MARINE FISHERIES INFORMATION SERVICE

TECHNICAL AND EXTENSION SERIES

No.23
September 1980

CENTRAL MARINE FISHERIES RESEARCH INSTITUTE
COCHIN, INDIA

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

EEL CULTURE IN INDIA*

Introduction

In recent years great strides have been made in fish farming in many countries, augmenting fish production substantially. Eventhough the main objective of fish culture is to produce more protein-rich food, there has been an emphasis, particularly in the developing countries, on the culture of luxury table fish to step up exports. Eels *(Anguilla* spp) are considered as a luxury food and consumed as a delicacy in several Asian and European countries. The Japanese eel *(Anguilla japonica)* is cultured commercially in Japan, Taiwan, and South Korea and the European eel *(Anguilla anguilla)* in Italy, Denmark, West Germany, France, Holland, etc. For the first time in India, experimental culture of short-finned eel *(Anguilla bicolor bicolor)* was undertaken in 1971 by the Central Marine Fisheries Research Institute at its Regional Centre at Mandapam Camp. Following the encouraging results obtained in the preliminary experiment, a regular project work on the culture of eels was undertaken by the Institute in 1974 and since then experiments are being conducted to develop and perfect the techniques for the culture of the short-finned eels in running fresh water and in re-cycled running water. Since elvers are the starting point for eel culture, an investigation was undertaken in December 1975 to survey the rivers of the Tamil Nadu coast for elver resources. Besides, induced breeding experiments in eel, the first of its kind in India, was initiated in this Institute in 1980. The present report highlights some of the basic information on the Indian eels and their culture, based on the results of the experiments conducted during the period 1974–1980.

The eel and its life cycle

Most of the eels spend their entire life in the sea, but the species of *Anguilla* spend their life both in marine and freshwater environments. The freshwater phase of the eel is taken advantage of and exploited in eel culture. There are 17 valid species of *Anguilla* distributed throughout the world. In India two species namely the short-finned eel *(Anguilla bicolor bicolor)* and the long-finned eel *(A. nebulosa nebulosa)* commonly occur in estuarine and fresh waters (Fig. 1).

The important features of field identification of the two Indian species are as follows:

Anguilla bicolor bicolor: Head shorter; snout broad, lower jaw not prominent. Vomerine teeth reaching as far backwards as those on maxilla. Dorsal fin commences above vent. Colouration: Dark olive dorsally and yellowish ventrally.

Anguilla nebulosa nebulosa: Head longer; snout not broad, lower jaw prominent. Vomerine teeth do not extend as far as the maxillary teeth. Dorsal fin commences far in front of vent. Colouration: brownish

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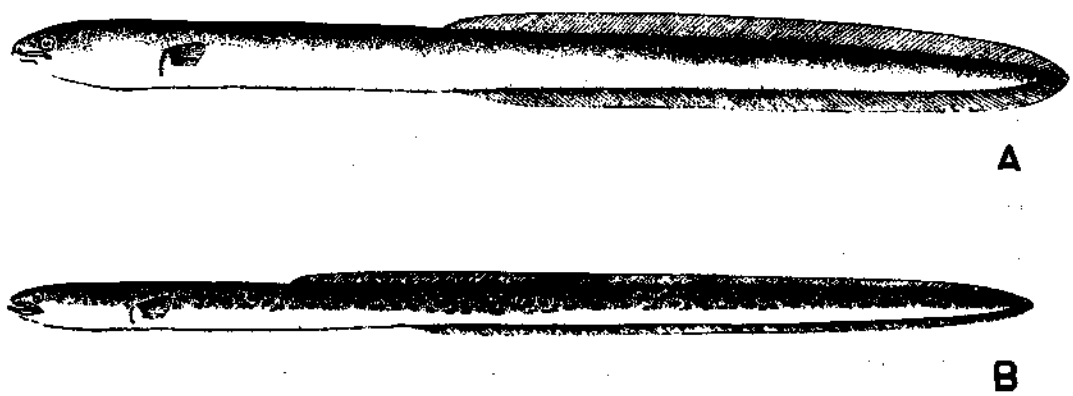

Fig. 1. A. The Short-finned eel, *Anguilla bicolor bicolor*
B. The Long-finned eel, *Anguilla nebulosa nebulosa*

dorsally, with black spots and blotches, some of which are continued on to the dorsal fin, and yellowish on the sides and ventrally.

