REVIEW OF LITERATURE

2.0 REVIEW OF LITERATURE

Earliest works pertaining to the efficacy of formulated feeds prepared from plant wastes, animal wastes, probiotics, medicinal herbs and veterinary growth promoters on growth, nutritional indices and feed utilization efficiencies of Indian major carp, *Catla catla* are reviewed and presented in this chapter.

2.1 PLANT AND ANIMAL WASTES SUPPLEMENTATION

Fowler *et al.* (1991) found out the effects of dietary supplementation of poultry by-product meal on growth performance, food conversion and body composition of fall Chinook salmon, *Oncorhynchus tshawytcha*. Keembiyehetty and Desilva (1993) noted the performance of juvenile *Oreochromis niloticus* L. reared on diets containing cowpea, *Vigna catiang* and black gram, *Phaseolus mungo* seeds. Abdel-Fattah and EL-Sayed (1994) evaluated soybean meal, *Spirulina* and chicken offal meal as protein sources for the replacement of fish meal for silver seabream (*Rhabdosargus farba*) fingerlings. Josman (1994) conducted an experiment to determine the effect of chicken intestine as a supplementary protein source on growth and feed utilization efficiency for potential murrel culture.

Water, protein, lipid, carbohydrate and ash contents in relation to body weight were studied in an air breathing fish, *Anabas testudineus* (Bloch) by Kumar *et al.* (1995). Gomes (1995) carried out an experiment to estimate the digestibility and growth performance for a number of ingredients of plant and animal origin in rainbow trout (*O.mykiss*). Gallaghar and LaDouceur (1995) analysed

the partial replacement of fish meal by the use of blood meal and poultry by-products in the diets for juvenile palmetto bass *(Morone saxatilis X M.chrysops*). Efficiency of dietary lipid levels on the growth, feed conversion and muscle composition of the walking catfish, *Clarias batrachus* was reported by Anwar and Jafri (1995).

Influence of dietary lipid levels on the growth and body composition of fingerlings of an Indian major carp *Cirrhinus mrigala* was analysed by Jafri *et al.* (1995). Mukhopadhyay and Ray (1996) tested the potential of deoiled sal (*Shorea robusta*) seed meal as a feed stuff in pelleted feed for Indian major carp, rohu, *Labeo rohita* (Hamilton) fingerlings. Nutritional requirements of Indian major carp, *L.rohita* and the effects of dietary lipid on growth, food conversion and body composition was reported by Hosan *et al.* (1996). Webster *et al.* (1997) conducted a feeding trial with juvenile channel catfish, *Ictalurus punctatus* to examine the effects of partially substituting canola meal for soybean meal in prepared diets.

Effect of dietary inclusion of cattle dung based biogas plant-effluent in the muscle, brain and liver tissue composition of rohu (*L.rohita*) was analysed by Gopal *et al.* (1997). Lin *et al.* (1997) found out the effect of feeding strategy and carbohydrate source on carbohydrate utilization by white sturgeon (*Acipens transmontanus*) and hybrid tilapia (*O.niloticus* X *O.aureus*). Effect of varying protein and lipid levels on the growth of rohu, *L.rohita* was assessed by Gangadhar *et al.* (1997). Effect of feeding *Artemia* enriched with stresstol and cod liver oil on growth and stress resistance in the Indian white shrimp, *Penaeus indicus* postlarvae was investigated by Citarasu *et al.* (1998).

Eusebio and Coloso (1998) used leguminous seed meals and leaf meals as a plant protein sources and evaluated their effect on growth performances in juvenile *P.indicus*. Apparent protein digestibility and mineral availabilities in various feed ingredients for salmonid feeds were reported by Sugiura *et al.* (1998). Research was carried out in the effect of phytoplankton, cornmeal and corn starch diets on growth performance and biochemical composition of the seed of little neck clam, *Ruditapes decussatus* by Camacho *et al.* (1998).

Mukhopadhyay and Ray (1999) studied the efficacy of incorporation of raw and fermented sesame (*Seasamum indicum*) seed meal into a fish meal based diet for rohu, *L.rohita* fingerlings on growth performance and feed utilization efficiency. Nutritional studies on common carp, (*Cyprinus carpio*) fed diets containing unheated and heated *Jatropha curcas* meal of a non-toxic provenance was reported by Makkar and Becker (1999). Dietary impact of algal and lipid supplementation at different feeding rations on the growth and fatty acid composition of juvenile clams, *Tapes philippinarum* was investigated by Caers *et al.* (1999). Chamundeswari *et al.* (1999) analysed the efficacy of soybean meal (*Glycine max*) on the biochemical composition of *L.rohita* fingerlings.

Comparative evaluation of heat processed winged bean (*Psophocarpus tetragonolobus*) meals as a partial replacement for fish meal in diets for the African catfish *(C.gariepinus*) was carried out by Fagbenro (1999). The feasibility of replacing fish meal protein with a high quality poultry meat meal was assessed in diets for gilthead seabream, *Sparus aurata* L. by Nengas *et al.* (1999). Efficacy of diets with the inclusion of hempseed meal, poultry by-product meal and canola meal for the replacement of

fish meal in practical diets for sunshine bass (*M.chrysops x M.saxatilis*) was evaluated by Webster *et al.* (2000).

Siddhuraju and Becker (2001) conducted a feeding trial to assess the potential nutritive value of mucuna seed meal as a dietary replacement for fish meal in practical diets of common carp *C.carpio*. Evaluation of an unconventional legume seed, *Sesbania culeate*, as a dietary protein source for common carp, *C.carpio* L. was carried out by Hossain *et al.* (2001). Lim *et al.* (2001) found out the dietary palm oil effects on growth performance, protein retention and tissue vitamin E concentration of African cat fish, *C.gariepinus*. Mbahinzireki *et al.* (2001) identified the suitability of cottonseed meal as a major source of plant protein in feeds for tilapia (*Oreochromis* sp.) by examining growth, feed utilization and mineral composition.

