus. Influence of maturation on nucleic acid concentration of *Clarias batrachus* was examined by Mustafa (1977b). Data pertaining to protein, RNA and DNA in the liver and brain of starved and starved-refed specimens of catfish *Clarias batrachus* was furnished by Mustafa and Mittal (1982a). Mustafa and Shams (1982) studied the heterogeneity in the nucleic acid distribution in heart, kidney, liver and white muscles of catfish *Clarias batrachus*. Distribution of protein, RNA and DNA in alimentary canal of the same species was studied by Mustafa and Mittal (1982b). Mustafa and Zofair (1983) established the relationships of RNA and DNA and specific gravity each of the muscle tissue of *Heteropneustes fossilis* with fillet condition factor. Hague (1984) provided an exhaustive account of the response of nucleic acids in *Cirrhina mrigala* tissue to dietary quality. Mustafa and Mittal (1984) described protein and nucleic acid relations in ripe, unspawned eggs of *Clarias batrachus*, *Heteropneustes fossilis* and *Labeo bata*. An overwhelming number of investigations reviewed above signify the use of RNA/DNA ratio as indicator of recent growth rates, nutritional level and biological condition of fishes.