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# TUNA LIVE-BAITFISH INVESTIGATIONS AT VIZHINJAM

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ABSTRACT

Rearing of some species of *Stolephorus* and a few other small sized fish was done within the breakwater area at Vizhinjam, southwest coast of India. 'Well-type' cages made of nylon netting were employed for the purpose. The fish were collected from lift nets operated during night using lights and during morning hours, as well as from commercial boat seines. They were transported to the cages, in large plastic cans and buckets. The period of transportation of fish from fishing site to the rearing cages ranged between 10 minutes and one hour. Mortality in respect of *Stolephorus buccaneeri* during transportation and during the first two days after stocking put together ranged from 10-20% and low thereafter. Transporting about 100 fish of about 75 mm length in cans of 50 litre capacity and continuous addition of fresh sea water during transportation were found to reduce the initial mortality of the fish. It survived in the cages for about three months. Similarly *S. devisi* also was found to be hardy ; it survived in captivity for about two months. In the case of *Stolephorus bataviensis* and *S. indicus*, however, the initial mortality was very high and the fish hardly lived for more than a few hours after stocking. The periods for which other fish were reared in the cages were : *Ambassis gymnocephalus* for nine months ; *Pranesus duodecimalis* 5 months ; *Sardinella gibbosa* two months and *S. longiceps* for four months. Initial mortality on capture, during transportation and stocking was negligible for the foregoing four species of fish. They were fed with pelletized feed. The dissolved oxygen, salinity and temperature of the surface waters of the rearing cages during the period were monitored. The encrusted fauna and flora of the cages are described. Some of the problems associated with rearing of live baitfish in cages have been identified and solutions for some of them outlined.

## INTRODUCTION

POLE and line fishing with livebait and purse-seining are at present the two economically viable methods of catching tuna in commercial quantities in tropical waters (Shomura, 1977). Of these two methods the pole and line fishing is the principal method for catching the skipjack tuna *Katsuwonus pelamis*. Though the skipjack is said to be widely distributed in the Lakshadweep Sea, a traditional fishery for it exists in an organised scale only in Minicoy. This is said to be due to non-availability of suitable baitfish in close proximity of other islands. Even in Minicoy, fluctuations in the availability of adequate supplies of baitfish, which are mostly represented by small sized percoid fishes has been reported to affect the tuna fishery often bringing about an abrupt suspension of fishing activity, thereby considerably affecting the economy of the islanders (Jones, 1958, 1960).

Though fragile, many species of *Stolephorus* are reported to possess most of the qualities of good baitfish as pointed out by several authors (Baldwin, 1975, 1977 ; Yuen, 1977 ; Smith, 1977) and form the major baitfish species used in many parts of the Central and Western Pacific Ocean, the best known among them being the nehu, *Stolephorus purpureus* (Uchida, 1970, 1977 ; Wilson, 1977 ; Smith, 1977). Most of these species also occur in the Indian Ocean,

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and their resource potential has been estimated to be very high along the southwest coast by the Pelagic Fishery Project of the UNDP (UNDP, 1974, 1976 a, b, c).

Investigations were undertaken at Vizhinjam to develop suitable methods of capture, transport and stocking in the sea for the wild stocks of *Stolephorus*, as well as to understand their basic requirements in captivity so that large quantities of this fish could be readily made available for livebait purpose in Minicoy. This would reduce the effect of day to day fluctuations in the baitfish supply on the pole and line fishing, eliminate a major non-fishing activity involving catching of bait and lead to expansion of tuna fishing activity in the Indian seas. This paper gives an account of the activities and results obtained in this endeavour in respect of *Stolephorus* and a few other non-predatory fishes incidentally caught during these investigations. In order to present the problem under investigation in its perspective a brief account on the anchovy fishery of the Vizhinjam area and the anchovy resource potential along the southwest coast of India are given in this account. Course of future development for the livebait investigations is discussed in the light of these findings.

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## Material and Methods

Live-fish for experimental purpose were collected from shore seines, lift nets and boat seines during 1977-1979. They were immediately transported in plastic cans and released into the culture cages or glass tanks and mortality of fish that occurred at different stages was noted. They were fed with different kinds of feeds. Descriptions of nets and lights, transporting equipments, culture rafts and cages employed during the work are given below.

Two types of lift nets were fabricated and used. The first type essentially consisted of a square box 3.5 × 3.5 × 1.5 m made of monofilament nylon netting and canes along the four sides of the bottom and the rim. To each corner of this box type net was attached a cord which passed over a pulley fastened to a bamboo pole. Thus the two cords of each side passed through two pulleys suspended from one bamboo pole and the two bamboo poles were rigged to the mechanised boat from which fishing was carried out. One adjustable light was suspended from a third pole rigged to the boat so that the light fell at the centre of the net area (Plate I A).