Nandeesha *et al.* (2001) studied the growth performance of two Indian major carps, *C.catla* and *L.rohita* fed diets containing different levels of *Spirulina platensi*. Potential of long term protein and lipid on growth of Atlantic salmon (*Salmo salar*) fed diets with partial replacement of fish meal by soy protein products at medium or high protein lipid levels was evaluated by Refsite *et al.* (2001). Borlongen *et al.* (2002) found out the potential of feed peas (*Pisum sativum*) as an alternative protein source in practical diets for milkfish (*Chanos chanos*).

Efficacy of rapeseed and cottonseed meal as the component ingredients in diets for fingerlings African cat fish, *C.gariepinus* and the growth and biochemical composition was determined by Davies *et al.* (2002). Vielma *et al.* (2002) reported dephytination of soy proteins increased phosphorus and protein utilization in rainbow

trout, *O.mykiss*. Effect of carbohydrate rich diets for the replacement of fish meal through common carp culture in manured tanks was investigated by Keshavanath and Jegadese (2002). Davis *et al.* (2002) analysed the nutritional value of feed peas, *P.sativum* in the practical diet formulations for *Litopenaeus vannamei*.

Millamena (2002) conducted an experiment to investigate the replacement of fish meal by animal by-product meals in a practical diet for grow out cultures of grouper, *Epinephelus coioides*. Gonzalez-Felix *et al.* (2002) investigated the enhanced growth, survival and fatty acid composition in juvenile *L.vannamei* fed with supplemented diets containing different oils in the presence and obsence of phospholipids. Raso and Anderson (2002) analysed the effect of dietary fish oil replacement on growth and carcass proximate composition of juvenile barramundi (*Lates calcarifer*).

The suitability of soybean or corn lecithin and poultry fat as partial replacements for menhaden oil on the body composition, growth performance and product quality of rainbow trout (*O.mykiss*) was investigated by Liu *et al.* (2002). Potential of meat meal to the replacement of fish meal in extruded dry diets for barramundi, *Lates calcarifer* was determined by Williams *et al.* (2003). The effect of varying dietary levels of soybean meal for the partial or total replacement of fish meal on the growth and body composition of rohu *(L.rohita*) was determined by Khan and Jafri (2003). Weatherup *et al.* (2003) studied the effect of dietary fat content on growth performance and body composition of farmed rainbow trout (*O.mykiss).*

Forster *et al.* (2003) used rendered meat and bone meal in the diets for shrimp, *L.vannamei* and analysed for their effect on growth performance, biochemical composition and survival. Fotedar (2004) evaluated the effect of fish and plant protein and lipid source on the growth, survival, condition indices and body composition of marron, *Cherax tenuimanus* (Smith). Fournier *et al.* (2004) tested the incorporation of a mixture of plant feed stuffs as substitute for fish meal in diets of juvenile turbot, *Psetta maxima.*

Hybrid striped bass (*M.chrysops* X *M.saxatilis*) fed with animal, blended and plant feed stuffs for the replacement of fish meal and growth performance was studied by Gaylord *et al.* (2004). Muzinic *et al.* (2004) conducted three feeding studies to evaluate the effects of total replacement of fish meal with a combination of soybean meal and brewer's grains with yeast in diets for two separate strains of juvenile Australian red claw cray fish, *Cherax quadricarinatus*. Replacement of fish meal by plant protein sources in the diet of a marine teleost, the European seabass, *Dicentrarchus labrax* was studied by Kaushik *et al.* (2004).

Theissen *et al.* (2004) assessed the digestibility and growth performance of juvenile rainbow trout *O.mykiss* fed with pea and canola products for the replacement of fish meal. The potential use of defatted soybean meal (roasted and solvent-extracted) as a partial replacement of fish meal in the isonitrogenous diet for juvenile cobia, *Rachycentron canadum* was analysed by Zhou *et al.* (2005). A feeding trial was conducted by Usman *et al.* (2005) to examine the effects of partially replacing fish meal in diets with poultry offal meal (viscera) on growth performance of humpback grouper, *Cromileptes altivelis*.

The use of meat and bone meal was evaluated as replacement of fish meal in the practical diets for the white shrimp *L.vannamei* (Boone) by Tan *et al.* (2005). Incorporation of maize gluten in the supplementary feed and its impact on growth and flesh quality of *C.catla*, *L.rohita* and *C.mrigala* was studied by Kaur and Saxena (2005). The effects of artificial diets on growth, survival and body composition of adult cuttlefish, *Sepia officinalis* Linnaeus were tested by Domingues *et al.* (2005). Campano-Torres *et al.* (2005) evaluated the dry matter and protein digestibility of three plant derived (soy paste, textured wheat and sorghum meal) and four animal derived (two sardine meals, squid meal and red crab meal) feed stuffs in the diets for juvenile Australian red claw, *C.quadricarinatus.*

Zhang *et al.* (2006) conducted a growth trial in flow-through system with juvenile gibel carp, *Carassius auratus gibelio* to evaluate the effects of gradual replacement of fish meal by meat and bone meal on growth performance, nitrogen and phosphorus loading. Bonaldo *et al.* (2006) determined the effect of dietary incorporation of soybean meal on growth performance, nutrient utilization and gut histology of Egyptian sole, *Solea aegyptiaca* juveniles. Effects of soybean meal based diet on growth performance, histology of the intestinal epithelium and on the gut microbiota of juvenile rainbow trout (*O. mykiss*) were investigated by Heikkinen *et al.* (2006).

