GENERAL INTRODUCTION
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To meet the growing demand of fishery products, primarily for human nutrition, aquaculture is emerging as a formidable animal industry. Improving dietary standards through production of animal protein is a recognized thrust area of research. Fishes rank first amongst the cultured animals as far as protein yield per unit food intake is concerned. Being poikilothermic, fishes expend less energy in thermoregulation compared to warm blooded farm animals where a major part of feed energy serves to generate body warmth at lower temperature (Tanner and Schmidtborn 1970). According to Van Es (1983) all homeotherm farm animals have a high requirement for maintenance, particularly for energy. In the dairy cattle this requirement equals the energy needed for producing 12 Kg milk. Growing pigs, veal calves and cow of 300 Kg or more utilize about 40, 40 and 60% of the total feed for maintenance, respectively. It is also known that yield per unit labour input in aquaculture exceeds that in other labour intensive enterprises such as poultry, dairy, piggery, etc. There are no such requirements of shelter and daily waste disposal as are seen in domestication of land animals. The cost of running a fishfarm is comparatively lower. The margin of success depends on the technological skill applied, market value and wise use of the aquafood. Supplementing the natural food by artificial diet
is particularly essential for better returns in ponds poor in productivity of natural food items. It enables more economic gains from high stock density culture. Huet (1972) is of the view that excretory wastes of fish population and the unused artificial feed act as excellent manures and increase the production of natural food items. In conventional carp culture the proportion of natural food and artificial feed is ideally 50:50. Feeding trials, however, show that carps thrive fairly well if maintained exclusively on artificially formulated diet in the form of dry concentrates. Whatever may be the proportion of artificial feed it is certain that the profitability of artificial feeding depends on the type of diet supplied. The compounded diets with high acceptability to fish, digestibility and conversion value give better results. In the developing world the predominant problem is one of producing additional animal proteins. In these countries where the population density is very high, competition for food occurs between man and animals. Of course mankind gets priority and the animals suffer. While most of the livestock are supplied conventional foodstuffs like oil cakes and meals fishes being more versatile in their feeding subsist well on non-conventional products. Evidently, fish nutrition is not merely a subject of academic importance insofar as the data on this aspect are badly needed for improving the production of human food from animals. Results of the present study unambiguously indicate the potential of throw-away or
cost-effective products in turning out superior and priced food for human beings. Artificial feeding in pisciculture furnishes a means of upgrading the low grade products. The steep rise in the cost of balanced ration has hit some culture systems and point to the need of utilizing the roughages and the recycling of so-called wastes to run fish farms. A survey of literature bears witness to this quest for cost-effective substitutes by which to formulate balanced diets which are rich in protein and can meet the nutrient requirements of the body. One should not underestimate the present and future need for food as well as global problems of food distribution which aquaculture can alleviate to some extent. What is important is to work to maximize sustained production of high-quality food.

In order to determine whether a particular species can be grown economically one must know its feeding habit and nutritional requirements and the cost of satisfying the same. Fish show a remarkable ability to control body composition and to digest and utilize widely different kinds of food materials. The stomach of fish is generally more extensible and thus permits them to gorge themselves with food. This characteristic is marked in carnivorous fish but not so in others. Carnivorous species are sometimes able to reduce costs by taking advantage of inexpensive foods or a source that is part of food pyramid such as the trash fish. Fish which thrive on food at lower level of food chain
(or pyramid) prove to be more economical because the energy loss at transformation level is lower and further the food items on which they subsist grows at the expense of economical ingredients.