As the life cycles of the different species under the genus *Anguilla* are more or less similar a general account of the same is given (Fig. 2). *Anguilla* spp. bread in the open sea at a depth of 400–500 m. After fertilization the egg hatches into a tiny larva, pre-leptocephalus and later becomes leptocephalus. The leptocephalus is transparent, leaflike with large number of myotomes and small, pointed head. The leptocephali are weak swimmers and their transport/drift from the open sea to the nearshore regions is effected by oceanic and coastal currents. The duration of the larval life in different species varies from three months to two and a half years. The leptocephali metamorphose into glass eels which are thread like and transparent (Fig. 3). On getting pigmentation the glass eels become elvers (Fig. 4) and approach the coasts. On entering brackish and freshwaters the metamorphosis is completed and the elvers in a few months become young eels. The latter grow in the brackish or freshwaters for some years and at this phase of life they are called yellow eels. On nearing sexual maturity the adult yellow eels cease to feed, acquire a silver colouration, leave the fresh and brackish waters and migrate to their spawning ground in the open sea where they breed. After spawning the silver eels are believed to die.

Thus, in the life history of the eel there are three phases viz., 1) marine larval phase (Letocephalus, glass eels, elvers), 2) freshwater phase of growth (yellow eel) and 3) adult marine phase of reproduction (silver eel).

The techniques of eel culture

It is necessary to adopt suitable techniques based on scientific study at all stages of eel culture as it will not only enable smooth and efficient management of eel farms but also will ensure high production and profits. Elvers are the starting point for eel culture. The seed elvers measure 55–100 mm in size and about 0.16–2.0 g in weight. They are collected from close to the banks of the rivers during night time with the help of suitable nets, when they ascend the rivers immediately after a freshet during October–March period. Very early stage elvers, known as glass eels, are completely transparent and thread like whereas the late stage elvers are pigmented and slightly thicker in size. The live elvers are transported in conventional fish tin carriers, specially made wooden boxes and in styroform boxes. In the initial phase of eel culture, elvers are stocked and reared in small indoor ponds which are known as elver