Dongmenza *et al.* (2006) found out the effects of dehydrated methanol extracts of moringa (*Moringa oleifera* Lam.) leaves and three of its fractions on growth performance and feed nutrient assimilation in Nile tilapia (*O.niloticus*). Deng *et al.* (2006) carried out an experiment to study the effect of replacing fish meal with soy protein concentrate on feed intake and growth of juvenile Japanese

flounder, *Paralichthys olivaceus.* Shamsi *et al.* (2006) investigated the effects of live foods and combination of both types (live and artificial food) on growth, feed utilization efficiency and survival of Nile tilapia, *(O.niloticus*) fry.

The nutritional response of large mouth bass (*Micropterus salmoides*) to replacement of fish meal by poultry by-product meal on the growth, tissue composition and haematological parameters was evaluated by Subhadra *et al.* (2006). A growth experiment was conducted to investigate the effects of dietary supplementation of meat and bone meal on growth and body composition of large yellow croaker (*Pseudosciaena crocea)* by Qinghui *et al.* (2006). Guo *et al.* (2006) investigated the effect of dietary cornstarch levels on growth performance, digestibility and microscopic structure in the white shrimp, *L.vannamei* reared in brackish water.

Growth and economic performance of Nile tilapia (*O.niloticus L.)* fed on three brans (maize, wheat and rice) in fertilized ponds were evaluated by Liti *et al.* (2006). Borgeson *et al.* (2006) examined the effect of replacing fish meal with simple (soybean and maize gluten meal) or complex (soybean meal, maize gluten meal, dehulled flax, pea and canola protein concentrate) mixtures of vegetable ingredients in diets fed to Nile tilapia (*O.niloticus*). Muzinic *et al.* (2006) used turkey meal as partial or total replacement of fish meal in practical diets for sunshine bass (*M.chrysops X M.saxatilis*) grown in tanks and evaluated the growth and body composition.

The effect of solvent extracted cottonseed meal as a partial or total replacement of fish meal was studied by Luo *et al.* (2006) in juvenile rainbow trout (*O.mykiss*). A feeding trial was carried out by

Goda *et al.* (2007) to examine complete and partial replacement of fish meal with poultry by-product meal, meat and bone meal and soybean meal in practical feeds for African catfish, *C.gariepinus*. Effects of dietary substitution of soybean meal for fish meal on consumption, growth and metabolism of juvenile giant fresh water prawn, *Macrobrachium rosenbergii* was studied by Du and Niu (2007).

Hernandez *et al.* (2007) studied the possible use of soybean meal in sharp snout sea bream (*Diplodus puntazzo*) diets by progressively increasing its inclusion level at the expense of fish meal in isonitrogenous and isoenergetic formulated diets. Piedecausa *et al.* (2007) determined the impact of dietary replacement of fish oil by vegetable oils on sharp snout sea bream, *D.puntazzo* growth and body composition. A feeding trial was carried out to investigate the influence of three palm oil products as the principal dietary lipid source on the growth performance, proximate composition, tissue fatty acid composition and nutrient digestibility of red hybrid tilapia, *Oreochromis* sp. (Bahurmiz and Keon, 2007). Effect of wet-incubation of dietary plant feed stuffs with phytases on growth, mineral digestibility and mineral deposition in common carp *C.carpio* was evaluated by Nwanna *et al.* (2007).

Potential of using rendered animal ingredients, poultry by-product meal, meat and bone meal, feather meal and blood meal to replace fish meal in practical diets for cuneate drum, *Nibea miichthioides* was examined by Guo *et al.* (2007). A feeding experiment was carried out by Peng *et al.* (2008) on juvenile black seabream, *Acanthopagrus schlegeli* to evaluate the effects of dietary replacement of fish oil by soybean oil on fish growth and liver

biochemical composition. Toko *et al.* (2008) analysed the effect of increasing levels of dietary soybean meal and cotton seed meal on growth and body mineral composition of juvenile African catfish, *C.gariepinus.* A feeding experiment was conducted to assess the potential of using a blend of poultry by-products meal, meat and bone meal, feather meal and blood meal to replace fish meal in practical diets for malabar grouper, *E.malabaricus* (Wang *et al.*, 2008).

The effect of partial replacement of fish meal by rendered animal protein ingredients (Poultry by-product meal and meat and bone meal) alone or in combination with lysine and methionine supplementation in practical diets for gibel carp was studied by Hu *et al.* (2008). Effect of apidaecin on common carp, *C.carpio* based on growth performance, feed utilization and immune parameters were investigated by Zhou *et al.* (2008). Tran-Duy *et al.* (2008) explained the effects of dietary starch and energy levels on maximum feed intake, growth and metabolism of Nile tilapia, *O.niloticus*.

Sicuro *et al.* (2009) evaluated the efficiency of olive oil by-product as a natural antioxidant in gilthead sea bream (*Sparus aurata*) feeds. Wassef *et al.* (2009) determined the impact of dietary replacement of fish oil by vegetable oils on gilthead seabream (*S.aurata*) growth performance, nutritive utilization, body composition and fatty acid profile as well as feed cost.

2.2 PROBIOTICS SUPPLEMENTATION

Sugita *et al.* (1990) observed the vitamin B12 producing ability of intestinal bacteria isolated from tilapia and channel catfish. Siwicki *et al.* (1990) reported oral administration of yeast products *Candida utilis* and *Saccharomyces cerevisiae,* which give rise to enhanced phagocytic activity of blood leukocytes in rainbow trout, *O.mykiss*. Gatesoupe *et al.* (1991) conducted a feeding trial to study the effect of the different strains of lactic acid bacteria on the production rate of rotifers, *Brachionus plicatilis* and their dietary value for larval turbot, *Scopthalmus maximus*. Noh *et al.* (1994) found out the effect of antibiotics, enzyme, yeast culture and probiotics on the growth performance and survival of Israeli carp.

