CAPTIVE BREEDING FOR CONSERVATION OF ENDEMIC FISHES OF WESTERN GHATS, INDIA

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Foreword

The Western Ghats of Peninsular India constitute one of the unique biological regions of the world. The streams and rivers originating from Western Ghats are blessed with rich expressions of fish biodiversity. They include several food fishes and the most attractive ornamental fishes, exclusively endemic to the region. The biodiversity of freshwater fish species in these places is however, under constant threat due to drastic disturbances to their habitats and physical modifications to their natural environment, deforestation, siltation, irresponsible fishing practices and various forms of pollution.

Despite the rich faunal diversity and potentials, the Peninsular fishes do not figure significantly in inland aquaculture or in the ornamental fish trade. This is largely due to lack of techniques for their breeding and seed production. Lack of information in their distribution, abundance and life history characteristics are also factors that limit adoption of effective conservation and management programs. It is in this context that the development of technology for captive breeding of endemic fishes of the region assumes relevance. The present publication 'Captive Breeding for conservation of Endemic Fishes of Western Ghats, India' is the outcome of a project entitled 'Germplasm Inventory, Evaluation and Gene Banking of freshwater fishes' carried out under the National Agricultural Technology Project (NATP) at the Regional Agricultural Research Station, Kumarakom, (KAU). This study documents captive breeding protocols for five endemic fish species of the floodplains of the Western Ghat, in Kerala. The induced breeding protocols of three of the species *viz.,Horabagrus brachysoma*, *Clarias dussumieri* and *Gonoproktopterus curmuca* are new reports to science. The manual also documents efforts on the development of a protected sanctuary to promote natural recruitment of endemic fish, *Etroplus suratensis* in the open Vembenad lake. I take this opportunity to compliment Dr. K.G.Padmakumar, the Principal Investigator and his team of researchers for their untiring efforts and consequent success. I am confident that scientific community and planners will use the information contained in this publication extensively as a tool for evolving management strategies for restoration of fish biodiversity in our river systems. The technology of captive breeding of these endemic species will also, no doubt help to widen the species spectrum in food fish aquaculture and ornamental fish trade.

Dr. K.V.Peter
Vice Chancellor
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Preface

India is blessed with a rich variety of wetland habitats that sustain a great wealth of fish diversity. The Western Ghats region alone contributes to over forty eight percent of the fish biodiversity. Despite the occurrence of a rich and diverse fish fauna, a wide array of anthropogenic disturbances have led to the decline and extinction of many endemic species, important either as cultivable or ornamental fishes. Two main strategies suggested for conservation and management of fish biodiversity are protection of vital habitats and stock enhancement by artificial stocking. Amongst these, stocking of young fish in to natural waters to increase its population size is the most widespread measure. This calls for development of breeding techniques for such species under controlled conditions. Mass multiplication of seeds will also facilitate their sustainable utilization in commercial aquaculture. This monograph documents the techniques and protocols for captive breeding and seed production of some of the prioritized food fish species of Western Ghat region, developed as part of the National Agricultural Technology Project (NATP). The efforts undertaken for the establishment of an engineered fish sanctuary, by simulating natural breeding situations is also illustrated. This study does not claim to provide all answers to the problem of fish germplasm conservation: however, it acknowledges the need for serious initiatives to the issue. In the backdrop of the growing awareness on the need to conserve, protect and manage fish biodiversity, it is hoped that this document will provide a way forward for planning meaningful interventions in conservation and utilization of our rich fish genetic resources. We thank all who have rendered support and were involved in more ways than one with this initiative.

Authors

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We take this opportunity to express our deep sense of gratitude to Dr.K.V.Peter, Hon.Vice Chancellor, Kerala Agricultural university for his constant interaction and encouragement to this piece of work. We are deeply indebted to the Mission Leader, Dr. D. Kapoor, Director, National Bureau of Fish Genetic Resources, Lucknow & Dr.S.P.Singh, Principal Investigator (Lead Centre) for consistent encouragement and unstinted support throughout the period of this study.

We are extremely grateful to Dr. C.K.Peethambaran, Director of Research, Kerala Agricultural University for valuable suggestions and constant encouragement. We also acknowledge the interest and support given to us by Dr.Vikraman Nair, former Director of Research.

We are deeply indebted to Dr. P.J.Joy, Associate Director of Research, Regional Agricultural Research Station, Kumarakom for his keen interest in the project and whole hearted support and constant encouragement The valuable support and appreciation to this work by Dr.D.D.Namboothiri, Dean College of Fisheries is gratefully acknowledged.

We place on record our sincere gratitude to Dr.A.G.Ponniah, Director, Aquaculture and Genetic Improvement Programme, The World Fish Centre, Malaysia, who has been an inspiring force for the study since the inception of this project.

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INTRODUCTION

India is blessed with a rich fish biodiversity with high degree of endemism in hot spot areas like Western Ghats and North East India. These areas harbor rich and diverse fish fauna comprising several rare and endemic species, many of which are commercially important either as food fish or as ornamental species. Out of the total length of 1600 km of the Western Ghats, over 500 km fall in Kerala and the region covers nearly 56 percent of the total geographic area of the state and 42 percent of the entire Ghat region. Bounded by the forested hills of the Western Ghats in the east and Arabian sea in the west, the state of Kerala has a steep and undulating topography, longitudinally divisible in to three physiographic divisions; the highlands, midlands and low lands, with reference to land configuration and heights above mean sea level. Due to its location on the windward side of the Western Ghats, the region receives plentiful rainfall with annual average of 2800 mm. The highland division of the state thus intricately balances the whole life supporting system of the state, transforming it in to a distinct biogeographic region.

With its rugged topography and heavy rainfall, the Western Ghats forms the catchments area of all the 44 rivers in the state. Located in the tropics, and richly endowed with warm temperature, and high rainfall, all congenial for intense biological activity, the rivers of Kerala originating from the Western Ghats and the extensive network of inland water bodies, backwaters, lakes, and reservoirs are potential habitats for a variety of fish fauna. It is no surprise therefore that Western Ghats region in Peninsular India are recognized as one of the hotspots of fish biodiversity in the world.

The characteristic bimodal rainfall pattern, diverse soil types and agro ecological zones invariably result in a variety of micro and macro environments that vary from high rainfall tropical to cool temperate and even hot and humid situations. It is this configuration that enables such diverse plant and animal life. The river systems flowing through the variegated mountain ranges decked with dense canopies of rubber and tea plantations, valleys, slopes and plateau therefore results

in several distinct habitats and physiographic endowments, all conducive for a variety of species requiring contrasting environments. This also owes to the distinguishable altitudinal variations of the landmasses from below mean sea level situations in the coastal wetlands to soaring heights of over 2500 m in the deeply wooded, ridges and peaks of the Western Ghats, all within a short span of 100-120 km. All the west flowing rivers debouch into a continuous stretch of 30 backwaters extending to over 325 km lying parallel to the 600 km coastline. Out of the 617 and odd freshwater fishes reported in India, over 210 species are available in Kerala part of the Western Ghats, and over 25 percent of these species are exclusively endemic to these places, all indicating the richness of piscean diversity in these river systems. Thus the majestic Western Ghats present all along the eastern border of Kerala, once considered as home of spices and medicinal herbs has lately become renowned as regions of rare and diverse fish species including ornamental fish species.

The fact that the fauna and flora in the Western Ghats in Kerala, possess a distinct similarity and parallelism with that of the south western Sri Lanka and the eastern Himalayan region extending from Assam to Malaya peninsula and archipelagos Java, Sumatra & Borneo, as noticed and reported by several workers indicate that the character and distribution of the flora and fauna is chiefly linked to geographical and climatic factors. The most impressive findings on the occurrence of freshwater fishes inhabiting the torrential streams in widely separated regions representing similar environments, described as the 'Satpura hypothesis'(Hora,1944) explains the extension and establishment of a continuity to Indo-Malayan forms of animals to peninsular India through the Satpura Highway. The fact that all these regions get the brunt of southwest monsoon, owing to the position of the hill ranges is a clear indication of the influence of climatic regime on the occurence and distribution of life forms.

However, the biodiversity of the Western Ghat is under severe stress due to a variety of factors. Unbridled exploitation of resources beyond sustainable levels often lead to depletion and even extinction of a number of species in these places. Deforestation, unsustained agricultural practices, sand mining, waste disposal and irresponsible

and destructive fishing practices such as dynamiting, electric fishing, poisoning etc are some of the threats to fish biodiversity. Unscientific construction of dams and reservoirs, not only affect the migration and proliferation of fish, but also affect summer flows in the river system that sustain fish life. With the enormous publicity given to the ornamental value of several of the fish species, more recently, endemic fish species are removed unscrupulously from these river systems for export. This is yet another threat to the endemic fauna.

There is a growing awareness on the imperative need to conserve, protect and manage fish biodiversity in these river systems. Being a signatory to the Convention of Biodiversity, natural resource management is the binding priority of the State. Information on the biodiversity strength is an essential prerequisite for its sustainable utilization. It is generally said that the greatest threat to biodiversity is the lack of awareness of the strength and the ignorance of what it really comprises. Despite all these richness ,only a very small fraction of endemic fish diversity is utilized scientifically and such a situation also results in introduction of undesirable exotics endangering the endemics further. In the context that many of the endemic fish species in these places are of value either as food fish or ornamental species, there is a dire need to standardize technology for mass production of seeds of such species which will aid to replenish and restore them in natural habitats through judicious ranching program. Mass multiplication of seeds of rare and endangered forms by captive breeding will also facilitate their sustainable utilization on commercial lines.

METHODOLOGY AND APPROACHES

The ultimate aim of captive breeding of fishes is optimum utilization of prioritised species for expansion and diversification of its farming or to facilitate their conservation by restoring them in natural habitats through ranching *In situ* conservation is also facilitated by establishment of aquatic sanctuaries. Species were prioritized based on the consideration of their culture potential and adaptiveness to local agro climatic conditions, endemicity and conservation status *ie.*, degree of endangerment or vulnerability. Hence *valuable* and *vulnerable* fishes in the floodplain river system were the focus of the study.

The study involved micro geographic surveys in biodiversity rich regions in the floodplain areas of river systems of the Western Ghat. The prioritized fish included strongly migratory 'whitefish' and more locally resident 'blackfish'(Hoggarth *et al.*,1999). Based on the earlier reports, the spatial and temporal distribution of prioritized fish species were gathered. Information on population abundance, variations and habitat information were also collected. As a prerequisite to captive breeding, biological characterization of the prioritized species was undertaken by assessing the critical life history traits, such as size and growth, feeding biology and reproductive parameters, so that such information for linking the same is useful to devise breeding methodology for the designated species.

Species inventory

As a first step, a desktop inventory, based on the published information on fish fauna of the region was made and a list of potential cultivable species was compiled. Experimental fishing was conducted in the riverine systems at different reaches, using diverse gears such as cast nets, gillnets, drag nets and other local fishing devices. The predominant size group in the collections and commercial catches in landing centers and markets adjacent to the river system were assessed. The emphasis was to gather information on the changing population status of the prioritized species and seasonal distribution of juveniles and spawning adults in different regions in the flood plains of the rivers system.

In addition to investigations on temporal and micro level distribution of the fish in the water body, an inventory of their natural habitat was prepared. The critical parameters recorded for habitat survey

inter alia included, stream order, reach length, climate, turbidity, flow rate, maximum and mean depth, length of channel, type of substrate, stream order, bank stability, soil erosion, riparian zone details, slope of habitat and gradient of stream. Critical environmental parameters monitored included Sechi disc transparency, pH, dissolved oxygen, alkalinity, and electrical conductivity.

Biological characterization

For biological characterization of the fish, in addition to size frequency distribution, crucial reproductive parameters such as fecundity, size at maturity, gonadosomatic index, oocyte size frequency, relative condition factor, food and feeding etc were monitored. In order to design strategies for captive breeding, critical parameters such as a)sex ratio b) anatomy of the reproductive system c) gonadosomatic index d)fecundity e)sperm density and motility f) spawning and spermiation cycle and g) mating behaviour details were monitored. Biological characteristics or diverse populations in different river systems and culture systems were categorised separately. Local knowledge on past and present abundance of the particular fish species, therapeutic properties, and such other values of the fish were also considered for species prioritization.

Breeding Evaluation

For prioritized species, either young ones or sub adults collected from nature were raised as brood stocks, in field germplasm repositories established onfarm and in cases where young ones could not be collected from nature, or when maturation process in farm conditions required longer periods, brood stock collected from wild were directly used for captive breeding trials. Induced breeding was performed through hypophysation using fish pituitary hormone extract or by administering commercially available inducing agents/hormonal formulations. Appropriate simulation and manipulation of natural breeding environment was facilitated for all species including those that exhibited intense parental care. Spawn and fry nursing was undertaken in prepared nursery systems and in few cases, potentials for culture was also assessed.

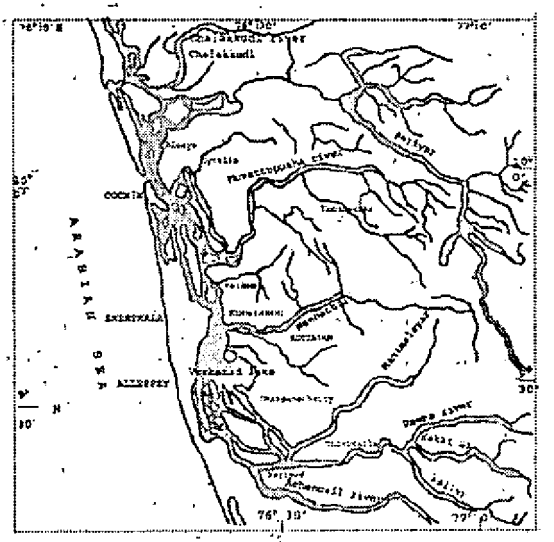
Prioritisation of species

Based on the criteria developed and standardised in the Conservation Assessment Management Plan (CAMP) workshop under the Biodiversity Conservation Prioritisation Project (BCPP) organised by the National Bureau of Fish Genetic Resources and Zoooutreach organisation, Coimbatore , (Anon,1998) and as per criteria fixed by the IUCN, ten fish species endemic to Western Ghat region with cultivable properties were prioritised (Table-I) for captive breeding studies in the project.

Fishery survey

A general survey of the Vembanad wetlands, downstream the riverine systems *viz* Pampa, Achencoil, Manimala, Meenachil and Muvattupuzha was carried out during the first year of the project. This fishery survey, covering the freshwater stretches of the above riverine systems, helped to evolve a baseline distribution map of the different prioritised species. Data on the population abundance, distribution and habitat parameters of the species were also compiled.