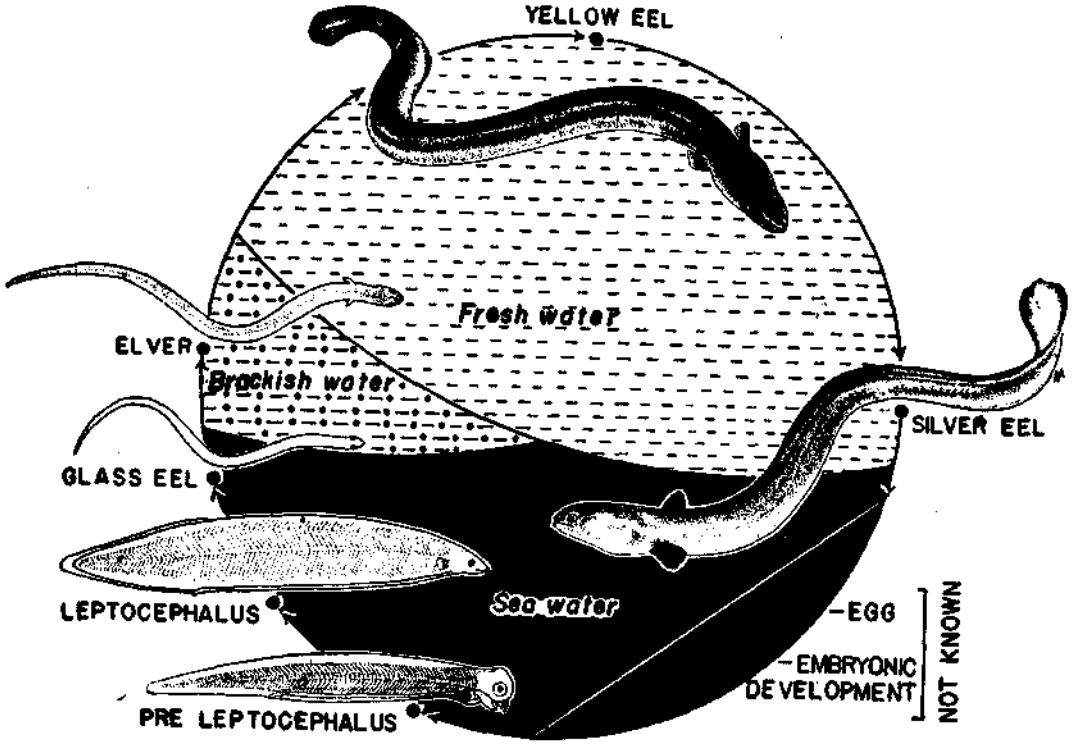

Fig. 2. Life cycle of eel

Fig. 3. Glass eels of short-finned eel

ponds. After about three months the grown up elvers are reared in bigger outdoor ponds known as fattening ponds. The optimum stocking density is 30 elvers, each weighing 0.16–0.2 g or 20 young eels of about 15 g per sq. m.

Artificial feeding is an important aspect in eel culture. Elvers do not take food for the first few days after their capture and they have to be slowly acclimatised to a regular feeding habit. Crushed earth worms are to be given to the elvers when they begin to feed and after about fifteen days a mixed feed of

Fig. 4. Pigmented elvers of short-finned eel

earthworms and fish meat. After about one month the growing elvers may be exclusively fed with fish meat. Elvers and eels prefer to feed in a dark place. Therefore the feeding place should be provided with a shelter. The feed is placed in a wire basket or tray and suspended just above the water surface to prevent contamination of water (Fig. 5). The elvers are given feed at a ration of about 30% of their body weight and the growing eels about 10% of their body weight Growth rate in eels is observed to be very rapid during April–October period. Therefore, it is advisable to give as much food as possible during the above period.

The success of eel culture also depends upon the proper maintenance of the culture tanks. The tanks should have a minimum water depth of about 60 cm. Even under optimum conditions of water supply, temperature, stocking density, food supply and maintenance, cultured eels exhibit a wide range in growth both in terms of size and weight. Therefore, at periodical intervals, in all stages of culture culling should be done which will ensure uniform size of eels at the time of harvest. Detection and eradication of diseases

Fig. 5. Cultured eels feeding in suspended tray

of the eel is another important aspect in eel culture. A general method of eradication of these diseases is to disinfect the water by chemicals or by completely flushing the tanks with large quantity of water. The introduction of concentrated dry feed facilitate mixing of drugs in eel food to control certain diseases.

The cultured eels (Fig. 6) are harvested when they reach marketable size which varies according to species and market demand in different countries. In Japan, the Japanese eel (*A. japonica)* is harvested when it reaches a weight of about 100 to 200 g which is attained in about two years from elver stage. The Taiwanese prefer comparatively larger sized eels than the Japanese and harvest when eels attain a weight of over 200 g. In Germany, the European eel *(A. anguilla)* is harvested when the male attains 150 g and the female 500–600 g. The production of eels per hectare varies with the type of culture method. In running water culture, eel

Fig. 6. Cultured adult short-finned eels

production is found to be about 4 times higher than that obtained in still water culture. The average yields realised from running water and still water eel farms in Japan are 26, 360 kg/ha and 6,120 kg/ha respectvely.

Culture methods

Eels are cultured in five different methods viz. 1) Still water method, 2) Running water method, 3) Recycled running water method, 4) Net preserve method and 5) Tunnel method. The first three methods only are commonly followed. In still water method the pond water will be more or less static and only about 5% of the total volume of the pond water is changed daily. The still water of the pond enables quick propagation and luxurient production of phytoplankton which in turn will increase the oxygen content of the pond by photosynthesis and thus provide a suitable condition for the eels to strive well. In the running water method, there will be a continuous flow of freshwater to the ponds and simultaneously an equal amount of water will be drained to keep the water level in the pond constant. In this method the eels are supplied with more oxygen through the constant flow of freshwater. In the re-cycled running water method, the same water in the pond is re-used again and again after filtration, sedimentation and oxygenation. The carrying capacity of the filter bed should be determined and the water quality checked at periodic intervals. The basic principle in eel culture methods is to rear eels in high densities in a confined area by providing extra oxygen and more suitable food to achieve maximum production in a short period of time. Depending on the facilities and quantity of water available, any one of the three methods could be employed in eel farming.