Growth and survival of Atlantic salmon, *S.salar* fry given diets supplemented with fish protein hydrolysate and lactic acid bacteria during a challenge trial with *Aeromonas salmonicida* was estimated by Gilberg *et al.* (1995). Pilet *et al.* (1995) showed the evidence for two bacteriocins produced by *Carnobacterium piscicola* and *C.divergens* isolated from fish and active against *Listeria monocytogenes.* Probiotic effect of lactic acid bacteria in the feed on growth and survival of fry of Atlantic cod, *Gadus morhua* was assessed by Gilberg (1997). Suyanandana *et al.* (1998) isolated new probiotic *Lactobacilli* and *Enterococci* from fish intestine and studied their effect on fish production.

The use of a potential probiotic *L.lactis* AR21 strain for the enhancement of growth in the rotifier *Brachionus plicatilis* (Muller) was suggested by Harzevili *et al.* (1998). Itami *et al.* (1998)

examined the potency of oral administration of peptidoglycan derived from *Bifidobacterium thermophilum* to kuruma shrimps on survival and immunity. Effects of supplementing the feed to Atlantic cod (*G.morhua)* fry with lactic acid bacteria and immunestimulant peptides during a challenge trial with *Vibrio anguillarum* had been attempted by Gilberg and Mikkelsen (1998). Influence of probiotic *S.faecium* M74 on growth and content of intestinal microflora in carp, *C.carpio* was tested by Bogut *et al*. (1998).

Efficacy of graded levels of G-probiotics on growth, survival and feed conversion of tilapia, *O.mossambicus* was analysed by Naik *et al*. (1999). Scholaz *et al*. (1999) studied the enhancement of vibriosis resistance in juvenile, *Penaeus vannamei* by supplementation of diets with different yeast products. Gomes *et al*. (2000) studied the use and selection of probiotic bacteria for use in the culture of larval aquatic organisms. Makridis *et al*. (2000) investigated the colonization of the gut in turbot by bacterial strains added to the water or bioencapsulated in rotifers.

Verchuere *et al*. (2000) reported in aquatic systems, probiotic bacteria may be active on gills, skin or ambient environment of the host and bacteria may be ingested with water or feed and who also reported the bacteria might be useful as food and as biological control agents of fish disease in aquaculture. Protein digestion in juvenile turbot, *S.maximus* and effect of dietary administration of *Vibrio proteolytics* was carried out by Deshrijiver and Ollevier (2000). Bogut *et al*. (2000) analysed the effects of *Enterococcus faecium* on the growth rate and content of intestinal microflora in sheet fish, *Silurus glanis*.

Probiotics (*Bacillus* S11) improved the growth rate, survival, immune response and enzymatic acids in black tiger shrimp, *P.monodon* (Rengipipat, 2000). Use of *Carnobacterium* sp. as a probiotic for *Atlantic salmon (Salmo salar L.)* and rainbow trout *O.mykiss* on growth and survival was observed by Robertson *et al.* (2000). Sharma and Bhukar (2000) analysed the effect of Aquazyn –TM-1000, a commercial probiotic on the water quality and growth of *Cyprinus carpio* (L.). Efficacy of feeding probiotic bacteria, *L.cremoris* on growth and survival of *M.rosenbergii* postlarvae was studied by Suralikar and Sahu (2001). Schwarz *et al.* (2001) found out the use of antimicrobial agents in veterinary medicine and food animal production.

Oliver-Novoa *et al.* (2002) explained the utilization of torula yeast (*C.utilis*) as a protein source in the diets of tilapia, *O.mossambicus* peters fry. A wide range of microalgae, yeasts and gram positive and gram negative bacteria had been evaluated by Irianto and Austin (2002). Enhanced resistance of rainbow trout, *O.mykiss* against *Yersinia ruckeri* challenge following oral administration of *Bacillus subtilis* and *B.licheniformis* (Bioplus 2B) was reported by Raida *et al.* (2003). Villamil *et al.* (2003) found out the effect of Nisin, a bacterial peptide that is ribosomally synthesized and produced by lactic acid bacteria, stimulated phagocytic activity of head, kidney and macrophages in turbot, *S.maximus*.

Lara-Flores (2003) identified the use of bacteria, *Streptococcus faecium* and *L.acidophilus* and the yeast, *S.cerevisiae* as growth promoters in Nile tilapia *O.niloticus*. Nikoskelainen *et al.* (2003) had suggested the enhanced immune response in rainbow trout, *O.mossambicus* fed with potential

prtobiotic bacteria *L.rhamnosus*. Effect of dietary probiotics on apparent digestibility coefficients of white shrimp, *L.vannamei* (Boone) was reported by Balcazar (2003). Influence of dietary brewer's yeast and commercial probiotcs on growth performance, immune response and resistance of hybrid striped bass, *M.chrysops* x *M.saxatilis* to *Streptococcus inia* infection was studied by Peng and Gatlin (2004).

Effects of probiotic, antibiotic sensitivity, pathogenicity and plasmid profiles of *Listonella anguillarum* like bacteria isolated from *P.monodon* culture systems was noticed by Vaseeharan *et al.* (2004). Effect of feeding *Lactobacillus* based probiotics on the gut microflora, growth and survival of post larvae of *M.rosenbergii* was conducted by Venkat *et al.* (2004). Bairagi *et al.* (2004) evaluated the nutritive value of *Leucana leucocephala* leaf meal, inoculated with fish intestinal bacteria *B.subtilis* and *B.circulans* in formulated diets for rohu, *L.rohita* fingerlings.