Fig. -1 Sampling Locations on Riverine reaches of Vembanad Lake



These studies revealed that most of this species were not represented in commercial fishery and contribution of few of the endemic reverine species represented viz, *Labeo dussumieri* and *Horabagrus*

brachysoma was only negligible even during the prime monsoon breeding season. *Clarias dussumieri* once abundant in the derelict coastal swamp was very poorly represented and has become an extreme rarity. *Etroplus suratensis* continued to contribute significantly to the catches in the open Vembanad lake though they were rare in the upper riverine reaches. Broodstock of the prioritised cultivable food fishes were established using the riverine stocks. The contribution of dominant endemic species to total finfish catch in the region during 1999-2000 & 2000-01 is summarised in fig.2

Fig. 2 Fish landing data in the riverine stretches of Vembanad Lake

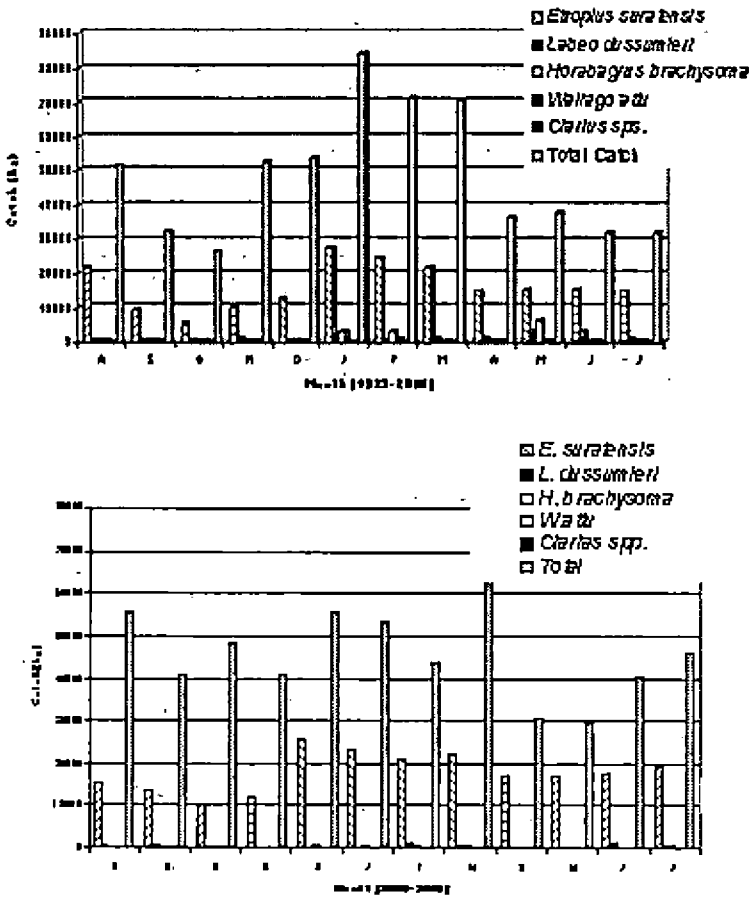


Table -1 : **Prioritized species endemic to Western Ghats and their conservation status**

Sl:No	Species	IUCN status	Max. Size (cm)	Category	Family	Distribution
1	*Horabagrus brachysoma* (Gunther) Manjakoori (Mal)	EN	50	Cultivable, excellent table fish	Bagridae	Kerala, South and North Canara
2	*Labeo dussumieri* (Val) Pullan(Mal)	EN	55	Cultivable highly priced table fish	Cyprinidae	Western Ghats of Kerala and Sri Lanka
3	*Channa micropeltes*(Cuvier) Manal waaha(Mal)	CR	100	Highly priced food fish	Channidae	Western Ghats, Kerala
4	*Clarias dussumieri* (Val) Mushi(Mal)	VU	50	Cultivable highly priced fish	Claridae	Peninsular India (Goa, Karnataka, Kerala & Pondichery)
5	*Gonoproktopterus curmuca* (Ham. - Buch.) Kooral(Mal)	EN	>120	Sport fish, cultivable highly priced table fish	Cyprinidae	Rivers of Western Ghats
6	*Wallago attu* (Bloch-Schneider) Aattu waala(Mal)	LR-nt	135	Cultivable , highly priced table fish	Siluridae	Pakistan, India, Nepal, Tailand Vietnam, Malaya, Indonesia
7	*Etroplus suratensis* (Bloch) Karimeen (Mal)	LR	>30	Cultivable brackish water and freshwater	Cichlidae	Western Ghats of Peninsular India
8	*Barbodes carnaticus*(Jerdon)	VU	>60 12 kg	Cultivable commercially important	Cyprinidae	Cauvery, Krishna river systems, Nilgiris, Wynad and Canar hills
9	*Mastacembalus armatus* (Lacepede)	LR	>60	Cultivable	Mastacembelidae	Western Ghat streams and rivers, India, Pakistan, Sri Lanka, Malaya Thailand, China
10	*Scatophagus argus (Bloch)*	DD	12-15	Brackish water cultivable and ornamental	Scatophagidae	Indian ocean from China to Australia, India ,Bangladesh and Sri Lanka.

CR : Critically Endangered, EN: Endangered, VU: Vulnerable , LR: Low Risk, LR-nt : Low Risk -near threatened, DD: Data Deficient

CAPTIVE BREEDING OF ENDEMIC FISHES

Increased pressure on fish resources, environmental degradation of aquatic habitat and poor fishery management are the greatest threat to endemic fish biodiversity in the Western Ghat river systems. Consequently, the fish biodiversity of the floodplain rivers in the region has been on the decline and the conventional management measures such as restriction of gears, mesh size limits, closed seasons, closed fishing area will not be effective and difficult to enforce. Fish species in river habitats that vary from fast flowing upland streams to slow meandering midland and low land reaches require contrasting approaches for management.

With increasing pressure on endemic fish biodiversity, a range of conservation techniques are applied to enhance the declining stocks. Apart from stocking of natural waters to improve recruitment, habitat enhancement by engineering vital environment that provide shelter, food and protection for spawning are some of the suggested approaches for conservation of endemic biodiversity. The situation calls for new approaches for managing the biodiversity of floodplain river systems.

Although India is a mega diversity country rich in fish germplasm resources, comprising over 617 identified inland fish species, only very few indigenous species are utilized in aquaculture. The Index of biodiversity in aquaculture in India is too low (0.13), only one fourth of that (0.51) of some of the South East Asian countries like Taiwan(Kutty,1999). Despite rich and varied water resources and faunal biodiversity comprising a variety of food, sport and ornamental fishes, several of them exclusively endemic to the region, the contribution of peninsular fishes to inland fish production is negligible. Freshwater aquaculture in India is generally considered to be carp centric, with the three Indian major carps contributing to over 70% of the total cultured fish production. Despite local taste preference and demand as high value nutraceutical fishes or as sport and ornamental specie, endemic

fishes do not figure any significantly in aquaculture systems and this is attributed to lack of appropriate technology for seed production of such indigenous species.

In the context that the biodiversity of inland fishes in the region is showing alarming decline, and several species endemic to the region is categorized as endangered, development of techniques for captive breeding will aid not only for their utilization in culture but also for their rehabilitation and restoration in their natural habitats. This call for strengthening of the data base on breeding and spawning behaviour of the target species. Ranching of hatchery reared seeds in open waters and protection of habitats harboring endangered species are two viable strategies to enhance and conserve fish biodiversity. Either of the above approaches demands a thorough understanding of the breeding behavior of the species. The biological attributes and population characteristics have a crucial bearing on the breeding characteristics of fishes.

The technique of induced breeding, a milestone event in inland fisheries development in the country involving a series of demonstrable events, such as gonadal maturation, ovulation and spawning, has taken off as a commercial activity since it was first reported by Chaudhuri and Alikunhi (1957). Although the original package of hypophysation that utilizes freshly collected pituitary glands of the same or allied species has given way for second generation techniques, combining synthetic analogues for induced maturation and manipulation of the environment. By and large the method has opened up avenues even for selective breeding and hybridization of fishes. The technology, a mile stone event in inland fisheries development has since taken off as a work practice for all in the line during the past few decades.

As captive breeding is the considered option for conservation management of endangered species and enhancement of inland fish biodiversity, while trying to breed other species, one will have to naturally get to know the critical environmental factors that contribute to the cascade of events culminating in spawning. A thorough understanding of the life history traits of the species, sex ratio, gonado somatic index

and fecundity sperm density courting and mating behaviour spawning and spermiation cycle are also vital for achieving success in breeding. With greater insights into the environmental factors and its biological processes, successful propagation of species is identified to depend to a large extent on the maintenance of a balance between physiological process and environmental conditions. It is well known that gonadal development in teleosts is directly under the influence of external ecological conditions. As gonadal development is controlled by hypophysis and hypophyseal activities are regulated by external factors through the nervous system, the ecological conditions have a crucial role. These critical factors stimulate the sense organs and the same when transmitted to the central nervous system induces the hypothalamus and the basophile in the hypophysis to initiate sexual activities such as chasing, and courting leading to release of leutinising releasing hormones and resultantly, spawning. The factors considered to influence spawning in carps, however, may not hold good for all fish species.

The significant environmental factors that induce and influence spawning are photoperiod, temperature and pH. Recent studies have shown that even chemical signals and pheromones play a significant role in bringing together mating partners together in space and time and they are reported to have priming effects for breeding (Moitra and Sarkar,1975; Pandian, 2001). Developing protocols and strategies for captive breeding therefore calls for information on a series of parameters , *viz.,* sex ratio, gonadosomatic index, fecundity, sperm density, spawning and spermiation cycle, and mating behaviour. Apart from this, anatomy of the reproductive system has been identified to be a critical factor that determine the success rates and amenability of stripping method in captive breeding (Nagahama,1983) as amongst some Silurids. Among viviparous fishes with spermatheca in their female reproductive system, even three to four successive spawning occur with a single insemination. These adaptations result in skewed sex ratio in favour of females. Sperm density of oviparous fishes is significantly higher than that of viviparous fishes. In some oviparous fishes where the duration of reproductive cycle is short, one male will be sufficient as mates for several females. Then

also, the sex ratio is skewed in favour of females (Koteeswaran, 2001). Nevertheless, innate phenotypic plasticity of fishes with reference to ecological and habitat changes including internal rhythm, exert profound influence on the regulation of seasonal reproductive activity. Knowledge of these traits, habitat requirements and breeding behavior mediated by neuro endocrine mechanisms are indispensable to plan and formulate species specific conservation strategies.

The global interest in fisheries enhancement probably caught momentum with the recommendation of the FAO Conference on food security, Kyoto, Japan where knowhow in enhancement was included in the action plan. Stocking, restocking and community management by fishers and establishing open access rights were significant recommendations that gained recognition and emphasis. Enhancements of indigenous carps and catfishes by as much as ten times from 2% to 24% of the catches has been reported to have been achieved by merely establishing connectivity between flood plains and main river as reported by Payne and Cowan (1998). Fish Aggregating Devices(FAD) such as brush parks have been demonstrated to attract fish in coastal lagoons by as high as nearly 36% increase in finfish Sri Lanka(Wijeyaratna and Coasta , 1987). Such engineered and simulated habitats have been shown to function as refuge and fish sanctuaries by preventing over fishing and poaching.

Adoption of appropriate conservation strategies also call for a thorough understanding of the social and economic factors and gaps in knowledge. Conservation measures can yield useful results only if a balance is established between capture and culture fisheries.By developing culture fisheries, the pressure on natural fisheries is eased considerably and this will help to conserve the endemic germplasm. Thus successful development of captive breeding techniques for endemic species can not only help to improve utilization of the endemic biodiversity for commercial purposes but also will discourage introduction of exotics that pose a more severe threat to endemic germplasm.

THE GOLDEN CATFISH

Horabagrus brachysoma(Gunther)

Local name : Manjakoori (Mal)
Conservation status : EN
Distribution status : Endemic to Kerala

Distribution : This is a catfish of limited distribution, confined to downstream areas of riverine systems, in central Kerala once abundant in the Vembanad lake, Sasthamkotta lake, Chalakkudyppuzha, Karivannurpuzha and periyar. Extends from Canara in the north to Neyyattinkara on the south

Taxonomy

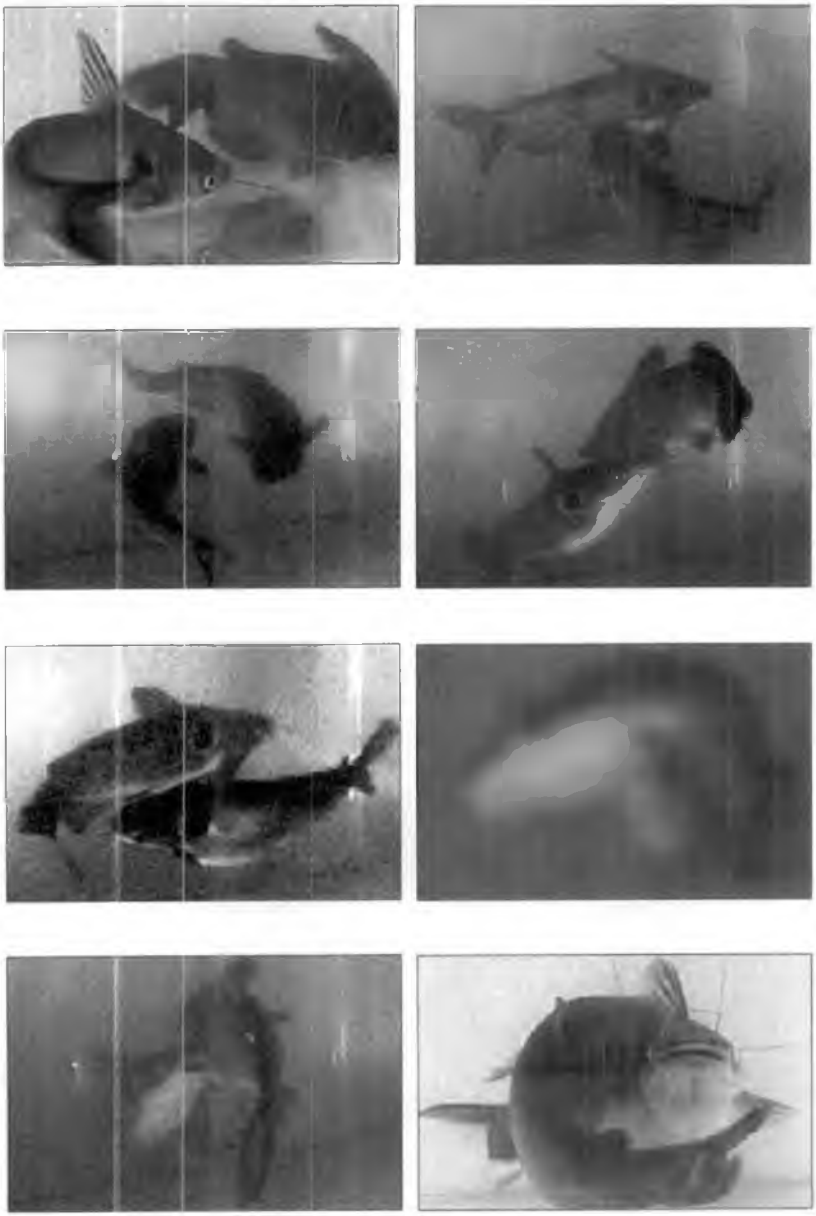
Phylum	:	Vertebrata
Class	:	Teleostomi
Order	:	Siluriformes
Family	:	Bagridae
Genus	:	Horabagrus
Species	:	*Horabagrus brachysoma*

Diagnostic features

Body moderately elongated and compressed at the tail region. Head large and anteriorly depressed. Abdomen rounded. Snout obtusely rounded. Mouth subterminal and with villiform teeth . Eyes large . Barbels four pairs. Adipose dorsal fin short and inserted far behind the dorsal origin. Caudal fin deeply forked.

Key to species: Occipital process extends to the base of the dorsal fin. Dark yellowish in color with black round blotch at the humeral region characterized by a light yellow ring.