Elver resources survey

One of the pre-requisites for the eel farming is the availability of seed elvers. In India elvers of the short-finned eel and the long-finned eel are known to ascend the rivers Hooghly, Godavari and Tambraparni. The availability of elvers in the other rivers is not clearly known. Therefore, the Central Marine Fisheries Research Institute has undertaken a survey to assess the resources of the glass eels and elvers and in the first phase of the survey programme, the entire Tamil Nadu coast was surveyed during December, 1975 to December 1978.

During the survey three types of nets viz. scoop net, drag net and elver net were used for collection of glass eels and elvers. The survey was conducted in 81 centres between Cape Comorin and Pulicat lake. Fiftytwo centres were found suitable for elver collection and in 23 centres either glass eels or elvers were collected during the survey. The tail end shutters and/or the first anicut across the river from the sea side are found to be the most suitable place for the collection of elvers. In most of the rivers in Tamil Nadu the immigration of glass eels and elvers takes place in the month of November after the onset of the north east monsoon. The survey had brought to light for the first time the immigration of glass eels and elvers of *Anguilla* spp. in Rivers Vaigai, Vellar, Gadilam, Penniyar, Coleroon, Vembar, Tambraparni, in the creeks of Ervadi and Pillaimadam, in several seashore pools on the Gulf of Mannar side at Mandapam, Vedalai and Seeniyappa Dharga, in Kaliveli tank near the regulator at Marakkanam and Kadharshapad backwaters near Pamban. Based on the extensive enquiries made and the results obtained in the preliminary survey, the following centres are considered potentially rich grounds either for glass eels or for elvers: 1) Srivaikundam Anicut and Maruthur Anicut on the River Tamraparni, 2) Lower Anicut on the River Coleroon 3) Melayur Anicut on the River Cauvery, 4) Sethiyathoppu Anicut on Vellar river, 5) Thiruvendipuram Anicut on the Gadilam river, 6) Vallur Anicut on Karattalaiyar river, 7) Lakshmipuram Anicut on the Arni river, 8) Several seashore pools on the Gulf of Mannar side at Mandapam, Vedalai and Seeniyappa Dharga and 9) Kadharshapad backwaters near Pamban. By employing the most suitable net at right time and at right place it is possible to collect large quantities of elvers.

Running water culture of eels

At the Regional Centre of Central Marine Fisheries Research Institute, Mandapam Camp experimental

eel culture was conducted during 1974-1976. The short-finned eel (*A. bicolor bicolor*) was cultured in running fresh water in fibreglass tanks. The average size of the elvers at the beginning of the experiment was 13 cm in length and 3 g in weight. The elvers were stocked at a density ranging from 330 g to 1500 g per sq. m. At the end of eleven months the elver had reached an average size of 27.8 cm and 43 g. Monthly growth rate works out to 13.4 mm in length and 3.6 g in weight. The maximum size at the end of eleven months was 38.9 cm and 115 g. The overall survival rate for the first year was 87%. At the end of second year the average size was 38 cm and 119 g. The Monthly growth rate during the second year was 8.5 mm and 6.4 g. The maximum size of eel at the end of second year was 51.4 cm in length and 275 g in weight. The average size of the eel at the end of third year was 41.9 cm in length and 177 g in weight. During the third year the monthly growth rate was 3 mm in length and 4.5 g in weight. The maximum sized eel at the end of the third year measured 68 cm in length and 726 g in weight. It was observed that the length increase was faster in the first year and slower during the second and third years while the weight increase was more in the second year as compared to first and third years.

Food Conversion: Experiments were conducted to study the conversion efficiency of seven animal feeds that were compounded locally. Silverbelly and prawn flesh were found to give better conversion ratio (7 : 1) than the other feeds. The next best conversion ratio of 7.38 : 1 was for a mixed feed made of sardine and clam meat. The sardine alone gave the lowest conversion rate. Though silverbelly and prawn were found to give more or less a similar conversion rate, the former is considered to be the more suitable feed for the eel culture because of its cheap price and easy availability.