Improved growth rate and disease resistance in farmed *Haliotis midae* through probiotic treatment was observed by Macey and Coyne (2005). Wang *et al.* (2005) reported the effects of *Bacillus* sp. used as biocontrol agent in northern white shrimp, *P.vannamei*. Kuhle *et al.* (2005) conducted an *in vitro* screening of probiotic properties of *S.cerevisiae* and food borne *S.cerevisiae* strains. Bandhyopadhyay and kumar (2006) observed the probiotic feed supplement made a positive correlation between immune response and survivality of Indian major carps, *C.catla, L.rohita* and *C.mrigala*.

The effects of dietary supplementation with *Clostridium butyricum* on the growth performance and humoral immune response in *Miichthys miiuy* were evaluated by Song *et al.* (2006). Kumar *et al.* (2006) reported *B.subtilis* bacteria used as a probiotic to Indian major carp, *L.rohita* (Hamilton). Bomba *et al.* (2006) reviewed the improvement of probiotics efficacy by synergistically acting components of natural origin. The effect of live and dead probiotic cells on the non-specific immune response, tolerance to stress and resistance to disease in tilapia, *O. niloticus* was investigated by Taoka *et al.* (2006).

Saeed *et al.* (2006) investigated the effect of *Bacillus* sp. bacteria used as probiotics on digestive enzyme activity, survival and growth in the Indian white shrimp, *Fenneropenaeus indicus*. Two feeding trial were carried out to evaluate the efficiency of probitics (*B.toyoi* and *B.cereus*) and maslinic acid on growth, survival and liver proteolytic activities of juvenile dentex, *Dentex dentex* L. by Hidalgo *et al.* (2006). Impact of effective microbes on water quality and growth of Indian major carp, *L.rohita* was studied by Vishwanathan and Narayanan (2007).

Lunger *et al.* (2007) examined the impacts of dietary NuPro® an organically certified yeast-derived protein source on the growth, feed efficiency, biological indices, fillet proximate composition and fillet quality in juvenile cobia, *Rachycentron canadiaum*. Ghosh *et al.* (2007) observed the effect of dietary supplementation of probiotic bacterial strain *B.subtilis* isolated from the intestine of *C.mrigala* (Hamilton) on reproductive performance in female live bearing ornamental fish.

Effect of dietary yeast supplementation to McConaughy strain of rainbow trout, *O.mykiss* was analysed by Barnes *et al.* (2007).

EL-Haroun *et al.* (2007) conducted a feeding trial to evaluate the effect of dietary probiotic Biogen® supplementation on growth performance and feed utilization efficiencies of Nile tilapia, *O.niloticus* (L.). Yu *et al.* (2007) conducted a feeding trial to study the effects of dietary *Bacillus* on the growth, digestive enzyme activity and serum biochemical parameters of the shrimp, *L.vannamei*. Balcazar *et al.* (2008) evaluated the ability of three lactic acid bacteria isolated from fish *Lactococcus lactis, L.plantarus* and *L.fermentum* to inhibit adhesion of several fish pathogens, *Aeromonas hydrophila, A.salmonicida, Yersinia ruckeri* and *V.anguillarum* to host intestinal mucus under *in vitro* conditions.

The effect of probiotic bacterium, *E.faecium* on growth performance and immune responses of tilapia, *O.niloticus* was analysed by Wang *et al.* (2008). Aly *et al.* (2008) reported the characterization of some bacteria (*B.pumilus, B.firmus* and *Citrobacter freundii*) isolated from *O.niloticus* and their potential use as probiotics. The need, principles and mechanisms of action and screening processes of probiotics in aquaculture was reported by Watson *et al.* (2008). Son *et al.* (2009) studied the effect of dietary administration of probiotic *L.planatarum* enhanced the growth, innate immune responses and disease resistance in the grouper, *E.coioides.*

2.3 MEDICINAL HERBS SUPPLEMENTATION

Effect of bioboost forte, Livol, an herbal product and Amchemic AQ on the growth and body composition of common carp, *C.carpio* (Linn.) was analysed by Shadhakshari (1993). Herbal products, Stressol - I and Stressol - II enriched *Artemia nauplii* fed to *P.indicus* post larvae increased the growth and feed efficiencies significantly and reduced the osmotic stress (Chitra, 1995). Efficacy of papaya leaf meal on weight, feed conversion ratio and specific growth rate of *P.monodon* postlarvae was identified by Penaflorida (1995).

Efficacy of an herbal product, Livol (IHF-1000) on growth, feed utilization efficiency and body composition of Indian major carp, *C.catla* (Ham.) was reported by Unnikrishnan (1995). Navarro *et al.* (1996) reported the plant extracts from *Eucalyptus globules, Punica granatum, Artemisia mozicana* and *Bovvania arborea* posses strong *in vitro* antimicrobial activity against the *Staphylococcus aureus*, *Eschericia coli, Pseudomonas* sp. and *Candida* sp. Several herbal principles have been tested for their growth promoting activity in aquatic animals by Jayaprakash and Eupharsia (1996).

Ayurvedic products and herbal products known for their antimicrobial properties especially in terms of treating bacterial disease and growth promoting, anti-stress and immune stimulating activities had been screened by Abraham *et al.* (1997). Kim *et al.* (1998) estimated the effect of Obosan supplemented diet on growth, feed conversion ratio, survival,

condition factor and body composition of Nile tilapia, *O.niloticus* and live flounder, *Paralichthys olivaceus*. Sahoo *et al*. (1999) reported the effect of immunomodulators on haematological parameters and immunity level in rohu, *L.rohita*.