Breeding behaviour in *Horabagrus brachysoma*



Ecological characterization

H.brachysoma or golden catfish mostly occur in riverine locations and lower reaches of the rivers of Meenachil, Chalakkudy, Pampa and Achencoil in southern Kerala. The species was found to abound fresh water habitats in the Vembanad lake at the confluence areas of these rivers. They occur in the granite side-pitching areas of the irrigation canals and the weed infested shallow locations in the Vembanad lake, flushed with riverine inflows, especially where submerged herbs of *Aponogeton* provide natural shelter habitats. As the fish prefer to hide in dark corners during day time and was observed to be more active during night hours, farm stocks were provided with hide outs comprising laterite blocks, broken pipes etc. The maximum size reported earlier is 50cm and in the present collection it is 42cm (800g).

Collection and transportation

H.brachysoma was collected from the riverine habitats of the lower reaches of the Pampa, Meenachil and Chalakkudy river systems in Vembanad lake, where this species contribute a seasonal fishery during rainy season. This species occasionally forms an important element in the fishery during rainy season, and are collected by gill nets and bamboo traps along the river courses. Broodstocks were also collected by drag netting and cast netting from shallow riverine reaches and were transported in FRP tanks. Being hardy but peaceful and nonjumping fish, it could easily be transported live in open country boats even without aeration.

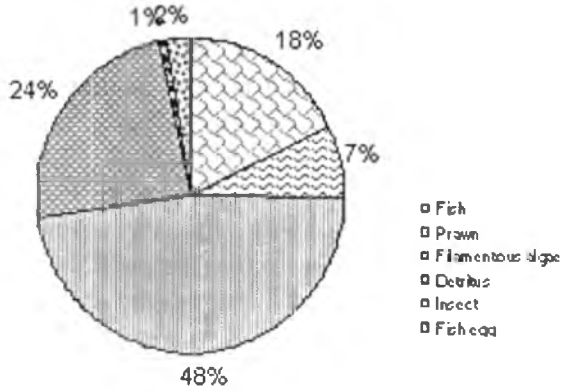
Male & Female broodstock

Food and Feeding

The fish is omnivorous, feeding predominantly on filamentous algae(48%), detritus(24%) fish offal (18%), prawns (7%), fish egg (2%), and insects (1%). No apparent difference in diet components was observed among various size groups. In culture system, the fish is found to accept commercial pellets and is found to relish kitchen waste

and domestic wastes.The gut content of specimens collected from riverine locations near inhabited areas were found to comprise predominantly such organic wastes.

Fig.3. Food composition of *Horabagrus brachysoma*



Reproduction

Sexual dimorphism

H.brachysoma is heterosexual. Sexual dimorphism is apparent among ripe fishes during the breeding season.Ripe females have distended and swollen abdomen and have bright red genital papillae during the breeding season. Eggs exude under slight pressure. Males however have a streamlined body, more bright and generally smaller in size. Fully ripe males exude copious milky milt on slight pressure. Amongst catfishes, this is one of the very few species that freely exude milky milt. The male to female sex ratio in catches was observed to be 1:2.3

Description of gonads

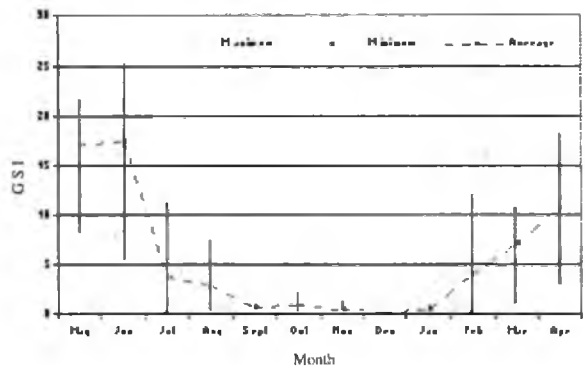
The ovaries are bilobed and asymmetrical; right lobe slightly bigger than the left. Mature ovary is light brown in colour and is highly vascularised. The testis is pale white and highly lobulated

Eggs in fully ripe females easily come out on slight pressure on the abdomen. The mature eggs of *H.brachysoma* is golden yellow,

glossy,heavily yolked, translucent and spherical with 1.6 to 1.7mm diameter

The Yellow catfish attain sexual maturity by the end of first year at about 17-18cm, in natural waters. However, under culture systems males were found to attain maturity even at 12cm(20g) and females at 13.5 cm(30g). The maturation phase begin in early pre monsoon and end in late monsoon suggesting the spawning period of the species from May to September. In nature, the fish was thus found to exhibit a protracted breeding during the monsoon season.

Fig.4 Gonadosomatic Index of *Horabagrus brachysoma*



The ripe and mature ovary at stage IV measure 3.6 – 7.5 cm in length. Mature testis are white in colour with a pinkish hue and measure 4.0 -8.7cm Fecundity of *H.brachysoma* range from 1140 to 123968. Gonadosomatic index for different size of females in the Vembanad lake varied from 3.49 to 29.67, as compared to 1.00 to 20.23 for fully matured and ripe males. Highest GSI for both sexes were observed during June and July immediately after the onset of monsoon. The mean spermatozoa count was $16.4 \pm 4.02 \times 10^9$ /ml.

Induced Breeding

Induced Breeding of this species was successfully accomplished at the Regional Agricultural Research Station, Kumarakom. Broodstocks raised in pond conditions were found to respond spontaneously to induced breeding as compared to fresh riverine collections.

Induced breeding by hypophysation was successfully accomplished by using carp pituitary gland (PG) @40-50mg/kg body weight or synthetic hormones (Ovaprim/ovatide) @1ml/kg body weight. Breeding set comprising male and female at 1:1 by weight or one female and two males in number was found to be effective, as the males are generally smaller, in this species.

Hormones were administered intramuscularly/intraperitonially. Males were provided with hormones at half dose of the female depending on the maturity condition of the brooders. The fish exhibit vigorous sex play and courting in 4 to 6 hrs and the induced fishes were found to breed in 8 to 14 hours depending up on the condition of the fish. Stripping method was also successfully accomplished after a latency period of 12-14 hrs, wherein the fully mature and freely oozing eggs are stripped out and fertilized with milt collected from the male. Dry stripping was found to be most effective.

Being hardy, the stripped fishes regain well after stripping and the males have been found to recoup the milting condition during the same season. The fertilised eggs of *H.brachysoma* is golden yellow, glossy, heavily yolked and translucent. The eggs are not adhesive, but free and demersal. After egg laying, the spent fishes were removed, the eggs collected and transferred to hatcheries or hatching trays with continuous flow of water and oxygenation.Eggs being smaller, conventional hatching hapas of mesh size 2mm can not be used for egg hatching.

As a part of the Gene banking of this threatened species, cryopreservation protocols for the milt was perfected for the first time, at this centre as part of this project, using Dimethyl Sulphoxide (DMSO) @ 10% as a cryoprotectant and modified HBSS as extender (Gopalakrishnan *et al.*, 2000)

Embryonic Development

The just extruded egg of golden catfish is spherical having a diameter of 1.6mm Embryonic development results in the formation of blastodisc and reach 16 celled stage with the fourth cleavage at about one hour, 32 celled stage at about two hours, and clear blastocoel begin to appear after 3 to 3.5 hrs. The blastula appears as a cap of cells over

Golden

Catfish

H. brachysoma

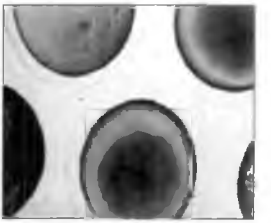
Sexual dimorphism

Hormon Administration

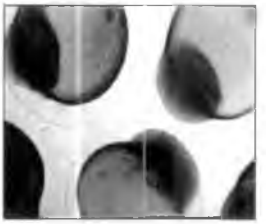
Stripping

Embryonic development in *Horabagrus brachysoma*

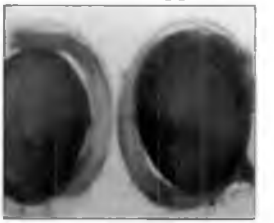
Fertilised eggs



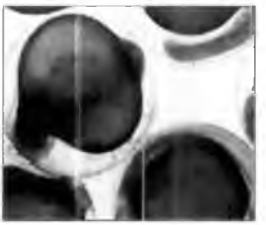
1 hr old egg



6 hr old

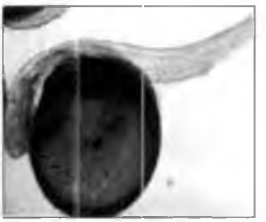


27 hr old



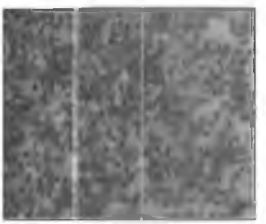
28 hr old

30 hr - hatching



Hatchling

Spawn



Hatchlings

Fingerlings

the yolk, and gastrulation is complete at 6 hrs. The germinal ring appear when the egg is 9 hrs old. At about 20 hrs twitching movement starts and rhythmic heart beat is appeared at 22 hr. The egg gradually begin to develop a creamy white periphery and embryo at this stage is found to be coiled around the yolk sac, with sporadic jerking movements. Just prior to hatching, rotary-lashing movements become vigorous and hatching occurs at 22 hrs and is protracted upto 30 hrs, depending largely on water temperature. The egg shell, over the dorsal side of the head breaks first and with vigorous lashing movements the larvae emerges out and the just hatched out larvae measure about 5mm

Table -2 **Developmental stages of *H.brachysoma***

Time after spawning	Developmental stages
01.00 hr	Blastodisc- 16 celled stage
03.00 hr	Blastocoel appear
06.00 hr	Gastrulation
09.00 hr	Germinal ring appear
14.00 hr	Notochord appears
16.00 hr	Optic vesicle formed
17.00 hr	Tail region detached from yolk
18.00 hr	Notochordal segmentation visible
20.00 hr	Twitching movement of embryo
21.00 hr	Heart become visible
22.30 hr	Heart beat visible
27.00 hr	Hatching

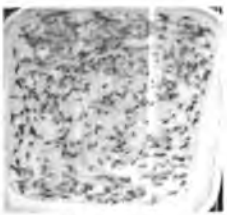
Hatching rate above 95% was achieved at water pH of 6.5 to 7. Hatching time was linked to water temperature and at higher temperatures(27^0C) hatching time was considerably reduced(22hrs). After hatching, hatchlings were separated and maintained in hatchling tanks. The hatchlings subsists on the egg yolk for 3 days and as the yolksac is fully absorbed the young ones are fed on artificial diets comprising egg custard and live plankton.Mass breeding of *H.brachysoma* under Chinese hatchery system has also been successfully accomplished, and the fish show a free mating behaviour.

Table -3 **Breeding protocols of *H.brachysoma***

Trial No	Fish weight (g) (2:1 ratio)		Hormone dose Ovaprim (ml)	Latency period (hr)	Fertilisation %	Hatching period (hr)	Hatching %
	Male	Female					
1	225	233	0.23	14	100	29	95
2	213	183	0.18	14	99	27	50
3	180	200	0.20	14	100	25	100
4	100	160	0.16	08	95	24	95
5	200	140	0.14	14	95	25	90
6	220	190	0.19	14	94	25	60
7	267	220	0.22	12	98	27	90
8*	230	320	0.33	08	50	22	06
9*	255	280	0.27	14	99	25	10
10	367	195	0.20	12.30	80	27	25

*fish PG @40-50mg/kg

Fry nursing



Fry stage

H.brachysoma spawn were reared in large open nursery hapas (5m x4m x1m) fixed in fertilised and manured nursery ponds. Feeding was done using egg yolk at spawn stage. Powdered compounded feed concentrate was utilized as feed supplements in addition to the live plankton. The fry/fingerlings were transferred to earthern ponds, 30-45 days after hatching. Fingerlings were also found to readily accept ground nut oil cake and rice bran mixture feed supplements.

Fry nursing is easily facilitated in earthen ponds. Ponds are prepared scientifically after removal of predators and are limed to neutralize acidity and manured with organic manure @5 tons/ha for production of plankton. The predatory insects in the aquatic

Hatchlings of Golden catfish

media are removed by spraying an emulsion of soap and oil mixture @ 56kg vegetable oil and 18 kg washing soap per ha. 12 -24 hrs before stocking the post larve and the prepared ponds are used for stocking of hatchlings @ 50-100/m^2. The seeds attain 6-7 cms, the appropriate size for open water stocking in 3 months.

This is the first report of captive breeding of Golden catfish, a potential food fish candidate species for aquaculture. These catfishes are highly valued for aquaculture owing to its omnivorous feeding habit, hardy nature and tolerance to high density farming situations. As the fish is capable of rapidly utilizing animal and slaughter house wastes, it will be a welcome addition to waste fed aquaculture systems. Owing to its wide tolerance to varying temperature regimes, this species is well suited to diverse agro- ecological situations.

Netting the farm reared stock

THE WALKING CATFISH
Clarias dussumieri dussumieri (Valenciennes)

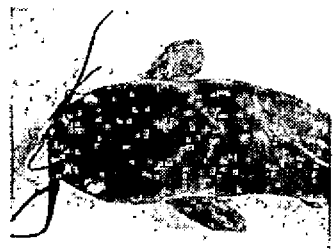
Local name : Naadan mushi(Mal)
Conservation status : EN
Distribution status : Endemic to Kerala
Distribution : Peninsular India
(Goa, Karnataka, Kerala and Pondicherry)

Taxonomy

Phylum	:	Vertebrata
Class	:	Teleostomi
Order	:	Siluriformes
Family	:	Clariidae
Genus	:	Clarias
Species	:	*Clarias dussumieri dussumieri*

Diagnostic features

Body elongated, compressed and abdomen rounded. Head moderate sized and greatly depressed, is covered with osseous plates dorsally and laterally, forming a cask covering to diverticulum of the gill cavity. Mouth terminal and transverse with villiform teeth. Barbels four pairs. Caudal fin is round.



Key to species : Distance from dorsal fin base to base of occipital process 2 to 3.5 times in head length. Snout broad. Nasal barbels not more than two times in head length. Dorsal fin with 66 to 69 fin rays and anal fin with 45 - 59 elements. Pectoral fin is strongly serrated on its posterior border. Colour: Dark brown on the back and pale below and flanks.

Ecological characterization

The fish inhabit derelict swamp waters in the wetlands, where organic debrits and rainwater accumulate and promote growth of abundant weeds. The fish has been found to abound in places where most other fishes are not able to thrive. The fish generally occur in water logged shallow areas with a loose peaty bottom, rich in decaying organic matter, retaining water and shrinking or drying up completely during summer months. The fish is observed to survive even in lower layers which are often completely deoxygenated. The fish once prevalent in Central Travancore mostly in coastal tracts has now become extremely endangered in the region owing to indiscriminate reclamation of the swampy wetlands and with the invasion of the exotic catfish, *Clarias gariepinus* in their natural habitats. Presently the fish is traced rarely in undisturbed and protected derelict water bodies , sewage pits *etc.*, often cut off, far from the main water courses.