A basic premise in any intensive culture system is to maximize growth at minimum cost, with an end product that is of high nutritive value and aesthetically acceptable to the consumer. Most of the recent work has been directed towards finding low-cost, readily available raw materials as protein sources for fish diets. Influence of diet and protein availability on a variety of fishes have been documented by Paioheimo and Dickie (1966a), Clady (1974), Lewis et al. (1974), Chodorowski (1975), Shelton et al. (1979), Timmons et al. (1980), Foltz et al. (1982) and Tacon et al. (1983). Joseph (1981) substituted chicken droppings as a feed ingredient and obtained positive results. Amongst the various meals fed to salmon fry best performance and feed efficiency was obtained with earthworm powder (Akiyama et al. 1984). Somokhovalova et al. (1982) reported economic viability by feeding sturgeons low value minced fish. Appreciable rise in efficiency occurred in trout fed blood-feather meal (Schulz et al. 1982). Good results have also been obtained with frozen zooplankton fed to sea bream larva Sparus auratus (Kentouri et al. 1981). Feeding beef tallow to Tilapia aurea Stickney and McGechin (1984), rice polish and groundnut oilcake to Indian major carp, Cirrhina mrigala (Sen et al. 1980) gave promising results. Teshima et al. (1984) reared milkfish
Chanos chanos on purified diets containing 35% casein and 15% gelatin as protein sources. Karossi et al. (1983) worked out chemical composition of potential Indonesian agroindustrial and agricultural waste materials for animal feeding. De Silva and Weerakoon (1981) determined the response of grass carp fry provided a mixture of coconut meal and zooplankton. Gropp et al. (1982) evaluated the efficiency of rapeseed, lupine and field bean in trout diet at 5 to 20%. While the latter two can be used up to 20%, the increase in rapeseed proportion declined the growth rate and feed conversion efficiency. Tath et al. (1980) demonstrated the high nutritional quality of intact animal material in diets through Instantaneous Growth Rate, Protein Efficiency Ratio and overall weight gain. Literature survey indicates the need for evaluating different feeds for procurement of more protein from low-cost raw materials. The daily feed intake is variable and for a given species it will depend on the mass ingested and the rate of processing (Brett 1971). Works of Brett and Shelbourn (1975) and Reddy and Shakuntala (1979) reveal the importance of feeding level in nutritional studies.

Temperature is an influential factor. Recent work indicates a direct relationship between environmental temperature and quantitative protein requirements (Delong et al. 1958; Kelso 1972; Weatherley et al. 1979; Wandsvik and Jobling 1982). That the temperature influences the amount of food consumed has been
ascertained by Hathaway (1947), Baldwin (1956), Bridges (1961) and Mollah (1984).

Studies on fish nutrition and bioenergetics are closely related. Physiological energetics concerns the rates of energy expenditure, losses and gains, and the efficiencies of energy transformation, as functional relations of the whole organism. Fish, like other living systems must conform to the laws of thermodynamics. Fish gain matter and energy as food, and they lose absorbed matter and energy as a result of catabolism (which provides energy for maintenance and activity). At any moment in their life the energy expenditure may be either greater or less than the energy content of the food which the fishes consume. This results in either an overall loss, or an overall gain in energy. Bioenergetics is the study of the balance between energy supply in the food and energy expenditure and requires an examination of the physiological processes by which energy is transformed into living organism. If body mass is to be maintained absorbed dietary energy (exogenous sources) must equal the energy loss for maintenance and activity. When exogenous sources exceed these requirements, growth can occur from the deposition of matter, which for fish is largely protein. Growth requires energy inputs, both as the new component of the tissue itself and to sustain the anabolic processes leading to the elaboration of the new tissue components. Successful fish culture depends upon the provision of diets containing an
appropriate balance of nutrients and adequate energy to permit the most efficient growth of fish.

The utilization of all the dietary components depends upon the level of intake and the make-up of the diet. In effect, both the quality and quantity of the diet influence the metabolic partition of the components between storage and catabolism as fuels. Young growing animals require more energy per unit weight than mature animals. The ingestion of food increases metabolic rate as a consequence of extra work due to the ingestion, digestion and utilization of the food. The energy demand must be satisfied before the body uses food for building and maintenance, or regulation. Total energy demand and consequently the necessary quantity of dietary energy required depends on the species. But it is also true that although the composition of the diet may differ, the actual energetic quality may be similar (Keast and Eadie 1985). Estimates of energy requirement should as far as possible be based upon estimates of energy expenditure, whether actual or desirable. Energy requirement has been defined as the amount needed to maintain health, growth and an appropriate level of physical activity.