Production: In March 1974, 7.28 kg of elvers were stocked in fibreglass tanks having a total surface area of 6.65 sq. m. At the end of one year the total weight of eels was 22.22 kg with a net increase of 14.94 kg. At the end of second year the total weight of cultured eel was 34.61 kg. The net increase in two years from initial stocking weight was 27.33 kg. The net production in one year works out to 2.2 kg/sq.m and in two years 4.1 kg/sq.m. The eel production in outdoor tanks is likely to be higher than those obtained in this study. This is well reflected in the re-cycled running water eel culture, an outdoor culture experiment conducted in 1978.

Re-cycled running water culture of eels

The experiment was conducted in an outdoor cement tank (6 m x 3 m x 1 m size) with natural mud bottom. By sluice gate arrangement the bottom water in the culture tank was gravitationally drained out and passed through a biological filter. The filtered water was allowed to settle in a settling tank. The clear water in the settling tank was made to overflow to the oxidation tank. From the oxidation tank the water was pumped into a small over head tank and from there the water was fed to the culture tank. Thus, the same water was re-used again and again after filteration, sedimentation and oxidation. Weekly once about 1/3 of the water in the culture tank was drained out and replenished with new fresh water. Water level in the culture tank was maintained at 75 cm depth.

An effective feeding method was adopted in this experiment. A sheltered feeding area was provided on one side of the culture tank in the form of a wooden platform with a small door in the middle. The eel feed in the form of a paste, made of minced silverbellies, broken rice powder and ground nut oil cake powder mixed in 2 : 1 : 1 proportion with 0.2% multivitamin, was placed in a plastic tray and suspended through the door at water level. The eels in the culture tank would immediately congregate near the tray, climb over it, dart to the feed, take a mouthful and slip back into the water. After gulping the feed, the eel would again climb the tray and take another mouthful of food. This process is repeated until satiation when the eels would settle down at the bottom of the tank. The tray with left over food would then be lifted out through the door. By this method contamination of water by food was effectively reduced. The eels were fed at a daily ration of 5 to 10% of their body weight.

In the re-cycled running water culture tank, 9 kg of young eels (208 in numbers, ranging in size from 20 g to 65 g with an average weight of 43 g), was stocked at a stocking density of 500 g per sq.m. in August 1978. The average weight of the eel had increased from 43 g to 84 g in 31 days, 132 g in 61 days, 203 g in 122 days and 232.8 g in 163 days. The eels were harvested after 163 days and the total production was 47.8 kg which shows a net increase of 430% of the initial stocking weight. The survival rate was 98.56%. The net production rate works out to 2.15 kg/sq.m in about 5 months.

When 43 g size eels were reared indoor in fibreglass tanks they reached only to 76 g in about 5 months, whereas in an outdoor mud bottom tank, similar sized

eel attained a weight of 233 g in the same period. This clearly shows that nearly three times higher production than those obtained in the experimental culture in the laboratory could be obtained, if the eels are cultured in the mud bottom outdoor tanks.

The results obtained in the experimental outdoor tank in re-cycled running water culture system have been found to be very high as compared to the results obtained in experimental eel culture in Europe. In channel system 30 g weight European eel had reached only to 160 g in 12 months, and in river ponds 49 g weight eel reached to 109 g in six months. In Japan, the Japanese eel of 60 g weight attained marketable size of 150–200 g in about 12 months.