C.dussumieri is piscivorous and also is also described as omnivorous feeding on a variety of food items, fish/crustacean flesh, copepods, ostracodes, oligocheates, dipteran larvae, gastropds, and aquatic plants. Maximum size reported is 50cm(3kg). In the present study, maximum size encountered in samples from coastal tracts of Alappuzha near the Pampa river system was 54cm, 1120g, much higher a size than the maximum (41.5cm and 450g) reported for the common species *C.batrachus* (Thakur and Das,1985).

Collection and transportation

C.dussumieri were collected with the onset of the first showers by placing traps in the migratory paths of rivulets connected to the confined pond systems in the sandy coastal tracts and derelict swamps adjoining the Pampa river systems. They were also collected from derelict ponds and wetlands in coconut gardens during annual pond renovation and desilting in summer. Live fishes were transported to farm in special brooder bags and raised to maturity in separate cement concrete ponds, as the fish is found to escape fast from earthern ponds in the low land situations. The fish was found to hide in dark corners and hollow crevices

and therefore the broodfish tanks were provided with protective hideouts and natural weed cover.

Food and Feeding

The fish is predominantly insectivorous and is a scavenger feeding on decayed organic matter though described omnivorous or even predatory. The fish subsists mainly on fish, insects and detritus, have biological and physiological adaptations to thrive in very low oxygen regimes. The food items include copepods, cladocerans, oligocheates, dipteran larvae, gastropds, aquatic plants and even filamentous algae. In culture systems, brood stocks were found to accept commercial feeds containing fish meal, forage fishes and fish offals. The fish doesn't appear to have a preference to a particular diet but feed on any food like material that happen to come across its way.

Reproduction

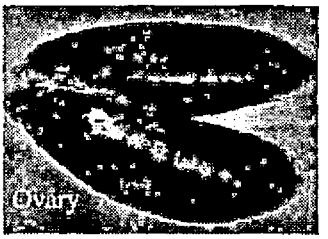
Sexual dimorphism

C.dussumieri is observed to be heterosexual, and sexes can be distinguished by secondary sexual characters becoming prominent during the breeding season. In males, the body is slender and streamlined, genital papillae is conical, long and pointed becoming prominently large during the breeding season. Fully mature females have soft, swollen and highly distended abdomen, genital papillae is short, oval and slit like and is drawn inside when pressure is applied. During the breeding season, the vent in female appear highly vascular unlike male which looks pale and slender. Sexually mature and ripe females are identified by easy extrusion of eggs when pressed on the abdomen. Ripe males cannot be easily selected as it doesn't discharge milt with any manual pressure and the milt is watery. In ripe males, the tip of the genital papillae is conspicuously firm and vascularised.

Description of gonads

Ovary of a ripe female is dark brown in colour, ventrally placed, considerably swollen, occupying almost 60-70% of the abdominal cavity even extending upto the base of the heart. The ovaries are bilobed, right

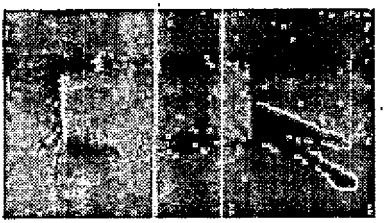
lobe slightly smaller than the left. Testis is leaf like and lobulated, located dorsal to the alimentary canal.The extruded eggs will appear yellowish brown with a clear germinal vesicle when viewed under microscope. Yolk occupy almost three fourth of the egg mass and mature egg vary in size from 1.15 to 1.65mm.



Maximum fecundity of 65258 was observed for a fish of size 43cm,550g with gonadosomatic index 24.4, during June. However, a female of size 200g was found to lay only 5148 eggs in the induced breeding trial.Maturity studies indicated that this species has a single spawning season coinciding with the monsoon. In nature, the fish breeds during the first showers with the accumulation of fresh rainwater in their habitats. During this season, the fish is seen migrating to nearby inundated ponds and rivulets on rainy days, crossing even long distances. With the break of the first monsoon showers, the fish in schools, traverses long land routes to reach the adjacent freshwater bodies when they are mostly caught. *C.dussumieri* is monogamous, a male courting with only one female, whenever more males were put with the females breeding response was negative.

Induced Breeding

Mature fishes of above 150-200g of over one year age, were selected for breeding. Fully mature brooders are selected by palpating the belly of the female for ovarian conditions and eggs come out freely on slight pressure. In the case of females, prime maturation can be ascertained by gently inserting a catheter through the genital papilla and sucking a few eggs gently. The eggs are examined under microscope; eggs with uniformly large size of 1 to 1.5mm are considered ripe and irregularly sized are considered immature. Uniformity in egg size is also



Single hideout for breeding

another criteria to judge the ripe condition for breeding. Mature males are selected by examining the genital papilla, which becomes more prominent and turgid as the maturity advances.

Induced breeding was carried out in 1.1 ton capacity fibre glass tanks filled with fresh rainwater maintaining a depth of 30-40cm. As the fish was found to hide in the exhaust pipes of the tank, separate hideouts were provided in the tank. Eggs being highly sticky, care was taken that only filtered water, devoid of dirt and suspended matter is used in the breeding tank. Being monogamous, brood fishes having equal body weight or one male and one female (1:1) was used as a suitable set for breeding. Induced breeding was accomplished through hormonal manipulation by intra-muscular administration of Carp Pituitary Extract (CPE). A series of trials on standardization of hormonal dose, indicated that carp pituitary extract @ 20-40mg/kg, administered in single dose is efficacious to induce ovulation. A slightly more than half of the female dose was administered to the males to induce them to courting. The standard practice of fertilising the eggs by stripping out milt from the male fish is not possible among *clarids* as the males do not milt freely by any usual procedure. The method adopted for *C.batrachus* has been to sacrifice the males and collect the milt extract from the crushed testis and utilize this prepared sperm solution to fertilise the stripped out eggs from females.

As the hypophysed *C.dussumieri* were found to remain sheltered and separated in the breeding tanks, a single hide out, 0.40 m long and 4" dia. PVC pipe, was provided to accommodate the breeding pair. This facilitated immediate and intimate contact of the spawners, facilitating courting and culminating in successful spawning. Owing to extreme rarity of *C.dussumieri*, this method of inducing natural spawning by hormonal and habitat manipulation was found useful to conserve the rare brood stocks. This procedure saved the sacrificing of very rare broodstocks.

Spawning in hypophysed fishes was found to occur after a latency period of 13 to 14 hrs and fertilisation rate of over 63-96% could be achived. The fertilised eggs were spherical ,heavily yolked, glossy , deep orange yellowish in colour and egg size varied from 1.3 to 1.6mm. The eggs are sticky and adhesive but easily removed by gentle water flow. The fertilized eggs were transferred to a flow-through incubation system, in shallow trays with a feeble flow of water . Unfertilized eggs that turns opaque and become buoyant are easily removed. At a water temperature of 27±1°C and pH 6.5 - 7, the egg incubation was completed in 16.30 hrs.

Embryonic development

The blastodisc begin to appear floating on the egg surface and morula stage is reached in 2 to 3 hrs. The germinal ring appears as a ridge, encircling the globular yolk in 4 to 5 hrs. Cerebral vesicles and notochordal somites become clear by 9th hour and by13th hr, the embryo remains encircled around the yolk and begin to exhibit vertical and lateral, twitching and rolling movements.By 14th hr, heart beat becomes conspicuous First hatching was found to occur at 16.30 hrs and all eggs hatch out in 19.20 hrs. The egg membrane becomes conspicuously thinner, close to hatching; tail emerge out first in the vigorous twitching movements. A hatching rate of up to 87-90% was achieved.

Table -4 **Developmental stages of *C. dussumieri***

Time after spawning	Developmental stages
01.00 hr	Blastodisc formation
03.00 hr	Morula stage
05.00 hr	Formation of germinal ring
06.00 hr	Embryo coiled around yolk
09.00 hr	Differentiation of head region, notochordal somites appear
13.00 hr	Twitching movement of embryo
14.00 hr	Heart beat clear
15.00 hr	Blood circulation visible
16 .30 hr	Hatching

The early hatchlings are demersal, with a heavy ovoid yolk mass hanging from the body ventrally. The spawn appear golden brownish in colour, congregate in quiet corners of the tank, away from the aeration points. As the hatchling development proceeds, the yolksac gets fully absorbed by the third day.

Fry nursing

The newly hatched larvae were served with artificial diets from the fourth day and the hatchlings were fed on chick egg yolk suspension for the first two days. Owing to the preference for live feed, the young ones are provided with freshly hatched artemia nauplii of size, 20-25u *ad libitum*. From the tenth day onwards the hatchlings are weaned to supplementary diets comprising minced prawn meet suspension and dried tubifex blocks.Owing to the obligatory aerial respiratory habit and hanging behaviour of the fry, to reduce energy loss in the vertical trips to gulp atmospheric air, the advanced fry were raised in shallow water depth of 10-12cm initially which was gradually increased and maneuvered. Thus to ensured high survival. The unused food particles were siphoned off and water exchanged periodically. Fry nursing was carried out in cement tanks and the fry reached over 5cm in two months when they are transferred to open nurseries. In the rearing systems the fingerlings are fed on Higashi starter and fish meal.

Being a hardy, air breathing species that can thrive well even in oxygen poor waters, *C.dussumieri* is a high value species for aquaculture. With its high growth rate as compared to *C.batrachus*, and due to neutraceutical properties, this endemic fish is considered a high value substitute candidate species to the surreptitiously introduced exotic African catfish which has turned out to be potential threat to local fish fauna.

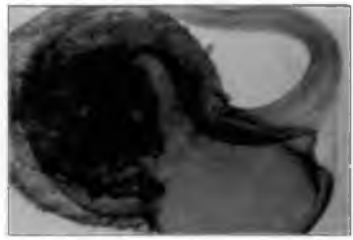
C. dussumieri fry

Clarias dussumieri

Embryonic development

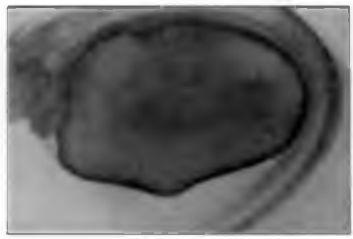
15 hr old egg

Hatching



Hatching....

Hatchling -8 hr old



15 hr old

36 hr old

Two day old hatchlings

Collection of Curmuca barbs from Western Ghats River systems

Sexual dimorphism in *G.curmuca*

RED TAILED SILVER SHARK

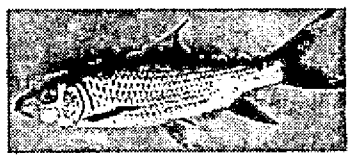
Gonoproktopterus curmuca (Hamilton-Buchanan)

Local name :Kooral (Mal) /Curmuca barb

Conservation status: EN

Distribution status :Endemic to Western Ghats, Kerala

Distribution :This fish occur in the hill streams of Bharatapuzha Chalakkudy, Periyar, Chaliyar, Bhavani, Achenkoil , Kallada, Pampa, Manimala and Moovattupuzha rivers of central Kerala and some of the reservoirs such as Malampuzha and Periyar.



Taxonomy

Phylum	:	Vertebrata
Class	:	Teleostomi
Order	:	Cypriniformes
Family	:	Cyprinidae
Genus	:	Gonoproktopterus
Species	:	*Gonoproktopterus curmuca*

Diagnostic features

This fish has a fairly deep body with convex dorsal profile and horizontal ventral profile. Snout is conical with a band of pores on the cheek. Eyes are moderate and mouth is sub terminal. Two pairs of maxillary barbels, lower one is as long as orbit, upper one is half as long. Dorsal fin is inserted anterior to pelvic fin. Scales are medium sized and lateral line has 38-42 scales.

Key to species: Last unbranched ray of dorsal fin is weak and articulated. It have a silvery colour , lightest on flank and belly . Caudal fin is tipped

with black (Talwar and Jhingran,1991) In young ones middle third of caudal fin is orange tipped with black. It has a deep black bar behind the gill opening (Menon and Rama Devi,1995).

Ecological characterization

This fish is found to inhabit in the hilly regions of rivers, usually in deep cool pools and shady parts and prefer running waters with moderately high to low velocities. *G.curmuca* is a sport fish and an excellent table fish. It lives and breeds in the hilly terrains but come down to the lower reaches for feeding. The fish breeds in small streams with sandy and weedy bottom. Males mature even at 10cm and females at 15 cm. Adults feed mostly on algae and occasionally on insect larvae. *G.curmuca* prefer cobble, gravelly, clayey, sandy and boulder filled substrate habitats and riffle reaches of western Ghats. Maximum size reported is 120cm.

Collection and Transportation

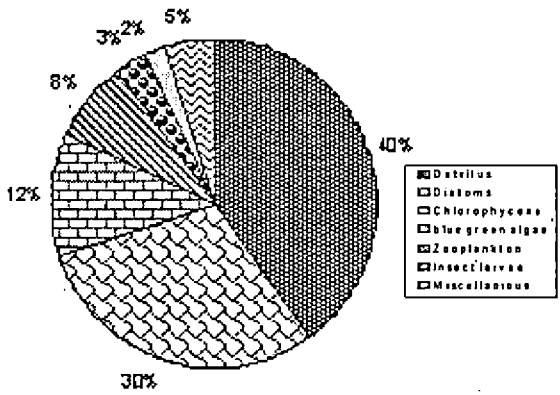
Collections were mostly made from the upstream reaches of Moovattupuzha river systems near Malankara reservoir and tail waters of Idukki near Moolamattom in Kerala. Natural stocks were also collected from Kallada and Pamba rivers. Being a fast moving hill stream fish, inhabiting the catchment areas of expansive reservoirs and their winding valley bottom waters, *G.curmuca*, were collected by gill neting and scare and drive method is most effective for this fast moving species. The trapped fishes were immediately transferred to FRP tanks fixed on trailer mounted vehicles and transported with oxygen cylinder attachments. Small sized fishes were transported in flexible polythene tube cylinders of 50cm diameter under oxygen packing. Being a jumping species and highly active the fish succumb fast if not handled gently.

Food and Feeding

Food and feeding studies of *G.curmuca* reveal that the fish is principally an algal feeder subsisting mostly on diatoms, green algae, plant detritus and occasionally zooplankters. Periphyton populations of pennate diatoms formed an important source of food in gut contents. In addition to plant material, rotifers, cladocerans and insect larvae

were also encountered as incidental food items. The fish has also been reported to feed on chlorophyceae, blue green algae and copepods.

Fig. 5 Food composition of *G.curmuca*



Reproduction

Sexual dimorphism

Sexual dimorphism in *G.curmuca* is perceptible only during breeding season. The males are slender with streamlined body and exude milky milt with slight pressure on the abdomen. The males were also characterized by a band of (2-3rows) of vascularised maxillary tubercles extending from the pre-orbital along the cheeks on either side. Most interestingly, immediately after breeding the tubercles loose its sharpness and brightness. The females are characterized by swollen and distended abdomen.