The dietary supplementing effects of kugija, *Lycium chinese* on immune responses of Nile tilapia, *O.niloticus* to *Edwardsiella tarda* was recorded by Kwon *et al*. (1999). Tefroli contains ingredients such as *Tephrosia purpurea*, *Eclipta alba, Phyllanthus niruri, Andrographis paniculata, Ocimum sanctum* and *Terminalia chebula* enriched with *Artemia* and fed to *P.monodon* postlarvae improved the growth and feed efficiencies significantly (Rani, 1999). Lee *et al*. (2001) was observed the effects of dietary herbs on growth and body composition of juvenile abalone*, Haliotis discus hannai.*

An eight week feeding trial was conducted in a static indoor rearing system to examine the effects of partial substitution of fish meal with *Seasamum indicum* protein with and without supplemental amino acids in diets for *L.rohita* fingerlings (Mukhopadhyaya and Ray, 2001). Efficacy of oral administration of medicinal herbs extract as a dietary supplement on non-specific immune responses, haematology and disease resistance on olive flounder, *P.olivaceus* was analysed by Jung *et al*. (2002). Effect of oral administration of onion (*Allium cepa*) and garlic (*A.sativum*) juices on physiological studies in *Clarias lazera* was investigated by Al-Salahy (2002).

Various herbal products such as *Hydrophila spinosa, Withania somnifera, Zingiber officinalis, Solanum trilobatum, A.paniculata, Psoralea codifolia,* purified Silajit and cod-liver oil has

the characteristics of growth promotion, anti-stress, immune stimulation and antibacterial. These preparations had a good influence in the *Penaeus* larviculture (Citarasu *et al.*, 2002). Maheshappa (2002) studied the effect of Livol IHF-1000 on growth and digestive enzyme activity of rohu, *L.rohita*. Immunostimulatory properties of the Indian medicinal plants were reported by Devasagayam and Sainis (2002).

Growth and immunostimulatory effects of the dietary intake of various medicinal plant extracts such as *Viscum album, Urtica dioica* and *Z.officinalis* on rainbow trout, *O.mykiss* were investigated by Dugenci *et al.* (2003). Jian and Wu (2003) observed the efficacy of traditional Chinese medicine on non-specific immunity and disease resistance of large yellow croaker, *Pseudoscianena crocea* (Richardson). Citarasu *et al.* (2003) noted that the influence of the antimicrobial herbs, *S.trilobatum, A.paniculata* and *P.cordyfolia* on the survival, growth and bacteria load of *P.monodon* post larvae. Effects of dietary lipid level and herb mixture on growth of parrot fish, *Oplegnathus fasciatus* was studied by Kim *et al.* (2003).

Screening of antioxidant activity of three Indian medicinal plants, *Sida cardifolia, C.dactylon* and *Evolvulus alsinoides* traditionally used for the management of neurogenerative diseases was carried out by Auddy *et al.* (2003). Effects of five Chinese herbal medicines as feed additive on the growth and intestinal microflora in common carp, *C.carpio* was observed by Liu *et al.* (2004). Immanuel *et al.* (2004) carried out a feeding trial to study the effect of butanolic extracts from terrestrial herbs and seaweeds on the survival, growth and pathogen, *V.parhaemolyticus* load on shrimp, *P.indicus* juveniles.

Growth and immune response of juvenile greasy groupers (*E.tauvina*) fed with herbal antibacterial active principle supplemented diets against *V.harveyi* infections were noted by Sivaram *et al.* (2004). Francis *et al.* (2005) reported the effect of *Quillaja saponin*, a natural growth promoter as a feed additive in the diets of Nile tilapia, *O.mossambicus*. Wang *et al.* (2006) analysed the effects of Chinese herb additives on growth, digestive enzyme activity and non-specific immunity in flounder, *P.olivaceus*.

Citarasu *et al.* (2006) found out the effect of methanolic extracts such as *Cynodon dactylon*, *Aegle marmelos*, *Tinospora cordifoli*, *Picrorhiza kurooa* and *E.alba* against white spot syndrome virus infection in black tiger shrimp, *P.monodon* with reference to haemotological, biochemical and immunological changes. Sudhakaran *et al.* (2006) explained the immunostimulatory effects of the medicinal herb *Tinospora cordifolia* Miers leaf extract in *O.mossambicus.*

Lin *et al.* (2006) used the medicinal herbs as a natural growth promoter in the diets for white shrimp, *L.vannamei* and studied their effect on digestibility co-efficient of nutrients. A feeding experiment was conducted to assess the impact of the herb, Kaunch (*Mucuna pruriens* Bek.) mixed with conventional diets (rice bran and groundnut oil cake 1:1) of major carp fingerlings in the raising of common carp, *C.carpio L.* fingerlings (Charula *et al.*, 2007). Kumari *et al.* (2007) investigated the effects of polyherbal formulation 'Immuplus' on immunity and disease resistance of Indian major carp, *L.rohita* at different stages of growth.

Growth and immunostimulatory effects of the oral administration of the medicinal plant, *E.alba* leaf aqueous extract was studied in tilapia, *O.mossambicus* (Christybapia *et al.*, 2007). Ji *et al.* (2007) analysed the effects of dietary medicinal herbs mixture, *Massa medicata fermentata, Crataegi fructus, Artemisia capillaries* and *Cnidium officinate* in the proportions of 2:2:1:1 in juvenile Japanese flounder, *P.olivaceus.* Impact of biomedicinal herbs, probionts and highly unsaturated fatty acids enriched with *Artemia* on growth and survival and reduction of pathogenisity in shrimp, *P.monodon* postlarvae was observed by Immanuel *et al.* (2007).