The importance of energy is evident from the fact that an organism without an energy storage capacity is constantly dependent upon energy flow from its food resource for survival; any significant interruption will result in death (Mackinnon 1972).
Animals tend to eat to satisfy their energy demands. The caloric content of the food will also affect the size of daily ration (Mayer 195, Rozin and Mayer 1961). Studies on energetics have been conducted on various aspects namely, body weight and temperature (Niimi and Beamish 1976: Micropterus salmoides); effects of dietary energy level and dietary energy source on growth, food conversion efficiency and body composition (Adron et al. 1976: Scopthalmus maximus, L.); energy utilization (Phillips 1969); energy costs at different levels of feeding (Soofiani and Hawkins 1982: Gadus morhua); energy metabolism (Elliot 1976, Mills and Forney 1981, Chekunova and Nanmov 1982, Beamish and Legrow 1983, Vetter et al. 1983). Metabolizable energy taken in as food which is not dissipated as heat is retained within the body in the form of new tissue elements. In growing animals part of the retained energy is stored as protein and part as fat. In almost all cases retention of energy and the deposition of new tissue results in an increase in the weight of the animal; and the weight gain of a young animal is usually a reliable indicator of the adequacy of the nutritional and management regimes. The energy cost of growth includes two components: the energy value of tissue or product formed and the energy cost of synthesizing it. The total cost will, therefore, depend upon the composition of the product.

If the intake is either above or below requirement, a change in body energy stores is to be expected unless energy expenditure is correspondingly altered. If changes in energy
expenditures do not occur, the energy store, mainly in the form of adipose tissue, will increase when the intake exceeds requirement and decrease when it is below requirement. Contrarywise, if more body protein is ingested than is needed for metabolic purposes, essentially the excess is metabolized and the end products are excreted, since protein is not stored in the body in the way that energy is stored in the adipose tissue. Thus there are important physiological differences between requirements for energy and protein. For energy, it is usually considered that once a level of body weight and physical activity has been fixed and the appropriate growth rate defined, there is only one level of intake at which energy balance can be achieved. The processes of protein synthesis and possibly of breakdown (turnover) require sources of dietary energy and are thus sensitive to energy deprivation. Consequently, the energy balance of the body becomes an important factor in determining nitrogen balance and influences utilization of dietary protein. It is known that the utilization of dietary protein is influenced by energy intake and notably by energy balance (Calloway 1954, 1975 as quoted from WHO technical report 1985, Munro 1951 as quoted from WHO technical report 1985 and Munro 1964). It has been demonstrated by Garza (1976 as quoted from WHO technical report 1985) and Iyengar (1979, 1981 as quoted from WHO technical report 1985) that at any given level of dietary protein, addition of energy improves nitrogen
balance until the response reaches a plateau, which represents the limitations imposed by dietary protein level. The effect of energy balance can be extended further by raising the protein intake. The influence of energy balance on nitrogen equilibrium extends from suboptimal up to excess levels of energy intake, so that any change in energy intake above or below the fish's need is likely to influence its nitrogen balance. Mitchell (1934) commented that when properly balanced with other foods, distinctive nutritive properties of an individual foodstuff would be entirely submerged in a resultant optimum combination, and except for the differences in digestibility the net energy value of all perfectly balanced rations is the same under same conditions of feeding. Various authors have worked on the effect of different protein and energy levels on the conversion efficiency in fishes (Shimeno et al. 1980; Eckhardt et al. 1981, 1983; Takeuchi et al. 1981a,b; EL-Dakour 1982; EL-Dakour and Khamis 1982; Schwarz et al. 1983; Zeiller et al. 1983). The protein requirement is tied to the general energy requirement at a given water temperature and the fish's ability to gain weight, at its inherent capacity. Some workers (Reinitz et al. 1978; Takeuchi et al. 1979; Watanabe et al. 1979) have expressed dietary protein levels as the reciprocal of the protein:energy ratio; i.e., the energy content per unit weight of protein, but this can not be recommended for general use since it implies that food intake is regulated by monitoring dietary protein rather than dietary energy control.
Phillips (1969) has suggested that 70% of dietary calories in trout feed is from protein, thus a greater percentage of dietary protein is metabolized for energy rather than utilized for body protein synthesis. Platt et al. (1961 as quoted from WHO technical report 1985) were largely responsible for the introduction of ratio of protein energy to total energy as a convenient and useful description of one aspect of dietary quality in human nutrition. It must be recognized that the concentration of all necessary nutrients should be considered while assessing the adequacy of a particular diet. It is inappropriate to consider protein and energy alone. Ultimately, the object of studies on dietary protein/energy relationships is to obtain estimates of the concentration of protein relative to that of energy, which could be recommended for diets designed to allow rapid growth. Digestibility appears to be the most important factor determining the capacity of the protein sources on a usual mixed diet to meet the protein needs. The available energy of a food determined as intake minus losses, is not the same as its true digestibility. The actual digestibility can be approximated by measuring the fecal energy loss in the absence of food (endogenous loss) and subtracting the value from the fecal loss in the presence of food. The effectiveness of diets formulated upon the basis of the digestibilities of the nutrients and energy in the component feeds can be evaluated by observing weight gain, feed efficiency and body composition of fish receiving the diets under particular culture regimes. The digestible energy
content of a diet will vary depending on its composition and the test species used in the digestibility trial. Differences in digestibilities may arise from intrinsic differences in the nature of food protein, the presence of other dietary factors which modify digestion, and chemical reactions that alter the release of amino acids from proteins by enzymatic processes. The digestibility coefficients most commonly applied are 90% for protein, 85% for lipid and 40% for carbohydrate (Phillips 1972). Factors affecting the digestibility must be examined in order to assess the degree of error likely to be introduced by use of 'standard' digestibility coefficients. Fat digestibility values for rainbow trout Salmo gairdneri range from 61 to 97% depending upon the source of the fat (Cho and Slinger 1979) and a range of 76 to 97% digestibility for various fats has been reported for channel catfish Ictalurus punctatus (Lovell 1977). In addition, the ability of channel catfish to digest fat appears to be influenced by temperature and the level of fat in the diet (Andrews et al. 1978). The digestibility of carbohydrate has been shown to vary with the complexity, source, treatment and level of inclusion in the diet (Singh and Nose 1967, Smith 1971, Cowey and Sargent 1972, Phillips 1972, Lovell 1977, Cho and Slinger 1979). In addition, there are intraspecific differences in the abilities of fish to digest and absorb carbohydrates. Digestibility of protein varies considerably depending upon the source, e.g.: protein digestibility values of 40-96% were reported for various sources fed to rainbow
trout (Cho and Slinger 1979, Jobling 1983). Austreng and Refstie (1979) compared different families of rainbow trouts and found remarkable differences in digestibility of protein, when dietary protein level was below 30%. These differences diminished when dietary protein level was increased. Further investigations are necessary to clarify the extent to which non-nitrogenous feed components affect the digestibility of protein. Whereas starch was found by Inaba et al. (1963) and Kitamikado et al. (1964b) to retard protein digestibility, no such effect was found by Rychly and Spanhof (1979). Dietary fat seems to have no influence on digestibility of protein (Kitamikado et al. 1964a,b).