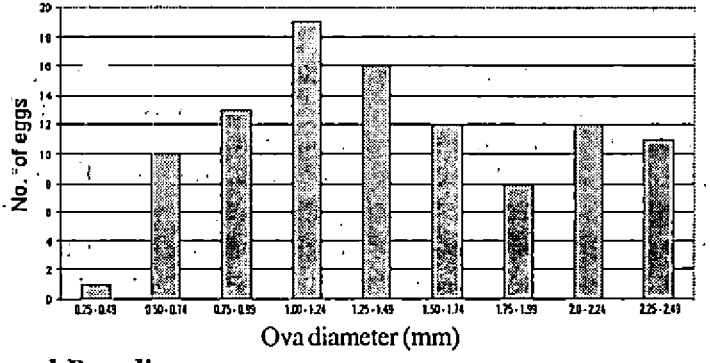
Description of gonads

Ovary is blobbed and asymmetrical, right lobe being smaller than the left, located immediately ventral to the air bladder. During the breeding season, ovary appear distended occupying almost half of the body cavity. Ripe ovary appear orange yellow in colour with close ramifcation of blood vessels. Mature ovary for a fish of 23.5 cm (140g) measured 7cm in length. Testis is bilobed, creamy white in colour and almost symmetrical extending to below the heart on either side of the air bladder and remain attached by mesenteries. The mature egg of

G.curmuca is heavily yolked and yellowish in colour. The eggs are uniformly spherical and their size vary from 1.3 to 1.6mm.

Fecundity of *G.curmuca* range from 6231 to 10729 in the collections from Moovattupuzha river system. Gonadosomatic index of mature females varied from 2.75 to 8.79 and that of male from 0.42 to 1.42. However, the realized fecundity of a 200g female subjected to induced breeding was only 3280. Frequency distribution of ova indicated two modes. Two clutches of eggs were observed in the same ovary (Fig.6) in almost all the specimens indicating that the fish spawns at least twice in a year. Major breeding season apparently coincides with the colder months from December to February with characteristically high G.S.I. during this season. The appearance of new recruits during early post monsoon months and also during pre monsoon months corroborate these observations. The sex ratio indicated an apparent skewness in favour of females and the mean ratio between males and females was observed to be 2:3.

Fig. 6 Distribution of eggs in a ripe ovary of *G. curmuca*



Induced Breeding

Mature brooders with perceptible sexual dimorphic features were selected for breeding. The fish could be successfully bred in captivity by hypophysation using carp pituitary extract @30-37.5mg/kg body weight for females and half the dose for males, administered intraperitonially. For this, mature females of 200-300g size and milting males with an average weight of 100g were utilized. Captive breeding trials were taken up corresponding to their natural breeding season

extending from October to January. Hypophysed fishes were maintained in FRP hatcheries of 1.2 ton capacity, maintaining a water depth of 60-70 cm at temperature 24±2°C and pH 6.5-7.0. When the hypophysed fish failed to breed naturally in the confined laboratory situations, artificial fertilisation by 'stripping' was resorted after a latency period of 20 hours. Fertilisation rate of over 94% was achieved in the dry stripping method. The fertilized egg is almost spherical with a diameter of 2.0 – 2.5mm, becoming transparent and golden yellow after fertilization. The eggs are heavily yolked and yolk occupied almost three fourth of the egg mass. Fertilized eggs were incubated at temperature 24-25°C and pH 7.2 to 7.5.

Embryonic Development

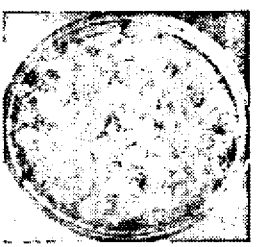
The embryonic development result in 16-celled stage in 2.0 hrs and morula stage in 3.5 hrs. The germinal ring become conspicuous after 17 hrs. Optic rudiments begin to appear at 21 hrs. At about 24 hrs, embryo movement become perceptible and rhythmic heart beat is visible at 22 hrs . The embryo appear coiled around the yolk at 26 hrs and the yolk sac is gradually extend farther into the tail region. After 32 hrs, twitching movement becomes more rapid. By 42 hrs, the tail elongates rapidly and appear coiled around the yolk. At this stage, circulation become clearly visible through the transparent embryo. Just prior to hatching, the embryo exhibits a characteristics rotary movement within the egg membrane which gradually becomes vigorous and hatching occurs at 44 hours. During hatching, tail emerges first and the hatching process is highly protracted and is completed only in another 12 hours. Hatching rate varied from 63-83%. The newly hatched larvae , are transparent and golden yellow in colour with size, 6-7mm. The hatchlings are demersal and are found to congregate at the tank bottom close to the aeration point. Heavy yolk that occupied almost two-third of the larvae, get exhausted in five days. The hatchlings are transparent and elongatge with stellate chromatophores, arranged in longitudinal bands. The hatchling become active swimmers on full utilization of the yolk and are fed on chick yolk suspension from the third day.

Table -5 **Developmental stages of *Gcurmuca***

Time after spawning	Developmental stages
01.00 hr	4 celled stage
01.30 hr	8 celled stage
02 .00 hr	16 celled stage
03.50 hr	Morula stage
17 .00 hr	Formation of germinal ring
21.30 hr	Optic rudiment and vertebral somites appear
24 .00 hr	Head differentiation ; Twitching at intervals
25.00 hr	Cerebral vesicles visible
26.30 hr	Embryo coiled around yolk
27.00 hr	Yolk extends into the tail region
28.45 hr	Optic and cephalic regions conspicuous
31.50 hr	Twitching become more rapid
32.40 hr	Heart beat become prominent
34 .00 hr	Yolk, globular on head &as leafy flap on tail
40.15 hr	Embryo freely rotate in the cytoplasm
41.45 hr	Notochord become conspicuous
42.45 hr	Tail elongation rapid; blood circulation clearly visible
44 .00 hr	Hatching

Fry nursing

The young ones of *Gcurmuca* thrive well on live feed comprising newly hatched *Artemia* nauplii and cladocerans. Fry nursing was performed in FRP tanks of 1.1 ton capacity and the fry accept powdered rice bran and Higashi fresh/ commercial feed.

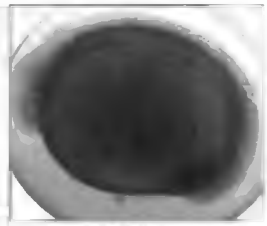


7 day old fry

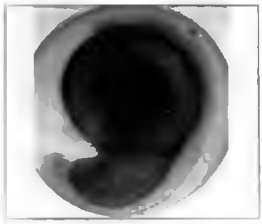
Curmuca barb is not only a high valued food fish, but it is also a cultivable sport fish of commercial importance for culture in hilly terrains and cooler waters. Owing to its bright black and red caudal colouration, the fish, popularly known as 'red tailed silver shark' or 'DMK fish' is also an attractive ornametal fish that fetch high price in the aquarium trade.

Embryonic development in *Gonoproktopterus curmuca*

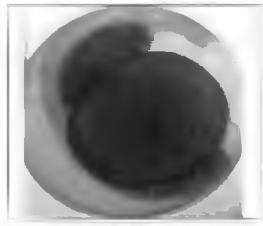
4 hrs



9.5 hrs

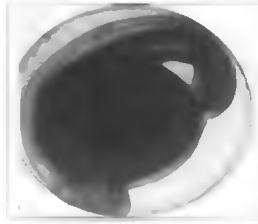


23hrs



27hrs

32hrs



37hrs

38hrs

43hrs

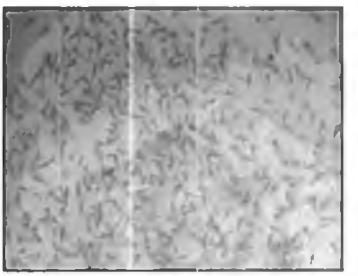
44hrs - Hatching

Hatchlings

Labeo dussumieri

Sexual dimorphism

Chinese hatchery system for captive breeding



Hatchlings

Fry

Finger lings of *L.dussumieri*

MALABAR LABEO

Labeo dussumieri (Valenciennes)

Local name : Tooli/pullan (Mal)
Conservation status: EN
Distribution status : Endemic
Distribution : Western Ghats of Kerala mainly Achencoil, Pampa, Manimala and Meenachil river systems and Kuttanad region of Vembenad lake and Sri Lanka

Taxonomy

Phylum	:	Vertebrata
Class	:	Teleostomi
Order	:	Cypriniformes
Family	:	Cyprinidae
Genus	:	Labeo
Species	:	*Labeo dussumieri*

Diagnostic features

Body is cylindrical or sub cylindrical and is elongated. Abdomen is rounded; mouth is sub terminal and transverse. Head is moderately sized. Snout is rounded or obtusely pointed. Lower jaw has a bony edge covered by lower lips which is usually fringed. Dorsal fin is inserted anterior to the pelvic fins.

Key to species : Dorsal fin with 12-14 branched elements. Lateral line is complete with 50-55 scales; barbels four. Dorsal fin is inserted midway between snout tip and caudal base. Caudal fin is deeply forked. Scales with a reddish centre, edged with a darker shade. A dull diffused dark spot on either side of the tail. Eight or nine parallel brownish stripes are present above and below the lateral line.

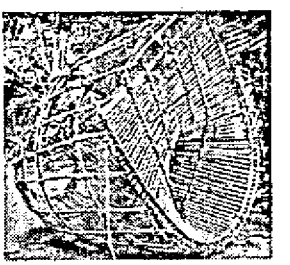
Ecological characterization

Labeo dussumieri is herbivorus and illiophagic in feeding habit. The fish feed by browsing at the pond bottom and subsist on detritus, decaying organic matter, diatoms, green algae and submerged aquatic vegetation. It is bottom dwelling in habit, and is categorised as a minor carp with reference to growth rate. It is a highly priced, excellent cultivable table fish. Two different populations have been identified to exist in the river systems of Vembanad lake. Populations collected from Manimala and Pampa has been found to exhibit a significantly different stock characteristics as compared to that of Meenachil river system. Larger sized specimens where always characteristic to Pampa river system. The species was found to abound in the upstream areas of the Vembanad lake and appear in good number in the fishery during the breeding season with the onset of monsoon. During the breeding season the spawners migrate to the flooded rivulets and wetlands for breeding, when they are fished in large numbers. During summer, the fish is found to thrive in the deeper waters in the upstream reaches of these river systems. This indigenous carp can be introduced as a substitute to bottom feeding Gangetic carps in freshwater fish culture systems.

Maximum size observed in our collections from Vembanad lake was 45 cm(1250 g) although maximum size reported earlier has been 55cm. The commercial size group in catches range from 19 to 43 cm and was predominated by 25 to 36cm in the fishery.

Collection and transportation

Brood stocks of *Labeo dussumieri* were largely collected during the breeding season coinciding with the break of monsoon. During this season fish appear in good numbers in the local fishery. Live fishes are collected using bamboo traps erected in the flooded rivulets. Spawners caught in the gill net collections succumbed faster due to rough handling. Maximum collections of *L.dussumieri* were possible from the lower reaches of the Meenachil



Fish trap

river system near Illikkal and Cherpunkal reaches and Kallungal from the Manimala river system.

Food and Feeding

L.dussumieri is herbivorous subsisting on mud, diatoms, chlorophyceae, green algae, submerged aquatic plants an detritus. They feed by browsing at the pond bottom. No significant preference for any particular diet was perceptible for diverse size groups. Intensity of feeding is poor during the monsoon coinciding with the breeding season when they are caught in large numbers.

Reproduction

Sexual dimorphism

Sexual dimorphism in *L dussumieri* is apparent only during the breeding season. Female can be identified by their distended and swollen abdomen and eggs oozing with slight pressure. The vent appear reddish and vascular in ripe females. Male have a streamlined body, exude milky milt on slight pressure. The pectoral fins of the males become rough during breeding season and is smooth in case of females, similar to that of the major carps.

Description of gonads

The ovaries are bilobed and slightly asymmetrical. Mature ovary is dark green in colour and is highly vascularised. The testis is pale white and is bilobed.

Presence of a distinct and a single mode of mature ova and only one clutch of mature oocytes in the ripe ovary is indicative of a total synchronous and short spawning habit of fish, with the onset of monsoon. The mature eggs of *L.dussumieri* appear greenish spherical with a diameter of 1.00 to 1.3mm

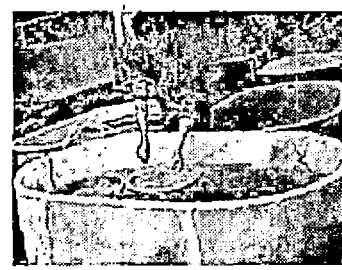
The fish was found to attain maturity by the end of first year at average size of 25.00 cm for females and 23.5cm for males. The male to female sex ratio was skewed perceptibly in catches with preponderance of males, and sex ratio was observed to be 3:2. The absolute fecundity of *L.dussumieri* range from 15198 to 2,50800. Gonado Somatic Index calculated for different lengths of females in the rivers adjoining

Vembanad lake varied from 6.17 to 30.4, close to the breeding season. Highest GSI for both sexes were observed during June-July. Spawning of *L.dussumieri* in river Meenachil was found to occur during monsoon, with peak breeding season during June –July and the fish spawns only once in a year.

Induced Breeding

Induced breeding by hormonal manipulation, by hypophysation has been described earlier (Kurup,1995). In this study successful spawning has been reported to occur at a hormonal dose of 8 mg /kg in females and 4mg /kg in the case of males as in two separate injections. In the circular breeding pools under the Chinese hatchery system *L. dussumieri* could be bred with carp pituitary gland at a minimum dose of 4mg/kg body weight. Synthetic hormones (Ovaprim/ovatide) @0.3ml/ kg in the case of female and @0.2ml/kg in the case of males, in single dose was also found to be the optimum dose for captive breeding. Mass breeding of *L.dussumieri* by simultaneous stocking of several sets of brooders and hormonal manipulation of 50-60% of the brood stock by sympathetic breeding was possible under Chinese hatchery system, where in spawning was easily facilitated in circular pools by providing circular and concentric water flow

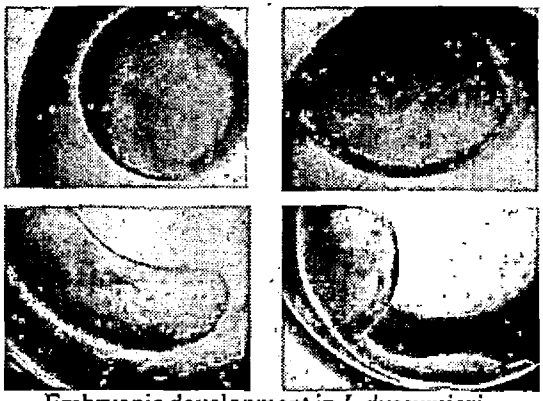
Under this system, the fish required only 40-50 cms water depths, both surface spawning with violent sex play and muffled spawning and with discharge of eggs and milt at the climax of estrus takes place under this system and higher fertilization rate is achieved. Spawning takes place in 9-10 hrs. The fertilized eggs of *L.dussumieri* is spherical translucent, demersal and non-adhesive with a diameter ranging from 4.0 to 4.5mm. Fertilisation rate ranged from 64 to 100%. The fertilized eggs are transferred to circular incubators of the Chinese hatchery system and hatching is facilitated in 10-12 hours ,with concentric flow of water @ 6-8 litres/sec as compared to 20-22 hours in the 'hapa' system. Hatching rate ranged from 80-100% in circular spawning pools.



Egg hatching was also performed in floating egg trays with continuous aeration and water exchange. The hatching rate was almost 100% under this flow-through system, facilitated largely through low volume stocking and superior water quality maintenance in such intensive egg incubation systems. Egg hatching is facilitated in 17-18 hrs.

