Aquarium fish keeping is developing day by day, in a fast and steady track, leading the ornamental fish industry to international frontiers. It is all the while introducing new varieties of fishes and aquariums unseen till date today. In the modern era it is becoming the most popular hobby increasing demand for the supply of ornamental fish all over the world.

Ornamental fish keeping is more prominent in connection with fresh water species. Ornamental aquarium fishes that are involved in trade however are not limited to the freshwater resources but today the estuarine and marine forms are slowly creeping in due to the latest interest in keeping mini-reef ecosystems. The ornamental fish industry is therefore a multi-million dollar industry involving the collection, rearing, transport and sale across international boundaries.

The fishes for this trade come from niches located at the diverse nations. India is a treasure house of biodiversity. Fish species cultured and marketed in India are mainly exotic while those that are exported to international destinations are indigenous ornamental fishes that possess low value in the local market. The country has rich stocks of this indigenous ornamental fish and the state of Kerala possessing 44 rivers is considered as a hotspot of indigenous ornamental fishes.

Significant studies relating to the fish diversity in rivers of Kerala were those of Kadhar (1993), Ajithkumar (1999) and Thomas (2004). The distinguished works related to the fish diversity of Thrissur district were the works of Thobias (1973) on the fishes inhabiting in paddy fields and rivers in Thrissur district, Antony (1977), who accounted for the hill stream fishes of Thrissur district and the vital studies of Inasu (1991) who described the systematics and bionomics of inland fishes in Thrissur district.

However the present works is focused on elucidating the ornamental potential of the two rivers Keecheri and Puzhakkal for this rich resource could amazingly contribute to national economy. In the Kerala state and especially the Thrissur district, the trade itself is unheard of to the local people. Therefore the resources are currently exploited as a food fish, when on the other side; there exist an outlet for the international recognition and demand of the same species coupled with multiple gains.

In the district of Thrissur there exist 5 rivers which are Ponnnai, Keecheri, Karuvannur, Puzhakkal and parts of Chalakudy river. Of this the Keecheri and Puzhakkal rivers originate from the Machad range located in the Talapilly Taluk. There is no published data on the potential of indigenous ornamental fishes of these two rivers and this is a maiden work in this area.
Being positioned close to the international airport and with all resources necessary for the ornamental fish industry, a systematic study that would create database on the fishes that abode in the stream, their distribution, population dynamics and current trends of trade of available fish species would help take the industry to the international frontiers.

Culture based ornamental fish industry has already been started for many exotic fish in India still wild collections have greater advantage if the resources could be sustainably utilized. It will not only provide a continuous supply of new species but also provides a steady supply from the natural niches providing a means of income to the local people.

Although Kerala has abundant water resources accumulated with ichthyofauna the composition of the fish varies from district to district, habitat wise and even niche wise. Awareness of stock and spatio temporal occurrence provides strong foundation for the growth of the ornamental fish industry.

The present work mainly aims the study of indigenous ornamental fishes of Keecheri-Puzhakkal river system of Kerala, their distribution and market.

On account of the ornamental fish industry the fishes have to get transported across geological boundaries. However this necessitates live fish transportation. But there are several constraints in the live fish transport. Handling and packing create stress in the fishes. There are different containers used for fish transportation but nowadays polyethylene bags are immensely used for transport because of their compactness and easiness in handling. But still metabolic wastes accumulate in the water and create stress for the fish. Therefore methods to alleviate stress are highly essential. The present works also aims at identifying the loading density for safe transportation of *Etroplus maculates*, and analyzing efficiency of 2-Phenoxyethanol, Clove oil and Lemon grass oil for reducing stress of handling and packing in *Etroplus maculates*.

**Objective of the study**

The present work aims at developing a comprehensive data base on the indigenous ornamental fishes of Keecheri-Puzhakkal river system including studies on population dynamics of *Amblypharyngodon melettinus muriyadensis* and *Mystus oculatus* and evaluating role of anaesthetics in combating stress.