Growth of fish is directly dependent on the intake and balance of the 10 indispensable amino acids contained in the protein component of the diet (Halver et al. 1957, 1959; Harper 1958). When only one or two amino acids are used to supplement a protein, then these amino acids will be assimilated much more rapidly by the fish than those linked by peptide bonds in the body protein. Future improvements in fish diets will stem from integration of economically available amino acid sources. It should be known that protein generally constitutes the bulk of the diet and is usually the most expensive component to supply. According to Cowey (1975) dietary protein level is not very different for a number of species and a value of 40% would cover most species. However, De Silva and Perera (1985) observed
consistently better growth of young *Tilapia nilotica* on 28-30% protein diets. Differences in the nutritional value of food proteins were recorded even at high protein intake (Ogino and Chen 1973, Cowey *et al.* 1974, Cowey 1975). These differences must be due to the greater requirement of amino acids by fish. When growth is occurring, not only is there a net deposition of protein, but the rates of both synthesis and breakdown are increased (Millward *et al.* 1975 as quoted from WHO technical report 1985; Golden *et al.* 1977 as quoted from WHO technical report 1985; Pencharz *et al.* 1977 as quoted from WHO technical report 1985). The rates of turnover vary from tissue to tissue, and the relative contributions of different tissues to total protein turnover change with age and adaptation to various levels of protein intake (Waterlow 1968 as quoted from WHO technical report 1985; Young *et al.* 1968 as quoted from WHO technical report 1985; Uauy *et al.* 1978 as quoted from WHO technical report 1985). The amino acids released by breakdown are allocated for protein synthesis. The daily turnover of body proteins is in fact several fold greater than the amino acid intake, showing that the utilization of amino acids is a major contributory factor to the economy of protein metabolism (Waterlow 1978). Elaborate work on protein requirement has been carried out on gilthead bream *Chrysophrys aurata* (Sabant and Luquet 1973), young ayu *Plecoglossus altivelis* (Arai and Nose 1983), channel catfish *Ictalurus punctatus* (Lovell 1972),