Table - 6 **Developmental stages of *L.dussumieri***

Time after spawning	Developmental stages
00.30 hr	Blastodisc visible
03.00 hr	Morula stage
07.00 hr	Elongation of yolk mass
09.30 hr	Embryo coiled around yolk, elongation of tail, heart and notochordal segmentation more clear
11.00 hr	Twitching movement starts
18.00 hr	Hatching



Embryonic development in *L.dussumieri*

Fry Nursing

Hatchlings are transparent and free swimming; yolk get absorbed in 1-2 days and the spawn was transferred to nursery hapas in prepared nurseries. After a week, the hatchlings are released to previously prepared earthern fry nursing ponds and seeds were raised almost exclusively on natural planktons formed by manuring and supplementary

feeding by using rice bran, ground nut oil cake and powdered commercial pellets @ 3-5% of the body weight. Fry attain 7-8 cm in three months and are easily collected by fry nets

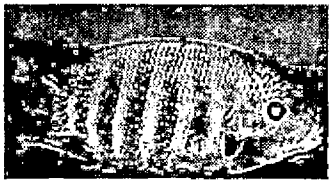
Mass breeding protocols under captive conditions and the cryopreservation techniques standardised for *L.dussumieri*, under a collaborative programme of the National Bureau of Fish Genetic Resources (NBFGR), Lucknow and Regional Agricultural Research Station (RARS), Kumarkom can form the basis for conservation management of this endemic species. Ripe specimens of 'Tooli' were collected from the Meenachil and Manimala rivers and transported live to the Kumarakom Centre and were used for cryopreservation studies (Gopalakrishnan *et al.*, 1999). On standardi- sation of cryo- preservation protocols the milt thus preserved has recorded high fertility rates and were found capable of producing viable and normal hatchlings

In openwater cage culture, under an intensive feeding regime with commercial pellets the fish has been found to attain 600 –700g during the first year. The fish commands a high price locally as compared to Indian major carps. Although, the life history parameters and breeding of this species has been studied earlier, in the present communication, the possibility of mass breeding of this species under the circular hatchery systems and enclosure fish culture found to be economical, is emphasized.

Cage reared *L.dussumieri*

THE PEARLSPOT

Etroplus suratensis (Bloch)



Local name : Karimeen (Mal)
Conservation status : LR
Distribution status : Endemic
Distribution : Western Ghats of Peninsular India and Sri Lanka

Taxonomy

Phylum	:	Vertebrata
Class	:	Teleostomi
Order	:	Perciformes
Family	:	Cichlidae
Genus	:	Etroplus
Species	:	*Etroplus suratensis*

Diagnostic features

Body is deep and laterally compressed, mouth small and terminal with a small cleft. Teeth villiform, present on both jaws. Palate is edentulous. Dorsal fin is inserted above the pectoral fin base; caudal fin is emarginate . Scales are weekly ctenoid.

Key to species : Body is light greenish with eight yellowish oblique bands on the body, the first passing through the occipital part of head and last across base of caudal. Scales above lateral line have a central pearly spot; possess some triangular black spots on the abdomen. Fins except pectoral are of dark leaden colour; the pectoral is yellowish with a jet black base. Anal fin has 12-13 spines and 11 or 12 soft rays. Specimens from salt waters are deep purple in colour with bands almost black.

Ecological characterization

The pearlspot, *Etroplus suratensis* is a high valued table fish endemic to peninsular India, inhabiting both inland and brackish waters. Owing to its wide salinity tolerance and omnivorous feeding habits, it is considered an ideal candidate species for fresh and brackish water aquaculture systems. The fish prefers a herbivorous diet, predominantly feeding on macro-vegetation, detrital matter, filamentous algae and occasionally insects and molluscan shells. The fish has high adaptability and ability to breed even in confined conditions.

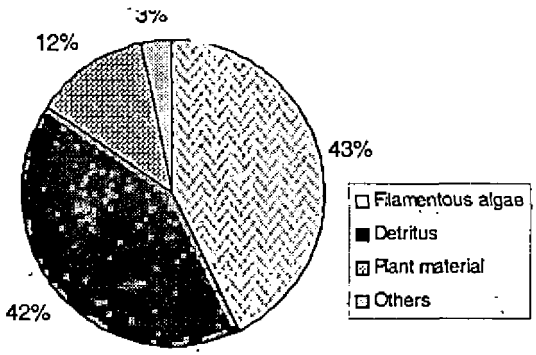
Collection and transportation

Broodstocks of *E.suratensis* were collected from the open Vembanad lake where the fish contribute to about 26% of the total catch using *peruvalai*(huge drag nets). The most dominant size group that occur the fishery was constituted by 16-18cm size followed by 18-20cm size groups. Collections were also made using cast nets by placing fish aggregating devices popularly known as '*Olivaippu*' whereby paired male and female fishes could be easily collected. Fishing by scare line method, although contribute significantly to the total catches of pearlspots, such fishes were not utilised, as the broodfish collected by this method easily succumb due to rough handling.

Food and Feeding

Food and feeding studies indicated that in nature, the fish prefer a predominantly herbivorous diet, comprising filamentous algae (43%), detrital matter(42%), macro vegetation (12%) and miscellaneous item(3%) comprising aquatic insects, molluscs *etc.*, in conformity with earlier findings. Young ones feed almost exclusively on zooplanktons and advanced fry thrive on filamentous algae, other vegetable matter and aquatic insect larvae. Jayaprakas (1980) observed that the adults prefer filamentous algae, diatoms and aquatic plants. Several earlier authors (Jhingran and Natarajan,1966 , 1969 ; Prasadam,1971; Kesava *et al*,1988) also observed preponderance of aquatic weeds followed by detritus and algae in diet of adult fishes.

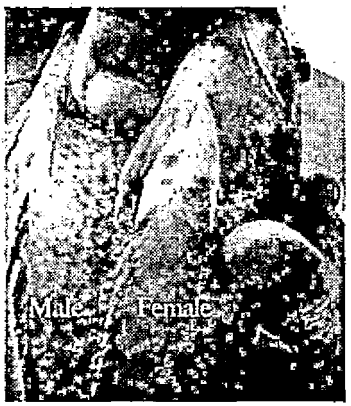
Fig. 7. Food composition of *Etroplus suratensis*



Reproduction

Sexual dimorphism

Pearlspot is heterosexual. No distinct sexual dimorphism is perceptible in this species, except during the breeding season. Females are generally smaller and has a muddy yellowish colour. Close to spawning, males have a greenish blue iridescence; pearly white spots and the color bands become dark and strongly marked and the fin rays become slightly reddish. Genital papillae in female is larger and broader, as compared to males where it is thin and pointed. In females, the genital papillae become much enlarged as an ovipositor close to breeding period. The fish is monomorphic and was found to form mating pairs close to breeding. Male to female sex ratio in catches was 1.1:1.



The fish attains maturity by the end of first year. In collections made from Vembanad lake, the fish was found to attain maturity at 14.5cm in females and at 16.9cm in males. The size at first maturity for this species in diverse environments has been reported differently by various authors. In earlier studies, the fish has been reported to attain maturity at 125mm (Thampi,1980) and 140mm (Jayaprakas

and Nair,1981) in Kerala waters while in Kali estuary, Karnataka the fish has been observed to reach maturity at 120 mm (Raju *et al*,1986). Pearlspot cultivated in pond systems has been reported to become mature at 100mm(Sumitra Vijayaraghavan *et al*,1981). The maximum size of the fish recorded in the present study in catches from Vembanad lake is 37cm(1200g).

Description of gonads

The ovary of *E.suratensis* is bilobed, lobes are more or less rounded, left lobe being slightly longer than the right and found suspended in the body cavity by mesenteries. Ripe and mature ovary is brownish in colour with high vascularisation; ovarian wall is thin, delicate and is easily rupturable. In mature fishes the ovary occupy almost half of the body cavity.

Testis Ovary

The testis of pearlspot is pale white, elongated and thread like. It is located on the dorsal part of the body cavity, originating anterio-dorsally, below the heart, extending posteriorly making a vertical dip and passing along the urinary bladder to join and open at the urinogenital papilla. As observed in the case of several cichlid fishes, the males do not freely milt.

The ripe and mature ovary at stage IV measure 5.5-7.0cm in length. Mature testis have dull pinkish hue and measure 7.0-10.5cm Fecundity of pearlspot is low, ranging from 1519 to 7554. The fecundity of pearlspot has been described differently by various authors and has been indicated to range from 506 to 6000 (Thampi,1980, Sumitra Vijayaraghavan *et al*,1981). Gonadosomatic index for different size groups of females in the Vembnand lake varied from 1.84 to 4.4. Highest GSI for both sexes was observed during April and June. Ovadiameter measurements indicated two distinct batches of eggs in the same ovary

implying that this fish belong to catogary C (Prabhu, 1956; Hickling and Rutenberg, 1936) *i.e,* spawning twice a year. The two G.S.I peak during June-July and March–April also conform to this findings (Fig.8). Pearlspot was reported to breed almost round the year in Vembanad lake, with peaks during Dec.-February and June-July (Krishnan and Diwan, 1990).

Fig.8 Gonado Somatic Index of *E.suratensis*

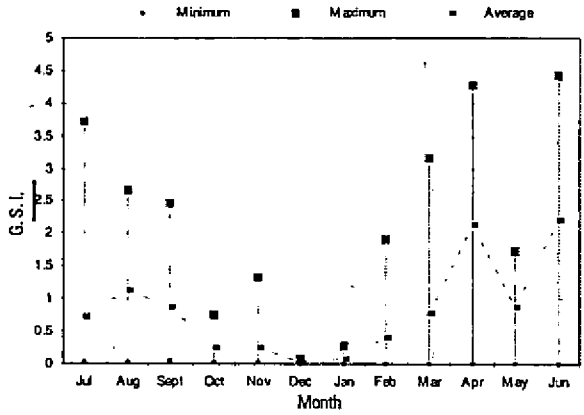
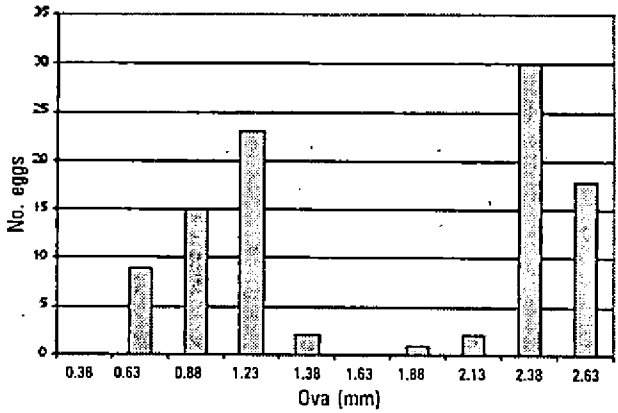
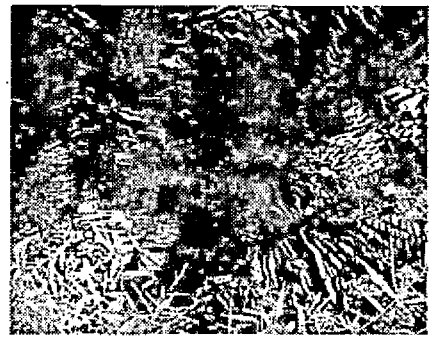


Fig.9 Frequency distribution of eggs in a ripe ovary of *Etroplus suratensis*



Captive Breeding

Breeding behavior is unique among cichlids, such as *E.suratensis*, which involve a series of events such as pairing, nest making and parental care. Before pair formation, breeding fishes form groups, the largest being comprised of 20-30 members. From among the members, some become 'attached' and courtship commences between such pairs. After pair formation, the paired couple search for solid objects, submerged in water for attachment of their adhesive eggs. Stones, coconut shells, coconut petioles, tiles, bamboo, wooden pieces or any other hard objects will serve this purpose. Materials submerged at depths less than a metre and raised sufficiently above the ground level are preferred. The nesting surfaces are cleared off, attached algae by browsing over the substrates and once this work is over, in 3-5 days, the courtship begins and the female lies flat to the spawning site and gently move from side to side. The eggs are attached carefully, one by one in a single layer with the help of it's cup like ovipositor or genital papilla.



Pits in pond

The eggs are placed on to the nest surface by pressing closely with the ventral fins, helping the extrusion of egg one by one. After a few such extrusions, the males in a similar but quicker movement from one end to the other, hover over and sprinkles milt on the eggs and fertilizes them. The whole spawning process lasts for about 1-2 hours, during which the process of egg placement and fertilization is continued several times. The eggs are cemented to the nest in a single layer, closely, without touching each other. The number of eggs in one brood varies from 300 to 1200 and is generally around 1000.

After eggs are laid, the parent fish, mostly females brood over the fertilized eggs fanning and oxygenating the eggs with their pectoral

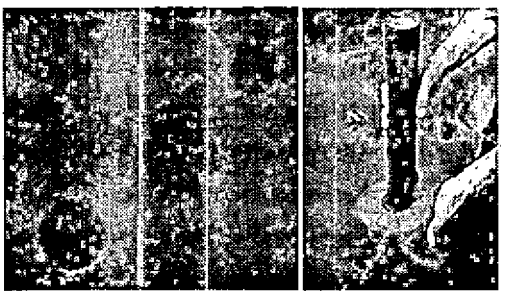
fin, engaging itself in active incubation of the eggs. Occasionally, the mother goes in search of food, leaving the nursing job to the male parent, who always guards the territory around the nest, remaining a little away from the nest, guarding and driving away any intruders. As the eggs are incubated, the parent fish makes a few cup like depression (*'thadam'*) on a firm ground, just below the selected spawning surface, by scooping out mud with their mouth. Both the couple participates in the process\

The male and female enter in hard labor, excavating several pits near the nest. These shallow pit nurseries measure about 4-6cm in diameter and 3-5 cm in deep. As the eggs hatch in about 75-80 hours, the hatched larvae are picked up by the mother in her mouth and transferred to the pits. The larvae are heavily yolked and sink to the bottom; a constant current of water is maintained over the pits by fanning the larvae with their fins and clearing off any adhering foreign particles on to the larval body. Approximately 7-15 pits are dug on the ground and the larvae are shifted from pit to pit and cared by the brooding pair. As the yolk gets absorbed and the pectoral fins become active, the parents lead out the hatchlings to the open water. The parental care is continued for some more time till the young ones attain about 4-5 cms.

Captive Breeding of *Etroplus suratensis* in Raceway system

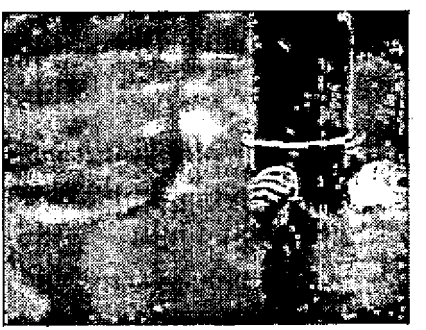
In the context that the fish exhibit a characteristic parental behavior, involving pairing, nesting and courting, captive breeding was facilitated by manipulating the breeding environment in a raceway system. The system consisted of a cement concrete trapezoidal tank of 14m x 4-6m with an area of 70 m^2. The floor slopes gradually from the broader end towards the narrower end, providing a depth of 0.5m at the broader end and 1m at the narrower end. The bottom of the tank is filled with sorted fine sand so as to provide natural soil base in the breeding

tank. The raceway breeding system is planted with cement concrete tetrapods and nesting surfaces of casuarina poles fixed on to movable cement concrete base. Artificial breeding pits of 6cm dia. and 4cm deep were provided for larval nursing. Tanks were filled to appropriate depth and a very gentle water flow is maintained. 'Attached' pairs were introduced in to the raceway provided with artificial nesting substrates for breeding. Pairing was encouraged by the simulated bottom substratum and soil base. In the light of observation that the breeding of this species in natural waters is linked to lunar periodicities, experiments on captive breeding were scheduled accordingly.