The goal of the industry could be realized only if the loss is minimized at every stage, therefore the present work was undertaken with the following broad objectives.
a) To record the fish diversity of indigenous ornamental fishes of Keecheri-Puzhakkal river systems of Kerala by conducting extensive survey and identify the ecological stability.

b) To identify the indigenous ornamental fishes possessing high potentiality as ornamental fishes and study the distribution pattern through seasons and places and identify the prospects of the rivers to promote the ornamental industry.

c) To study the population dynamics of *Amblypharyngodon melettinus muriyadensis* and *Mystus oculatus* to facilitate sustainable fishery. The study included computation of length–weight relationship equation, estimation of relative condition factor, sex ratio and distribution of maturity stages on a length group and month basis. This enables judicious collection of the species.

d) To evaluate the current trends in indigenous ornamental fish trade and estimate prospects of Keecheri-Puzhakkal river system in context of world trade. The Commercial fitness of fish species of Keecheri- Puzhakkal river system would enable identification of suitable species for trade.

e) To identify the maximum loading density of *Etroplus maculatus* for transport. To estimate the appropriate anesthesia dosage of 2-Phenoxyethanol, Clove oil and Lemon grass oil for short exposure and long term transportation. To determine the efficiency of 2-Phenoxyethanol, Clove oil and Lemon grass oil in combating stress in handling and packing by monitoring haematological indicators and assessing water quality parameters.

**Materials and methods:**

1. Fishes were collected from thirteen sites that included Kundukad, Thanikudam, Viyur, Puzhakkal, Enamavu, Vazhani reservoir, Machad, Mangad, Chiranellore, Madukara, Idianchira, Enamakkal lake and Chetuva estuary. Morphometrics were studied and fishes identified based on descriptions of available literature and databases such as Fish base online publication.

2. Species wise composition and distribution of indigenous ornamental fishes was studied by collecting fishes at regular intervals from fixed sites in the two rivers, Keecheri and Puzhakkal. Collected Fishes were subjected to diversity analysis to estimate Abundance, Dominance, Diversity, Richness, Evenness and Jaccard’s coefficient. Dendrogram was created to identify similarity and rank abundance plot was produced to describe the status of the habitat.

3. The length frequency data was created for the two species *Amblypharyngodon melettinus muriyadensis* and *Mystus oculatus* by measuring the total length of the fish. The fishes were
divided into groups of 5mm length and the data was tabulated. The Length-weight regression equation was computed for males and females. The parameters ‘a’ and ‘b’ of length weight relationship were estimated. Significance of difference between the regression coefficients of the two sexes at 5% level was tested by ANCOVA. Relative condition factor was estimated using the formula \( K_n = \frac{W}{w} \), where ‘W’ represents observed weight and ‘w’ calculated weight derived from the length-weight relationship equation. The different maturity stages during different months and along different length groups were estimated by assessing the changes in the ova diameter.

4. To estimate the decennial trends in ornamental fish export from India the export data from MPEDA was analysed and summarized in the form of tables. Graphs and suitable charts were prepared for the best interpretation. The recent inclination in export of different species of indigenous ornamental fish from India was analysed by preparing the check list of Indigenous ornamental species that are currently exported from India by perusal of MPEDA export data and customs data. The Commercial fitness of ornamental species was estimated by using the scoring method.

5. Studies on Handling and packing stress in fish transportation included firstly the estimation of appropriate loading density of *Etroplus maculatus*. Fishes were sorted into groups weighing 2±1g, 4±1g, 7±1g and 10±1g and packed in polythene bags filled with 1 litre water and survival of the fish were observed and recorded for 48 hours. The safety concentrations of anaesthetics 2-Phenoxyethanol, Clove oil and Lemon grass oil were assessed by determining induction times and appropriate dose identified. The blood was analysed to estimate haematological stress indicators that included plasma cortisol, plasma glucose, haemoglobin, erythrocytes and haematocrit. Oxygen, carbon dioxide, pH and ammonia in the water in packed polythene bags were estimated using standard procedure.

**Result and discussion**

1. **Icthyofaunal diversity**: A total of 140 fishes were obtained in the present survey from the Keecheri-Puzhakkal river system. 92 fishes were collected from the Keecheri river and 90 from the Puzhakkal river. Of the thirteen sites studied the Chetuva estuary possessed highest fish diversity followed by Puzhakkal site and the Enamakkal backwaters. *Dawkinsia filamentosa* was the only species found in all the sites invariably. Of the total 140 fishes that were collected in the present study 69 species were identified to be riverine
indigenous ornamental fishes. Six species were identified to be critically endangered and thirteen species endangered. Ten percent of the fish were identified to be endemic to Kerala.