Protein metabolism contrasts with carbohydrate and fat metabolism in that when a surfeit of protein is ingested there is no form or organ in which protein may be stored in major quantities. The actual task of the protein is to build up the body's own protein substance. In this function they may be replaced by no other nutrient and they are vital for the body. Muscles, organs and blood consist essentially of protein. It is, therefore, understandable that especially the young organism which is still growing has a high protein requirement. Quality and quantity of dietary protein strongly influence growth rate of fishes. Increase of dietary lipid proportion in the diet has been shown to spare some dietary protein from energy utilization for use in growth (Millikin 1982b). Reduced cost of diets may occur if some lipid can be replaced with carbohydrate on a gram-for-gram basis without loss in protein sparing action (Millikin 1983).
A fairly good number of experiments indicate that although the major percentage change in the body components occurring during growth involve water and lipid in a way that reflects an inverse relationship between them, protein can change in a pattern that is related both to lipid and to water (Brett et al. 1969; Groves 1970; Love 1970; McComish 1974; Elliot 1976; Craig 1977). Such interrelations in biochemical components have been elaborated in this thesis.

The unprecedented interest in protein synthesis is the result of rapidly advancing knowledge of the chemistry and metabolism of nucleic acids. It is just appropriate that reviews on nucleic acids bear mention of protein biosynthesis. Nucleic acids contain the necessary information to direct the synthesis of new and genetically specific protein. DNA manifests its genetic function primarily by carrying the information for determining the amino acid sequence in the various proteins of the cell. The code for the determination of the sequence is represented by non overlapping nucleotide triplets in the DNA molecule. The DNA's message is carried to the cytoplasm by messenger RNA (m-RNA) and protein synthesis is executed by involvement of ribosomal RNA (r-RNA) and transfer RNA (t-RNA). The formation of m-RNA from DNA is called 'transcription' whereas the term 'translation' is applied for the process ultimately leading to the production of polypeptide chains.
Studies on fish nucleic acids show a definite relationship between RNA, DNA and growth rate. Growth is accompanied by an increase in RNA and a decrease in DNA. Earlier investigations by Leslie (1955) and Bulow (1970) leave no doubt that RNA concentration reflects the level of metabolic functions of a tissue. Since DNA is normally located in the nucleus and is present in constant amount in each diploid somatic cell, it is evident that the concentration of DNA per unit weight will be high in tissues with little cytoplasm and extracellular material and low when their proportions are relatively larger (Leslie 1955). Although variations in actual amount of DNA in the individual somatic cell can not entirely be ruled out, the differences that occur in the DNA concentration, can be attributed to other factors such as the number of cell/unit weight of tissue and polyploidy. Tissues with larger number of cells in a given weight and with higher degree of ploidy are known to yield greater concentrations of DNA (Leslie 1955; Mustafa 1978). Vendrely (1955) documented that frequency of polyploid cells and degree of polyploidy of individual cells in a tissue are related to metabolic activity. According to Love (1970) when fish doubles its body length the number of cells are halved and the DNA concentration is also expected to reduce similarly. This is so because growth in body length of fish is known to proceed through increase in the sizes of muscle cells rather than their number. Besides this the depletion of cellular
constituents is also understood to cause shrinkage of the cells (Love 1970), which in turn brings the cell nuclei into greater proximity. Therefore, it is quite logical to expect that the increase in the concentration of nuclei (the storehouses of DNA) also increases the DNA concentration per unit weight of the tissue. From the foregoing discussion it becomes evident that alterations in DNA concentration in a given weight of tissue can be used to provide information about changing masses of cells, and can be applied for determining the degree of depletion suffered by the body tissues under various conditions such as maturation and fasting. Earlier investigations (Hawk et al. 1954, Hotchkiss 1955, Leslie 1955, West and Todd 1963) documented that the quantity of DNA in individual cells does not actually change with changes in physiological states like feeding, fasting, etc. Perhaps some synthesis of DNA occurs during growth of muscle cells. Indeed, this DNA synthesis in the cell may be a necessity to control the increasing amount of cytoplasm during growth in cell volume (Love 1953). Since cytoplasm is the site of profound turnovers of various metabolic substances, it may be possible that the process of depletion during maturation besides affecting the other organic and inorganic substances of the cells does not spare the RNA. Observations of Brachet (1955), Leslie (1955) and Bulow (1970) on the decline of RNA during starvation and increase during feeding, especially the protein rich diets, emphasized that food deprivation