Artificial breeding Pits and Substrate

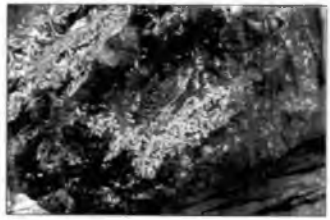
As the female completes egg laying, the nest containing the attached eggs were allowed to be incubated in the breeding tank facilitating natural parental care by the breeding pairs or are transferred to indoor incubation tanks for hatching. For this, the 'nest' along with the eggs were immediately transferred to the incubation tanks each of 1.1 ton capacity provided with continuous aeration. On hatching, the heavily yolked hatchlings instinctively congregate in the artificial pits provided on concrete base and are nursed in the larval rearing tank. Around 900 – 1200 eggs were produced per brood.



Pearlspot breeding under controlled conditions

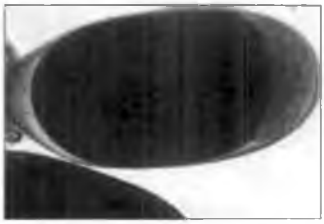
Raceway system for breeding *E.suratensis*

Eggs of Etroplus on different substrates



Embryonic Development - *E.suratensis*

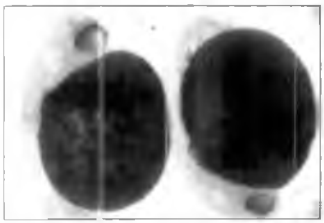
Attached Eggs

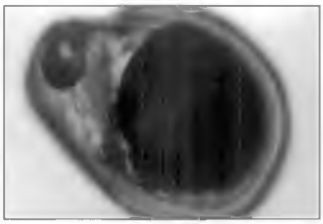


Developing Egg 5 hrs

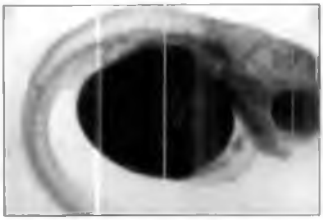
68 hrs

Hatching





Hatchlings



1 day old hatchling

5 day old

Hatchling pits '*thadams*'

Fry

and over 95% survival was obtained under artificial larval rearing system employed in this method.

Embryonic Development

The eggs of *E.suratensis*, is oblong in shape, demersal having a length of 2-2.5mm and width of 1mm, remain cemented to the nesting object by a stalk. The yolk is dark brown in colour. The blastula appears as a cap of cells over the yolk. Later a transparent crescent shaped area become visible on one side of the blastula which is the first sign of formation of embryonic membrane. The gastrulation commences when the egg is about 10 hrs. The formation of the germinal ring is slow, owing to the enormous quantity of yolk present. At about 18 hrs the germ ring is conspicuous on the equatorial plane, from the periphery of which the embryo extends anteriorly. At about 38-40 hrs heart beats rhythmically. During this time the embryo is found to almost envelop

Table 7 Embryonic development in *Etroplus suratensis*

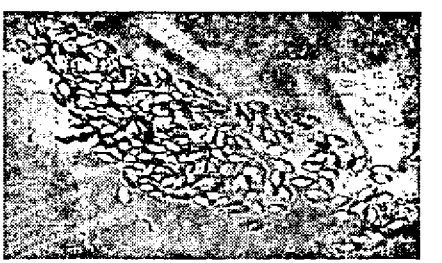
Time after Spawning	Developmental stages
1.00	Blastodisc appears
1.30	Two blastomeres
4.00	Blastula appears
18.00	Germ ring is conspicuous
38.00	Heart beating starts
42.00	Head and tail region more conspicuous
46.00	Cerebral vesicles are clear
48.00	Twitching movement starts
52.00	Tail become free
64.00	Embryo encircles 90% of the yolk
80.00	Hatching

around the yolk. Hatching takes place when the embryo is 75-80 hrs old. Over 80% of the hatching was completed by 98hrs and the time lag between the first to the last hatching was very high around 26 hrs. The egg shell above the dorsal side of the head breaks and the tail emerges out in the vigorous lashing movements. The larvae moves out and the hatched out larvae measure about 4.5 mm. The yolk is voluminous with large oil globules and the larvae sinks to the bottom.

The newly hatched larvae congregate in pits and corners with head down and tail up exhibiting lashing movements of the tail. The hatchlings is characterised by large eyes, pigmented all around the eye ball and is almost transparent throughout the entire trunk and tail region and has a spout-like snout typical of the species. As the yolk is fully exhausted, by about the 6th day, the larvae freely moves about and become capable of feeding on particulate food materials and become free living individuals.

Hatchling, *E- Suratensis*

Fry nursing

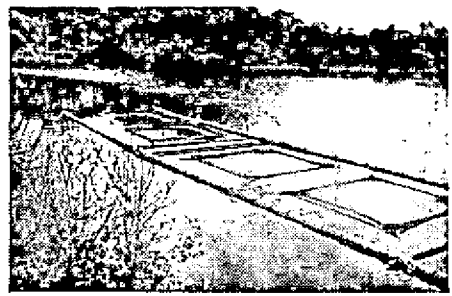


The larval development was found to be complete in 7 days, from the day of hatching. The yolk get fully absorbed by this time and the hatchlings attain an average size of 11mm. The newly hatched larvae, after the resorption of yolk, were fed on cooked and powdered chick egg yolk of appropriate particle size. The hatchlings were found to reach fry stage, in one month, when fed on cultured zooplankton and powdered Higashi-Fresh (Protein 20%). The larvae attain upto 3- 3.5cm in two months in tank. This invariably opens up a simpler technology

for mass production of seeds with least dependence on finer protocols of hormonal manipulation.

Cage culture of *Etroplus suratensis*

The culture potentials of *E.suratensis* was also probed under enclosure fish culture systems as the species has been reported to be a slow grower in pond culture systems growing hardly to 120-130g in pond fish culture systems in 8 to 10 months (Thampy *et al.*, 1981). Pearlspots(*E. suratensis*), was found to attain an average size of 250 g in 175 days in such openwater cages under an intensive feeding regime the seeds of pearlspots were stocked in polythene net cages of 3 - 4 m^3 fixed on floatng bamboo in the open lake. Being an ominivorous species, in addition to the commercial feeds, the fish also utilise filamentous algae and detritus. Probably the cage enclosures provide favoured substratum for the growth filamentous algae which form an additional food source for this species in enclosure systems. Owing to the algal browsing behaviour of pearl spot, this fish can be employed as a 'scraping' species in cage fish farming to control clogging of net cages.



Cage farming

Table -8 Growth performance of *Etroplus suratensis* in cages

	Stocking Density No/m^3	Period of rearing (days)	Average Size at				Maximum size at harvest		Survival (%)	Biomass accrual g/day	FCR
			Stocking		Harvest						
			Wt. (g)	Lt. (cm)	Wt. (g)	Lt. (cm)	Wt. (g)	Lt. (cm)			
1	44	175	62.5	11	250	21	400	23	70.45	1.07	4.61
2	230	182	32	8	185.7	19	325	20	86.95	0.84	3.05
3	110	166	50	9	200	20	350	21	100	0.90	2.91

As this species is a delicacy in Kerala with high market value, the fish has been subject to heavy fishing pressures in vembanad lake. And there is an organised fishery for this species. Natural recruitment of pearlspot is also severely hindered by human interferences and habitat disturbances caused by indiscriminate dredging of the lake bottom for sub soil lime shell deposits. Large scale reclamation of the shallow lake areas and the long chain of canals in the coconut gardens adjoining the lake that provide natural breeding habitats for this species, is yet another problem that limits their recruitment in the context that, the major constraint for taking up fishery enhancement programmes or utilization of this species in aquaculture is the lack of standardized technologies for mass production seeds by captive breeding and hatchery production is of immense relevance. In the context that the breeding habit of *E.suratensis* is unique, protection of their natural habitats is yet another strategy for conservation and enhancement of this species in natural waters.

FISH SANCTUARY

FOR *ETROPLUS SURATENSIS* IN VEMBANAD LAKE

The most valuable species are the once generally exploited to the maximum. With the boom in backwater tourism, Etroplus, the high valued food fish in Vembanad lake is subject to increasing pressures. This is evident from the decline in average size of this species in catches. The disappearance of the once luxuriant mangrove form- ations in the Vembenad waters, consequent to ecosystem alter- ations and its correlation with the poor breeding recruitment of pearlspot, *Etroplus suratensis*, indicate the direct inter relationship of fringe vegetation on natural recruitment of this species.

Habitat protection and management are recognized as the corner stone of fishery enhancement. To enhance, conserve and rehabilitate declining fisheries of pearlspots, utilizing the unique biological characteristics of the species, a 'fish sanctuary' for pearlspot (Karimeen), the first of its kind in the country, was established in open Vembenad Lake at Kumarakom on an experimental basis. For this, a circular area of 10ha was cordoned off by planting coconut and bamboo piles at close intervals. This notonly helped to hinder fishing by obstructing the operation of crafts and gears but also helped as a fish aggregating device. In order to provide appropriate water depths for nesting and breeding of *Etroplus*, artificial sand hills and valleys were formed by pumping dredged sand on the lake bed in the designated sanctuary. To facilitate natural breeding of the fishes, a variety of artificial 'nest' and 'reef' substrates such as half split coconut shells, large boulders of laterite blocks, specially designed cement concrete tetrapods and coconut piles were planted as 'paaru' and 'reefs'. These structures simulated breeding habitats for fish, in the open lake sanctuary. The substrates installed on the lake floor, provided nesting surfaces for fish, as the fish is known to attach

their eggs on underwater substrates.These substrates also functioned as fish aggregating devices and the feeding surfaces with the development of periphyton on it. While developing this system, the habitat requirements and spawning behavior of this species was taken in to consideration. Additionally, mangrove canopies were also developed around the margin of the sanctuary, by forming small islands using in filled up earth in cement concrete rings.

Although, the major objective of the fish reserve has been protection of a minimum spawning stock to ensure recruitment to fished areas, the spill over effects of the sanctuary by adult fish movement from fish reserve to the adjacent waters was perceptible in the fishing zones close to the sanctuary. Population census by visual fish counts and sighting frequency of pearlspot the target species in the designated sanctuary indicated that the fish utilize the sanctuary habitats and deposited substrate materials abundantly for breeding. The increased fishery recruitment and yield of fish, in the sanctuary zone during the succeeding seasons indicate this engineered breeding habitats are viable strategies for conservation of endemic fish species. With the increased availability of fish, the fish sanctuary zone in the lake has also become favored resting places for water birds. While developing this engineered habitats, cooperation of the local fisher communities were availed and their participation helped the maintenance of this system. Considering the social benefit of the system, the Kumarakom grama panchayat has come forward to support the maintenance of the system in partnership with fisher communities fisher communities.

Given the critical level of over exploitation of lake fisheries, the protective sanctuaries and engineered spawning habitats has been found to be a viable management option to maintain spawning stock and sustain fisheries. Although habitat management is recognized as the corner stone of fishery enhancement and is widely adopted in developed countries, where annual fish surveys are organised to monitor the stock, it is for the first time that such a model has been tested in our country. Since stock enhancement is not a programme to be started and left abandoned, a wider programme of fishery management by the establishment of a network of sanctuaries of the kind, is suggested for conservation of such endemic species, subject to heavy exploitation.

Artificial Substrates as Breeding Habitat for *E. Suratensis*

Depositing laterite boulders as substrates

Coconut shells as substrates

Cement concrete tetrapods as breeding substrates

Meenachil Fish Count - 2004




River-fish inventory in a participatory mode




BIODIVERSITY INVENTORY PARTICIPATORY APPROACHES

'Meenachil Fish Count 2004' - Know your river campaign

Background

Water is a favoured subject of debate across the world in the context of the projected scarcity of freshwater and its commodification globally. The devastating drought situation that crippled Kerala during 2003 has brought to light the dire need for conservation of the riverine resources. In most of these debates, the emphasis has been on the scarcity of water for human use. The very tragic erosion of endemic fish biodiversity resources in the river system consequent to drying up of the riverbed and the irreversible loss of this precious life forms seldom figured in these discourses. Damages to life forms are neither emphasized nor highlighted when assessing drought damages.

Located in the tropics, the state of Kerala is richly endowed with a warm climate and high rainfall distinguishable into two monsoons, all congenial for biological activity. The undulating topography and the several soil types result in innumerable macro and micro environments in these river systems manifested in rich fish diversity. The greatest threat to biodiversity was identified to be the ignorance and lack of awareness of what it really comprises.

It is in this background that the Kumarakom centre, NATP-fish Germplasm project with the support of the Kottayam Nature Society, the Directorate of Field Publicity, Govt. of India and the Department of Forests and Wildlife, Govt of Kerala, took up the attempt to inventorise the fish fauna of the river Meenachil. This is the first attempt of its kind in the country.

Approaches

The river Meenachil, the lifeline of Central Travencore lies between 9^0 25' to 9^0 55' N latitude and 76^0 20' to 76^0 55' E longitudes and is located in Alappuzha, Kottayam and western boundary of Idukki districts with a total length of 78km. The Meenachil river is formed by several streams originating from the Western Ghats.

The present study, Meenchil fish count 2004, was organized to focus attention on the critical problems of water, forest, land and biodiversity endowment of the river Meenachil.

1. The study aimed to identify the biodiversity strength of the river system and to inventorise the fish fauna, for conservation and utilisation
2. The study was also intended to monitor the major environmental variables in the river system and to identify the ecologically sensitive hotspot' areas for restoration/rehabilitation of the threatened species for conservation and management.

Methodology

Fifteen representative stations were surveyed along the 78 km length of the river on 4th April 2004 at the same time by 15 teams. The survey covered 1) Stream profile inventory, 2) Habitat inventory, 3) Resource use inventory, 4) Fish inventory and 5) River Environment Monitoring.

Although a variety of methods for stream inventory are available, the method described by Armantrout(1992) and followed by American Fisheries Society was adopted in the study. Over 200 participants from various walks of life, *viz.* naturalists, researchers, professionals and faculty members and students of Universities voluntarily participated in the count.The volunteered participants in each team comprised a minimum of three resource persons or fisheries professionals and a skilled fisherman. Each team was provided with a separate set of sampling equipment, fishing gears ,water analysis kits, data sheets and instruction sheets and a fish identification brochure to undertake the assignment scientifically. The river inventory work started at the stroke of 6.00 am at all stations on 4th April continued till 10.00 am or after covering a distance of 4 km riverine stretch. The teams for the upper stretches covering the high range tracts reached the point, the previous day and camped at the site to facilitate the work simultaneously at all fifteen identified reaches. Others stayed at the base camp at RARS, Kumarakom and reached their respective sites by 5.00 am.