Influence of extract isolated from the plant *Sesuvium portulacastrum* on growth and metabolism in fresh water teleost, *L.rohita* was evaluated by Johnson and Banerji (2007). Yu *et al.* (2007) found out the effect of dietary medicinal herbs on the growth, survival, digestive enzyme activity and serum biochemical parameters of the shrimp, *L.vannamei.* The impact of dietary medicinal herbs on growth and non-specific immunity of red sea bream, *P.major* was analysed by Ji *et al.* (2007). Growth, feed conversion ratio, net production efficiency and digestive enzyme activity were observed in *P.monodon* (Fabricus) postlarvae fed with different percentages of the herbal appetizer *Z.officinalis* enriched *Artemia* by Venkatramalingam *et al.* (2007).

Screening of the antiviral activity of Indian medicinal plants including *C.dactylon* against white spot syndrome virus in shrimp, *P.monodon* was carried out by Balasubramaniam *et al.* (2007). Ahraf and Goda (2007) conducted a feeding trial to evaluate the effect of dietary Ginseng herb (Ginsana® G115) supplementation on growth performance, feed utilization efficiency and

haematological indices of Nile tilapia, *O.niloticus* (L.) fingerlings. Effects of dry and fresh *Azolla pinnata* were evaluated as feed ingredients for fingerlings and adult Nile tilapia, *O niloticus* by EL- Sayed (2008).

Herbals such as *C.dactylon, Piper longum, P.niruri, Tridax procumbens* and *Z.officinalis* were extracted with acetone, butanol and petroleum ether and screened against the pathogen *V.harveyi* infection (Punitha *et al.*, 2008). Balasubramanian *et al.* (2008) examined the antiviral activity of a large scale produced plant extract of *C.dactylon* on white spot syndrome virus in black tiger shrimp, *P.monodon* by *in vivo* testing after administration through oral route. Zakes *et al.* (2008) determined the impact of dietary inclusion of medicinal herbs (*Astragalus radix* and *Lonicera japonica*) on the growth performance, proximate body composition, fatty acids profile (whole fish, muscle tissues and viscera) and cytological and histological indicators of the liver and middle intestine of juvenile pikeperch (*Sander lucioperca* L.).

The effect of two Chinese medicinal herbs (*Astragalus membranaceus* and *Lonicera japonica*) and boron on the non-specific immune responses of Nile tilapia (*O.niloticus)* and resistance against *A.hydrophila* was assessed by Ardo *et al.* (2008). Efficacy of dietary medicinal herbs and *Bacillus* on survival, growth, body composition and digestive enzyme activity of the white shrimp, *Litopenaeus vannamei* had been observed by Yu *et al.* (2008). Citarasu (2009) reviewed more than 50 herbal plants for their biological effects such as growth promotion, immunostimulation, antistress, antibacterial, antifungal, antivirals, appetite stimulators and aphrodisiac in aquaculture operations.

2.4 VETERINARY GROWTH PROMOTER SUPPLEMENTATION

Roem *et al.* (1990) studied the vitamin E requirement of blue tilapia *(O.aureus)* in relation to dietary lipid level. Hardi *et al.* (1991) reported the effect of dietary vitamin mixture on the immune response of the Atlantic salmon (*S.salar L.*). Effect of sources and dietary concentration of ascorbic acid on tissue concentrations of ascorbic acid in channel catfish was determined by Naggar and Lovell (1991). Role of micronutrients in immune response and disease resistance in fish was documented by Lall and Oliver (1993). Dietary impact of vitamin C on growth, immunity and disease resistance in Atlantic salmon, *S.salar* was explained by Waagbo *et al.* (1993).

Impact of vitamin nutrition on fish immunity and influence of antioxidant vitamins (C and E) on growth and immune response of rainbow trout (*O.mykiss*) was explained by Verlhac *et al.* (1993). Influence of supplemental chromium and vanadium on the utilization of different carbohydrates in hybrid tilapia, *O.niloticus* X *O.aureus* was reported by Shiau and Lin (1993). White *et al.* (1993) noticed the effect of different dietary levels of vitamins C and E on tissue levels in the Atlantic salmon, *S.salar*. Eid and Ghonim (1994) estimated the dietary zinc requirement of *O.niloticus* fingerlings.

Effect of copper and zinc supplementation on growth and non-specific immune response of zebra fish, *Brachydanio rerio* was investigated by Rougier *et al.* (1994). Bureau *et al.* (1995) found out the efficacy of dietary chromium supplementation on growth performance, biochemical composition and blood glucose of rainbow trout (*O.mykiss*) fed with prepared diets. Schaefer *et al.* (1995) analysed the effects of phosphorus supplemented diet on growth

and mineralization in mirror carp (*C.carpio* L.). Effect of dietary Vitamin E supplementation on growth was reported in *L.vannamei* and Atlantic salmon, *S.salar* (Hamre and Lie, 1995). Effect of dietary Vitamin E in relation to different lipid level was estimated in turbot, *S.maximus* (Stephan *et al.*, 1995).

Dato-Cajegas and Yakupitiyage (1996) published their work on the effect of dietary mineral supplementation on growth and biochemical composition of Nile tilapia, *O.niloticus*, cultured in a semi-intensive system. The effect of different combinations of dietary calcium and phosphorus on the growth of juvenile *H.laevigata* was explained by Coote *et al.* (1996). Efficacy of dietary zinc supplementation on growth of rainbow trout, *O.mykiss*, was detected by Riche and Brown (1996). Watanabe *et al.* (1997) described the role of trace minerals in fish nutrition. Essentiality of dietary mineral mixture supplementation to white fishmeal diet for tiger puffer was explained by Furuichi *et al.* (1997).