which accompanies maturation of fish exerts the most powerful influence upon the concentration of RNA in the tissue. Inasmuch as the RNA concentration of the body tissues is known to be related to the amount of food intake (Leslie 1955), the increase in the concentration of RNA during growth of fish appears to be the result of increasing consumption of the food. The increase in food utilization during growth in early life is necessary to meet the enhancing metabolic demands of the fish. Insofar as the period of most rapid growth of fish occurs in the pre-maturity stage, the increase in the level of RNA is an absolute necessity for an active protein synthesis which is mainly responsible for accomplishing the fish growth (Bulow 1970). A major advantage of RNA measurement is that it could be used to assess growth rate occurring at a given time and would not necessarily require periodic measurements to compare levels and detect changes. In rapidly growing organisms, RNA quantities are high. Any factor that prevents or slows growth is reflected by a reduction in RNA (Buckley 1979, 1982, 1984; Martin et al. 1985). Temperature influences concentration of this nucleic acid (Buckley 1982, 1984; Buckley et al. 1984). Coutant (1985) found out for young juvenile an optimum temperature of 26°C. Buckley (1980) has shown that as long as nutritional requirements are met, the RNA-DNA ratio increases with temperature until the thermal optimum is attained. Lowering environmental temperature may affect feeding activity or
cause a decrease in protein assimilation efficiency of the body to a level unmatched by its mobilization. Since the amount of DNA is constant per cell within a species the ratio of RNA to DNA is indicative of the amount of RNA per cell (Hotchkiss 1955). This ratio is considered a more accurate index of metabolic activity than RNA concentration alone inasmuch as it is not affected by differences in cell numbers. Individuals with high RNA-DNA ratios can be imagined to actively synthesize and accumulate protein and grow faster than the ones with low ratios and stunted growth. Buckley (1979) expressed the view that though the RNA-DNA ratios reflect the past feeding levels of fish, these are in fact to some extent determined by the pre-sampling nutritional status itself, but it can not be said with greater certainty whether the effect of nutritional success on growth rate is actually mediated or simply accompanied by a change in RNA:DNA ratio. Bulow (1970) demonstrated that quantitative determination of RNA and DNA can be used as biochemical indicators of growth of fishes. That RNA:DNA ratio and growth rate are significantly correlated has been evaluated by various authors (Bulow 1974, 1975; Haines 1973; Satomi 1978; Wilder and Stanley 1983). The RNA:DNA ratio provides an indication of how well a fish is feeding, synthesizing protein and presumably growing at the time of sampling. It is necessary to understand the internal environment of the fish before applying the RNA/DNA ratio method for its conventional purpose. Bouche(1975)
has reported decrease in levels of messenger, transfer and ribosomal RNAs in carp liver during winter. Evidently, the little quantity of nutrients entering the body fail to meet the maintenance requirements, needless to say to provide for storage in liver. Protein stability strengthens the view that the fish prefers accumulation of nutrients other than protein. In winter the RNA meets the same fate as other cytoplasmic inclusions and hence its concentration declines. While these changes are taking place little increase in protein 'dilutes' the DNA but this can be attributed to the gravimetric adjustments of constituents in unit weight of tissue. Possibility of an actual breakdown of DNA can be ruled out. Changes in the external environment are accompanied by reversal of some pathways in the internal environment of fish. Food intake must increase and perhaps the efficiency of protein synthesis from raw materials in the diet enhances to sustain growth process. Macromolecular composition is extremely sensitive to feeding level (Bulow 1970, Buckley 1979, 1980). The published information leaves no doubt on the close relation between the amount of food consumed and RNA levels of tissues (Brachet 1955; Leslie 1955; Bulow 1970, 1971; Mustafa 1977b; Buckley 1979, 1980; Mustafa and Mittal 1982a). If the views of Love (1958) and Mustafa (1977a, 1978) are given credence, epigenetic DNA synthesis must be considered for controlling the volume of cell cytoplasm growing due to accumulation of larger quantities of RNA, etc. The interactions between RNA, DNA and protein have been
documented by previous authors, notably Mustafa and Jafri (1977, 1979), Mustafa (1979), Mustafa and Vitial (1982a,b; 1984), Emmerson and Emmerson (1976) and Hurton and Nilsson (1980). Earlier studies (Bolow 1970; Buckley 1979, 1980) furnishing data on rise in both RNA and protein concentrations of fish tissues with increasing feeding rate, focus on RNA as template and organizer for protein biosynthesis, leaving no doubt concerning decrease in potential maximum rate of protein synthesis and limitation of cellular growth as consequences of its loss from cells. The energy harnessed from protein is used for the various maintenance requirements. For example, during starvation protein catabolism has been known to occur in larval plaice Pleuronectes platessa (Ehrlich 1974a), herring Clupea harengus (Ehrlich 1974b) and winter flounder Pseudopleuronectes americanus (Buckley 1980). The fact that RNA content of cells is determined by protein level of the diet (Brachet 1955, Leslie 1955, Mustafa and Jafri 1977), the supply of protein-free diet or a complete cessation of feeding actively effecting a decrease in RNA is more than likely.