Results and Discussion

1) Altogether 52 fish species were inventorised in the survey which included several endemic species such as *Barilius bakeri, C.micropeltes (Manal Waha), Labeo dussumieri (Pullan) , Batasio travancoricus and Gonoproktopterus curmuca(Kooral)*. Out of these, over 20 species were categorized as vulnerable, endangered, threatened or critically endangered as per the IUCN criteria.

2) In the context that the river was almost dry in most locations and was discontinuous, the observed species number, indicates the species richness of the system. Highest species diversity was noticed at Kidangoor- Cherpunkal tract, with its relatively high water column.

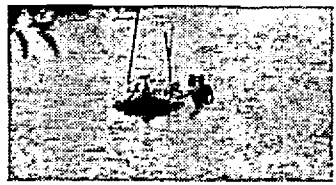
3) As expected, the fish species diversity was perceptibly high in reaches with rich riparian vegetation cover. The loss of vegetation on the banks in the upper reaches as well as of feeding streams like Pannagamthode in midland area have serious repercussion on the aquatic fauna

4) Environmental monitoring of the river system at different locations revealed that with reduced summer inflow, salinity has reached as high as 13.44 ppt at the Kaippuzhayar region close to the Vembanad lake. Incursion of saline waters far upstream the Kodoorar was perceptible. Abnormally high concentrations of Phosphates were observed in the static deep pools in the highland locations apparently exposed to detergents as these only residual water bodies were put to use as wash and bath Ghats by the local residents. Dissolved Oxygen concentration were extremely low at locations of organic loading and with the cessation of flow this situation was more conspicuous in the Poonjar region.

5) The greatest threat to fish biodiversity in the river systems has been the rampant sand mining at several places. However, even in such midstream stretches, the alarming reduction of sand cover to as low as 0 to 50cm has been highly distressing.

6) Dominance of exotics such as *Oreochromis mossambicus* (Tilapia) in pristine Western Ghat locations as Kolahala- medu has been a

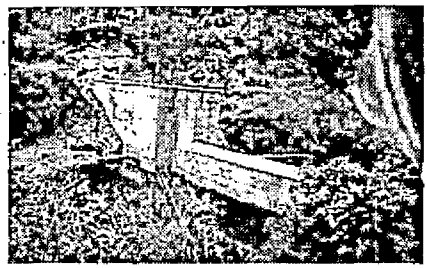
matter of great concern, especially since these highland locations of the river origin are considered virgin hotspots of endemic fish fauna.



7) Riparian encroachment is a serious issue in stretches along Kulathukadavu, Erattupetta, Kidangoor, Marottikadavu and Kavalippuzhakkadvu reaches.

8) Pollution from solid waste dumping was perceptible along riverine stretches at Erattupetta, Pala, Peroor and Thazhathangadi reaches. In the lower reach of the river at Kavanar, plastic waste and waste from the tourist boats were observed to pose serious threat to the river environment. Pollution from oil spills was also serious at this region, where residents complained that food fish taste crude oil. Effluents from rubber industries posed threat to the aquatic fauna at locations on the Kodoorar reaches.

9) Unscientific construction of check dams without provisions for fish ladder apparently affected the migration and proliferation of fish species in the river system.



10) Destructive fishing practices such as *Oothapidutham*, dynamiting, poisoning and use of destructive gears such as huge gill nets, observed in the Kodoorar reaches also posed threat to biodiversity.

11) Acid leachates with the surfacing of subsoil acidity from dried paddy land has been observed to cause serious threat to the aquatic fauna in the lowland reaches. During the first rains and with tidal ingression of high waters, this acid waters lead to mass mortality of river fishes. Unscientific land use practices of drying of lowland paddies after summer rice lead to the recurrence of this phenomenon.

12) Large scale removal of boulders and cobbles from the upstream reaches lead to rapid land slides and is a threat to the riverine environment as these substratum cover are natural habitats of a variety of highland fish species.

13) With the enormous publicity given to the ornamental value of several of the river fish species in the International ornamental fish trade, more recently the endemic fish species are being removed unscrupulously from these river systems for export. This pose a serious threat to several endemic fishes, as even the last fish is being picked up from these river pools during summer.

Table 9: Diversity and Endemicity of Fish Species in Meenachil

Sl.No	*Species*	Endemic to WG	IUCN Status	Family
1	*Aplocheilus lineatus*	√	NA	Aplocheilidae
2	*Ambassis gymnocephalus*		LRlc	Ambassidae
3	*Ambassis dayi*	√	EN	Ambassidae
4	*Amblypharingodon melettinus*	√	NA	Cyprinidae
5	*Anabas testudineus*		VU	Anabantidae
6	*Anguilla bicolor*		DD	Anguillidae
7	*Barilius bakeri*	√	VU	Cyprinidae
8	*Barilius gatensis*	√	NA	Cyprinidae
9	*Batasio travencoria*	√	EN	Bagridae
10	*Channa marulius*		LRnt	Channidae
11	*Channa striatus*		LRlc	Channidae
12	*Channa micropeltes*	√	CR	Channidae
13	*Chela dadyburjori*	√	DD	Cyprinidae
14	*Chela fasciata*	√	NA	Cyprinidae
15	*Danio malabaricus*	√	NA	Cyprinidae
16	*Danio aequipinatus*		LRnt	Cyprinidae
17	*Etroplus suratensis*	√	LR	Cichlidae
18	*Etroplus maculatus*	√	NA	Cichlidae
19	*Glossogobius giuris*		LRnt	Gobiidae
20	*Garra mullya*		LRlc	Cyprinidae
21	*Gonoproktopterus curmuca*	√	EN	Cyprinidae
22	*Hyporamphus limbatus*		CR	Hemiramphidae

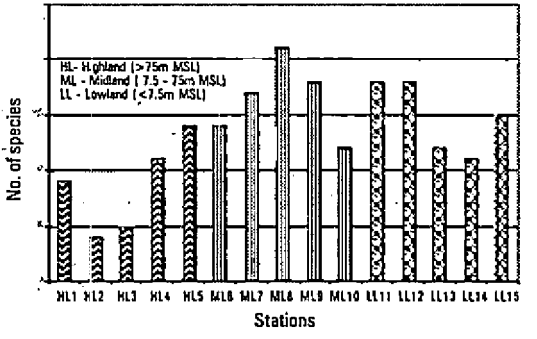
Sl.No	Species	Endemic to WG	IUCN Status	Family
23	*Horabagrus brachysoma*	√	EN	Bagridae
24	*Heteropneustis fossilis*		VU	Heteropneustidae
25	*Labeo dussumieri*	√	EN	Cyprinidae
26	*Lepidocephalus thermalis*	√	NA	Cobitidae
27	*Macropodus cupanus*	√	NA	Belontiidae
28	*Mastacembalus armatus*		VU	Mastacembelidae
29	*Mystus armatus*	√	NA	Bagridae
30	*Mystus cavassius*		LRnt	Bagridae
31	*Mystus gulio*		NA	Bagridae
32	*Nemachielus thermalis*		NA	Balitoridae
33	*Nemachielus triangularis*		LRlc	Balitoridae
34	*Oreochromis mossambicus*		#	Cichlidae
35	*Osteobrama dayi*	√	NA	Cyprinidae
36	*Pangio goaensis*	√	NA	Cobitidae
37	*Puntius amphibious*		NA	Cyprinidae
38	*Puntius fasciatus*	√	EN	Cyprinidae
39	*Puntius filamentosus*	√	NA	Cyprinidae
40	*Puntius jerdoni*	√	EN	Cyprinidae
41	*Puntius sarana*		VU	Cyprinidae
42	*Puntius ticto*		LRnt	Cyprinidae
43	*Puntius vittatus*		VU	Cyprinidae
44	*Periophthalmus*		CR	Gobiidae
45	*Rasbora daniconius*		LRnt	Cyprinidae
46	*Tetraodon travancoricus*	√	EN	Tetrodontidae
47	*Wallago attu*		LRnt	Siluridae
48	*Xenentodon cancila*		LRnt	Belonidae

CR : Critically Endangered, EN: Endangered, VU: Vulnerable , LRnt : Low Risk -near threatened, LR : Low Risk, LRlc : Low Risk – least concern, NA: Not Assessed, DD: Data Deficient √ - Endemic to Western Ghats , # - Exotic

Table 10: Water quality parameters in 15 different stations of Meenachil river on 4/4/04

Sl.No.	Stations	DO (ppm)	pH	Salinity	Alkalinity ppm	Hardness mg/l	Phosphate µg/l	Nitrate µg/l	Nitrate µg/l
1	Kolahalamedu	6.0	6.5	0.09	20	0008	1412.26	0047.73	322.47
2	Adivaram	7.6	6.5	0.09	48	0012	282.11	1050.00	031.46
3	Adukkom	5.2	6.5	0.09	24	0021	139.83	1384.09	070.78
4	Poonjar	2.0	6.5	0.09	72	0030	134.92	0420.00	353.93
5	Kalathukadavu	5.6	6.5	0.09	84	0008	149.64	0063.64	039.32
6	Erattupetta	5.6	6.5	0.09	24	0014	137.38	1185.22	055.05
7	Pala	7.6	6.5	0.09	72	0018	112.85	0031.82	338.20
8	Cherppunkal	7.6	6.5	0.09	28	0018	098.13	0047.72	314.60
9	Kidangoor	8.4	7.0	0.09	36	0020	122.65	0031.82	322.47
10	Peroor	6.8	6.5	0.09	28	0026	122.65	0031.82	314.60
11	Kodoorar	4.4	6.5	0.72	32	0126	090.77	0047.72	039.32
12	Thazhathangadi	8.0	6.5	2.62	28	0560	167.27	0031.82	306.74
13	Kavanar	4.4	6.5	12.81	28	2360	107.94	0159.09	306.74
14	Pennar	4.8	6.5	12.81	24	4000	103.03	0175.00	047.19
15	Kaippuzhayar	2.8	6.5	13.44	32	2340	103.03	0222.72	055.06

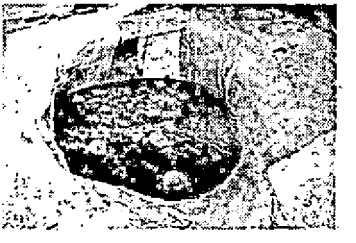
Fig: 10 Species richness in different reaches of Meenachil river



Recommendations

1) The Meenachil river system support a rich endemic fish fauna, amongst which several species are endangered and threatened which calls for concerted efforts for scientific conservation management.

2) In the context that the deep pools in the river system function as the last summer refuges of many a fish species, such pools or *kayams* may be categorized as protective sanctuaries and conserved.



3) As fish biodiversity is immediately linked to the riparian tree cover, there is a dire need for river bank afforestation, with appropriate local tree species.

4) Fish abundance is found to be directly linked to the water quality and the situation calls for an environmental surveillance system to continually monitor the system.

5) With the alarming decline of the sand bed and cessation of flow, the river system is virtually on death bed and its biodiversity endowments are in peril. As sand cover is the very life support system of the river, the situation calls efforts for a massive River Rehabilitation Programme to revive life to Meenachil

6) Introduction of exotics species in virgin stretches in Western Ghats should be strictly regulated.

7) Pollution from solid waste dumping was perceptible along riverine stretches at Erattupetta, Pala, Peroor and Thazhathangadi reaches and the situation calls for a massive 'Cleanse River' program and the polluters (including the panchayaths / Municipalities) should be made responsible for the damages.

8) Unscientific construction of check dams without provisions for fish ladder affects the migration and proliferation of fish species. Hence fish ladders should be provided in all check dams to facilitate fish movement.

9) Riparian encroachment is a serious threat to the river and it should be curtailed.

10) Lack of summer flows in the system appears to have been augmented with the diversion of water from Menachil to Idukki reservoir. This has also impoverished the fish diversity drastically at the upper reaches. This calls for a rethink on the inter basin transfer of waters.

11) Destructive fishing practices including *Oothapidutham*, poisoning, dynamiting etc. has to be checked at all cost and responsible fishing only encouraged.

12) Since dry paddy lands in acid tracts of Aymanam, Arpookkara,Kallara Kaipuzha and Kumarakomn region cause acid water leaching causing mass mortality of fish, these lands should be kept wet year round. Utilization of such rice polders as freshwater reservoirs will go a long way in the replenishment of fresh water resources.

13) Large scale removal of small boulders and cobbles from the upstream reaches also pose threat to the riverine environment as these substratum cover facilitate habitats for a variety of fish species. Hence it should be banned.

14) The recent practice of removal of endemic fish species in large numbers to be exported as ornamental fish pose a serious threat to the endemic fauna. Export of endemics from natural waters for which breeding protocols are not available should be considered as bio piracy and strictly forbidden

15) A massive river ranching programme of endangered fish species must be undertaken to rehabilitate threatened species.

Table 11: Life history parameters of selected fish species of the Western Ghats

Species	Feeding behaviour	Max. size in catches	Sex ratio	Max. G.S.I.	Breeding season	Max. Fecundity
H.brachysoma	Omnivore - small fishes, filamentous algae & detritus	650	3:7	29.67	May - July	123968
C.dussumieri	Omnivore - Fish, insects & detritus	700	3:4	24.4	June - July	65258
G.curmuca	Herbivore, Illiophagic - filamentous algae & aquatic weeds	500	2:3	8.8	Dec. - Jan.	10729
L.dussumieri	Herbivore, Illiophagic - Detritus, diatoms, green algae & submerged aquatic plants	1250	3:2	30.4	June - July	250800
E.suratensis	Omnivore - detritus & filamentous algae	1120	1.1:1	4.4	Year round	6624
C.micropeltes	Piscivore, predatory	1350	*	1.87	Aug. - Sept.	66000
W.attu	Carnivore / piscivore	8000	3:2	22	May - July	195215

* Data deficient

Table .12. Breeding protocols at a glance

Species	Breeding Season	Sexual dimorphism		Inducing Agent/ kg (body weight)*	Latency period	Percentage fertilization	Incubation period (hrs)	Hatching %
		Female	Male					
H.brachysoma	Monsoon (June – July)	distended & swollen abdomen,bright red genital papillae, eggs exude under slight pressure.	streamlined body, exude milky milt on slight pressure.	Ovaprim (1ml)Fish PG (50mg)	13-14 hrs	69 -100	24 – 30.	50-100
C.dussumieri	Monsoon (July)	soft, swollen & distended abdomen, short, oval and blunt genital papillae	body slender & streamlined, long, large & pointed genital papillae.	Fish PG (30-40mg)	13-14 hrs	49 -96	16-17	23 - 87
G. curmuca	Winter (Dec-Jan)	swollen and distended abdomen	slender, streamlined body and exude milky milt at slight pressure. characterized by a band of (2-3rows) of vascularised maxillary tubercles during breeding season.	Fish PG (30-37.5mg)	20 hrs	85 -94	44	64- 83
L.dussumieri	Monsoon (June – July	distended & swollen abdomen, eggs oozing with slight pressure, smooth pectoral fin	stream lined body, exude milky milt on slight pressure. pectoral fin -rough	Ovaprim(0.3-0.4ml)Fish PG (4mg)	6-8 hrs	64 - 100	20-22(hapa system)10-12 (Chinese hatchery)	60 - 100
E.suratensis	Throughout the year	generally smaller, a muddy yellowish colour; Genital papillae / ovipositor in female is large and broad	larger ,distinct colour bands with greenish blue iridescence and slightly reddish fin rays, G. papillae thin and pointed.	——	——	——	75- 80	2 - 70

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