2. **Spatial and temporal distribution of icthyofauna in Keecheri and Puzhakkal rivers:**
The results indicate that a strong pattern of longitudinal gradient was observed in the distribution of icthyofauna. The down reaches of the rivers had freshwater and secondary fresh water fishes migrating from estuaries. The abundance distribution of individuals collected per species sampled from the Keecheri-Puzhakkal river system is indicative of a typical left skew showing that most of the fish species are relatively rare and a few species alone are dominant. Species diversity and richness increased from upstream to downstream and they were high in the post monsoon and premonsoon season. Results of pair wise comparison show that diversity at Puzhakkal site was significantly high.

3. **Studies on population indices:** The total length of the *Amblyparyngodon melettinus muriyadensis* ranged from, 43mm to 110 mm while that of *Mystus oculatus* ranged from, 45mm to 110mm. Length-weight equations were computed, separately for males, females and sexes combined for both fish species. In the case of male and female the regression coefficient was found to be significant indicating that there exists significant relation between length and weight in both species. The length group 71-75mm predominate the catches in both *Amblyparyngodon melettinus muriyadensis* and *Mystus oculatus*. The sex ratio shows that females predominates the catch in both species. Teji (2010) conducted studies on reproductive biology and induced breeding of *Amblyparyngodon melettinus muriyadensis*. The present work is focused on natural availability of different stages of the fish for ornamental industry. The monthly distribution of different life stages of *Amblyparyngodon melettinus muriyadensis* shows that ripe female were observed in the catch from the month of February while spent fish were observed from March. The percentage of ripe female increased from March. The monthly distribution of *Mystus oculatus* shows that mature and ripe females were observed in the catches from the month of April. Studies on distribution of maturity stages indicate that the best time to collect the brooders is the premonsoon season for both fishes. The juveniles are abundant in the months from June onwards. The present study proves that both the fish species studied are available throughout the year and they could be collected for the aquarium industry prudentially.
4. **Indigenous ornamental fish trade:** The export of live ornamental from India during the period 2003-2012 indicates that the main importer was Southeast Asia, in terms of quantity and in terms of value. The check list of indigenous ornamental fish created in the present study shows that 380 native fishes possessing aquarium preferences are currently exported from India to worldwide destinations. According to the data on the indigenous fish exports from India during the period September 2012 to August 2013 the lowest export price was for *Pangassius pangassius* followed by *Trichogaster trichopodus*, whereas members of the family Channids recorded highest export price. While one hundred and twenty nine native species were traded from India during the period September 2012 to August 2013, it was identified that twenty seven species are sourceable from Keecheri-Puzhakkal river system. The ornamental potential of indigenous ornamental fishes of Keecheri-Puzhakkal river system indicates that *Aplocheilus lineatus*, *Etroplus maculates*, *Horadandia atukorali*, *Pethia punctata*, *Pseudosphromenus cupanus*, *Channa gachua*, *Channa marulius*, *Garra mullya*, *Etroplus suratensis*, *Parluciosma daniconius*, *Dawkinsia filamentos*, *Carinotetraodon travancoricus* have high potential as ornamental fish.

5. **Anaesthetic efficiency in combating stress in fish transportation:** It was identified that maximum loading density for juveniles of *Etroplus maculates* weighing 2 ±1g in one litre water and for 48 hours without anaesthesia was 50g while it increased to 80g, 90g and 120g for 4 ±1g, 7 ±1g and 10±1g size fish respectively. The results reveal that 60mg, 12mg and 8mg were the concentrations for transportation with anaesthetics 2-Phenoxy ethanol, Clove oil and Lemon grass oil for the 48 hour transportation. The analysis of plasma cortisol reveal that the cortisol value increased during the transportation experiment but it decreased after unpacking after 48 hours of transportation. The plasma glucose also followed the trend of cortisol that is, increasing after the start of the experiment and decreasing after 48 hours after unpacking. In the case of haemoglobin, erythrocytes and haematocrit the increase was gradual and the values remained high even after 48 hours after unpacking. The water quality changed during transportation with accumulation of carbon dioxide and ammonia and reduction in oxygen. However all three anaesthetic treatments indicated lower value for all the stress indicators evaluated. Therefore they were identified to be efficient in combating handling and packing stress in *Etroplus maculates.*