Disease

It is a known fact that as the intensity of fish culture operation increases there is greater chance of problems from fish disease. In eel culture about 20 types of diseases are reported from Japan. During the experimental culture of the short-finned eel in running water, seven kinds of eel diseases viz., fungus disease, tail-fin rot disease, gas disease, red pest and blotches disease, swollen intestine disease, gill disease and cripple body disease were identified. The fungus disease was observed in elvers on their body as an outgrowth of whitish grey mass spreading from the affected region. The tail-fin rot disease was noticed both in elvers and in growing eels. Mostly the glass eels were affected by the gas disease, when the O_2 or N level in the water was too high. By bringing down the temperature of the water by adding ice blocks the gas disease could be effectively controlled. The red pest and blotches disease was observed in elvers as well as in grown up eels; the visible symptoms of this disease are rash-like reddening of the body musculature, particularly near the abdominal and anal regions. The swollen intestine disease has been found to attack both the elvers and the growing eels whereas the gill disease and cripple body disease were observed only in grown-up eels. The incidence of eel diseases met with in the present experiments was insignificant. However, further intensive research work is necessary in order to develop suitable diagnosis and control measures of the diseases in large scale culture practices.

Export value of elvers and cultured eels

Elvers and cultured eels have a great export potential as there is a high demand for the same in Japanese market. Faced with short supply of elvers for culture

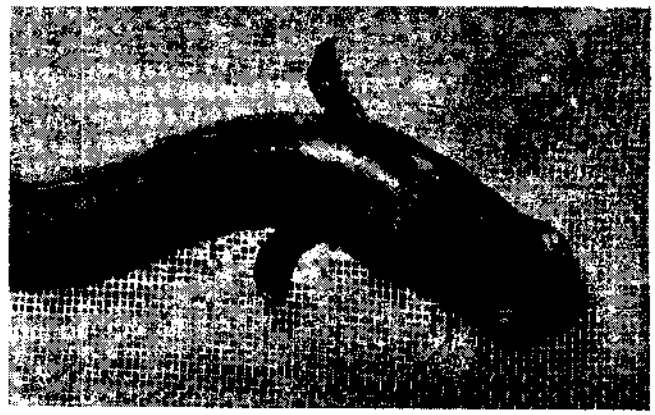

Fig. 7. Head portion of hormone-injected male

Fig. 8. Hormone-injected female

Purpose, Japan imports large quantities of elvers from many Asian and European countries. In 1971 Japan imported elvers worth $ 10 million. The wholesale price in Japanese market in that year ranged from $ 66 to $ 88/lb for elvers, from $ 35 to $ 50/lb for juveniles and from $ 2.5 to $ 3.0/lb for adult eels. Realising the export value of elvers and cultured eels, the Marine Products Export Development Authority of India came forward to finance a sponsored project on 'Elver Resources Survey and Eel Culture'. The project functioned from 15-11-1978 to 31-3-1980 at Mandapam Camp and Madras with the technical expertise of Central Marine Fisheries Research Institute. During the tenure of the first phase of the Project the entire Tamil Nadu coast was surveyed more intensively for elver resources, live elver and cultured eel transportation experiments were conducted and a sample consignment of 10 kg of cultured eels air lifted to Japan. Although India has fairly good elver resources they are practically unutilised at present either for culture or for export purposes.

Induced breeding in eels

Experiments on induced breeding in the short-finned eel (*A. bicolor bicolor*) were initiated in August 1980, with the adult eels of about 6½ years old, cultured in the laboratory in running water from elver stage. The male and female eels were gradually transferred from fresh water medium to sea water in three days period and later on maintained in sea water aquarium tanks for 75 days to get acclimatised to the marine environment. The Carp pituitary and two hormones viz., Gonadotrophin F.S.H (Follicle Stimulating Hormone) and Gonadotrophin L.H. (Lutinizing Hormone) are used in this work. These are administered in different dosage and in combinations to the eels to stimulate the maturation process. The eels are favourably responding to the injections and the secondary sexual characters like enlargement of eyes, darkening of the pectorals and silver colouration of the body have appeared in them (Figs. 7 & 8). The experiments are being continued.

Prospects

The survey conducted by the Central Marine Fisheries Research Institute has brought to light many promising centres for large scale collection of elvers. The techniques of live elver collection and their transportation have been developed. A suitable culture technology for the Indian short-finned eel have also been developed by the Institute. Based on the results of the experimental culture of eels it has been possible to establish the possibility of increasing the production by undertaking commercial eel culture in recycled running water. In addition to eel culture, collection and export of elvers could also be taken up as a profitable enterprise with the development of export market. Apart from earning foreign exchange for the country, this would offer employment opportunities to a large number of marginal fishermen.