Effects of dietary vitamin C on growth performance, survival and tissue concentration of ascorbic acid in *H.tuberculata* and *H.discus hannai* was determined by Mai (1998). Effect of dietary zinc supplementation and phytase pre-treatment of soyabean meal or corn gluten meal on growth, zinc status and zinc-related metabolism in rainbow trout, *O.mykiss* during 170 days feeding trial was analysed by Ramseyer *et al.* (1999). Hossain and Furuichi (1999a) determined the effect of calcium supplementation to tiger puffer (*Takifugu rubripes*) fed a semi-purified diet for 8 weeks. Hossain and Furuichi (1999b) also reported dietary calcium requirement of giant croaker, *Nibea japonica*, redlip mullet, *Liza haematocheila* and black sea bream.

Shiau and chin (1999) conducted an experiment to estimate the dietary biotin requirement of juvenile hybrid tilapia, *O.nilotics* X *O.aureus*. Mohamed *et al.* (2000) estimated the effect of dietary biotin on weight gain, specific growth rate, protein efficiency ratio and feed efficiency ratio in catfish (*C.batrachus*) after 60 days of feeding. Metabolic response of rainbow trout, *O.mykiss* to different dietary phosphorous concentrations was studied by Sugiura *et al.* (2000).

The nutritional effect of vitamin E in diets for *L.vannamei* postlarvae was investigated after 34 days of feeding by Ruff *et al.* (2001). A feeding experiment was conducted by Ng *et al.* (2001) to evaluate the need for mineral supplementation and also the suitability of two mineral supplements (a formulated mineral mix and a commercial Orykta™ mineral supplement) in practical diets for the African catfish (*C.gariepinus*). Bei-ping *et al.* (2002) performed an experiment for 120 days to determine the dietary phosphorus requirement on growth (weight gain) and carcass level (protein and lipid) of the young abalone, *H.discus hannai*.

Sahoo and Mukherjee (2003) observed the growth improvement and immunomodulation by dietary vitamin C supplementation in healthy and alphatoxin B1-induced immunocompromised rohu (*L.rohita*). Wang *et al.* (2003) reported the effects of the different levels of dietary vitamin C on growth and tissue ascorbic acid changes in parrot fish, *Oplegnathus fasciatus*. Mitra and Mukhopadhyay (2003) studied the growth rate, nutrient utilization and tissue biochemical changes in *L.rohita* fed with natural and prepared diet.

Pan *et al.* (2003) analysed the effect of chromium picolinate on growth and carbohydrate utilization in tilapia, *O.niloticus* X *O.aureus*.

Efficacy of vitamin A supplemented diet on vitamin A metabolism and early biological response in juvenile sea bass (*M.chrysops* X *M.saxatilis*) was detected by Hemre *et al.* (2004). Maranesi *et al.* (2005) reported vitamin B6 supplementation increases the growth and fatty acid composition of muscle tissues of rainbow trout, *O.mykiss*. Vitamin E requirement of grouper, *E.malabaricus* at two lipid levels and their effects on immune responses was analysed by Lin and Shiau (2005). Helland *et al.* (2005) studied the mineral balance and bone formation in fast growing Atlantic salmon (*S.salar*) in response to dissolved metabolic carbon dioxide and restricted dietary phosphorus supply.

Effects of dietary chromium picolinate supplementation on serum glucose, cholesterol and minerals of rainbow trout (*O.mykiss*) were reported by Kucukbay *et al.* (2006). Influence of dietary phosphorus levels on growth, body composition and metabolic response of juvenile silver perch (*B.bidyanus*) was identified by Yang *et al.* (2006). Ye *et al.* (2006) observed the effect of dietary calcium and phosphorus on growth, feed efficiency, mineral content and body composition of juvenile grouper, *E.coioides*. Sarkar *et al.* (2007) investigated the effect of dietary levels of citric acid and/or amino acid-cheelated trace element on growth, feed conversion ratio and nutrient retention in red sea bream, *P.major.*

The efficacy of dietary L-ascorbic acid dosages on immunity, growth and survival of the fingerlings of *L.rohita* was evaluated by

Misra *et al.* (2007). Lin *et al.* (2008a) reported the efficacy of dietary copper on growth and feed utilization efficiencies of juvenile grouper, *E.malabaricus*. Tewary *et al.* (2008) examined the effect of vitamin C on growth, nutritional quality and immunomodulation in the Indian major carp, rohu (*L.rohita*). Barrows *et al.* (2008) determined the effect of vitamin premix in extruded plant based and fish meal based diets on growth efficiency and nutrient retention of rainbow trout, *O.mykiss*.

Sukumaran *et al.* (2008) conducted a feeding trial to study the effect of graded levels of dietary phosphorus along with vitamin and mineral mix on haematology, serum protein concentrations and HSP70 expression in fingerlings of the Indian major carp, *C.catla*. Remyla *et al.* (2008) found out the influence of zinc on cadmium induced haematological and biochemical responses in fresh water teleost fish, *C.catla.* An eight week feeding trial was conducted by Lin *et al.* (2008b) to study the effect of manganese on weight gain, feed efficiency and survival in juvenile tilapia, *O.niloticus* X *O.aureus*.

Huai *et al.* (2009) explained the efficacy of vitamin and mineral mixture supplementation on growth performance, digestibility and body composition of juvenile pacific white shrimp, *L.vannamei.* An experiment was conducted by Selcuk *et al.* (2009) to determine the effects of supplemental dietary L.carnitine and chromium picolinate along with vitamin and mineral mixture on growth performance and serum total protein, cholesterol, triglyceride and glucose of rainbow trout (*O.mykiss*) after 58 days of feeding trial.

Even though a voluminous literature is available on the feed supplements of fresh water and marine fishes, studies relating to the low cost supplementary diet and nutritional indices of *C.catla* have not been carried out so far. The present investigation was therefore undertaken to study the, "efficacy of formulated feeds on growth, nutritional indices and feed utilization efficiencies of *C.catla*".