Within certain (normal) limits the relative liver weight (more precisely, the liver weight:body weight ratio) is an index of the nutritional condition or health of an organism. Abnormally low proportion indicates stress and poor condition. Large liver, high liver weight:body weight ratio, greater liver RNA:DNA ratio could indicate healthy, well-fed, rapidly growing fish. According
to Love (1970) decreased liver DNA could be due to large amounts of other constituents such as lipid, and the same author explains that the low protein in muscle indicates severe depletion.

To know the relation between RNA, DNA and nutritional status of the fish, the biochemical aspect of the work was specifically included in the protocol of this study. The results obtained prove conclusively that response of RNA and DNA concentrations to dietary formulations is different in fry and fingerlings and that under a wide range of conditions the nucleic acid data can be applied to ascertain short-term changes in growth and protein composition of fish tissues. When several types of dietary components are tried on fish the nucleic acid technique proves more useful in finding out the relative performance of compounded rations. Feedstuffs of both plant and animal origin were selected for the present study. The former category included mustard oil cake, linseed oil cake, cotton seed, water hyacinth, wheat bran, sugarcane roughage and the second category comprised frog offal, fish offal, raw slaughter house waste, paddy pest (Hieroglyphus) meal, blood meal and egg shells. Some of these products are considered outright waste and the others are available at economic rate. Potential of many of these ingredients in fish nutrition is indeed encouraging. That the approach of work is need-based is obvious from the surge of interest in recent years in collecting, tabulating, storing and retrieving information about least-cost
feeds on global scale.

A wide range of experimental design and methodology employed in fish nutrition studies makes difficult the comparison of results obtained by various research groups and the realistic interspecific comparisons are almost impossible. It is important that limitations of comparison between experiments are taken note of in advance and effort made to avoid any problem in selecting a diet. At the behest of research oriented bodies in India a project was initiated in collaboration with the United Nations Development Programme and Food and Agriculture Organization to assist in the elaboration of diets on nutritional requirement of cultivated carps. The programme was started for determining their amino acid requirements and analysis of amino acid concentrations of locally available dietary ingredients. The International Network of Feed Information Centres (INFIC) contributes to more efficient animal production throughout the world by improving access to reliable information on the composition, nutritive value and practical use of feeds for animals. Some of the basic problems in the application of the technology include the standardization of feed nomenclature, their chemical and biological characterizations, communication and application of feed values to improve production for the end users. INFIC can play a leading role in providing a nomenclature, through standardized international feed numbers, descriptors, coding, recording and data processing of feed. Many countries have already joined INFIC and
benefits must accrue through the knowledge and application of feeds which would greatly enhance production (Ranjhan 1985). Accurate prediction of fish growth is essential in scientific management of any fishery. The extensive studies carried out earlier on feeding relations with temperature, body size, metabolism and growth clearly show the complexity of the system underlying measurements of growth efficiency. The problem of adequate feed supply continues to be one of the major constraints to animal production particularly in many developing countries. This study was designed to formulate practical diets for fishes using certain non-conventional ingredients and to know their performance.

Different species of freshwater teleosts including carps (Cyprinus carpio and Cirrhina mrigala), catfish (Heteropneustes fossilis) and murrel (Ghanna punctatus) formed the basis of the present experiments. These fishes are commercially most important and constitute capture as well as culture fisheries of fairly good magnitude in Indian sub-continent.