The second type of lift net as described by Floyd (1971) was fabricated and used. It consisted of a metal ring of 1.5 m diameter to which was attached a conical mosquito netting. The net was operated from a T-shaped wooden frame attached to the rear end of the boat. An adjustable light was suspended by means of a cord passing through a hook attached to the vertical limb of the T-frame.

A portable generator working on petrol was the source of electricity to illuminate the surface waters. Initially a generator of 1500 W and 230 V with 1000 W white bulb was used. But later the combination was changed to one of 750 W and white bulb of 230 V, 500 W. The latter was found to be relatively better in attracting livebait. Subsequently an inverted kerosene pressure lamp of about 200 CP illumination was used in place of electric illumination.

Night fishing with lift nets using light was done for fifteen days from 20th March to 26th

April 1978 using different sources and intensities of lights. Fishing was done both inside the breakwater area (depth range 10-15 m) and in the open sea off Vizhinjam (depth range 20-40 m). First, the net was lowered to about 2 m below the surface and the light was switched on. Periodically the lift net was hauled up and the catch was transferred by hand nets into 50 litre capacity cans filled with fresh sea water on board the vessel.

*Rafts and cages*

Well-type circular cages were suspended from rafts anchored in the breakwater area of the Vizhinjam Fishing Harbour Project, depth of water at the site being about ten metres. Rafts of 6 m × 3 m size were constructed using teak poles, bamboo poles and painted and sealed empty diesel drums of 200 litre capacity as floats (Plate I B, C). Each cage measured 3-5 m deep and 2 m in diameter and was made of monofilament nylon netting of blue colour with a square mesh of 3 mm size. A cage of 3.5 m height can hold 9.5 kl of water in the portion of the cage immersed under water when suspended from a raft. Similarly a cage of 5 m height can hold about 14 kl of water. Rings made of metal (brass, iron) rods of 16 mm thickness were provided one each at the top and bottom of the cage. Each cage was covered with a lid of one metal ring covered with netting of the same material. Two such cages can be suspended from a single raft. As the work progressed more rafts and cages were fabricated, as a result of which by July 1978 there were four rafts and eight cages available for stocking live-bait fish.

*Transportation, stocking and feeding*

Transportation of fish from fishing site to the rearing cages was done in plastic cans thickly covered with coir and of about 50 litre capacity. Fresh sea water was continuously added to the fish cans during transport to make up for the depletion of dissolved oxygen. On reaching the culture site fish were transferred into the cages and a sample of fish was taken for recording the species composition, length range (total length in mm) and weight of the fish stocked. Details of artificial feed supplied to the fish in captivity are furnished elsewhere in the text.

*Environmental factors*

Observations on temperature, salinity and dissolved oxygen of the surface water of the rearing cages were made between 9 and 10 a.m. during the period of rearing of fish. Harvey's method was employed for estimating salinity and Winkler's method for dissolved oxygen. The fauna and flora fouling the cages were also examined. The survival capacity of *S. buccaneeri* in different salinities were also examined on fish kept in glass tanks of 75 × 50 × 50 cm size in the laboratory. The fish reared in the cages were used for this purpose. Before starting the experiment the fish were kept in the tanks for three days. Lowering of salinity was done by adding fresh water. In this account 'anchovy' refers to the fishes of the genus *Stolephorus* Lacépède.

## Anchovy Fishery at Vizhinjam and its Resource Potential along the Southwest Coast

The average annual catch of *Stolephorus* at Vizhinjam during 1965-'78 was around 275 tonnes. The fishery has two principal seasons namely, June-July and September-October accounting for about 30% and 45% respectively of the annual landings. Boat seines land bulk (64%) of the annual catch, followed by gill net (28%) and shore seine (8%) at an average catch rate (cpue) of 5.53 kg, 24.36 kg and 11.86 kg respectively. Boat seines which have been found to be the only source of live anchovies for culture work at present are operated throughout the year. But the main season of their operation is from May to October with peak during June to August. The catch rate of anchovy varies between 7.3 kg and 21.7 kg during September-October. Despite high effort by boat seine (about 6,600 units) anchovy catch is generally low during August indicating a seasonal movement of this fish away from the inshore waters of the Vizhinjam area. The seasonal trend of the anchovy landings from all the gear (monthly average values) is given in Fig. 1. Two species form bulk of the anchovy landings. They are *Stolephorus devisi* (47%) and *S. bataviensis* (31%). Among the rest,

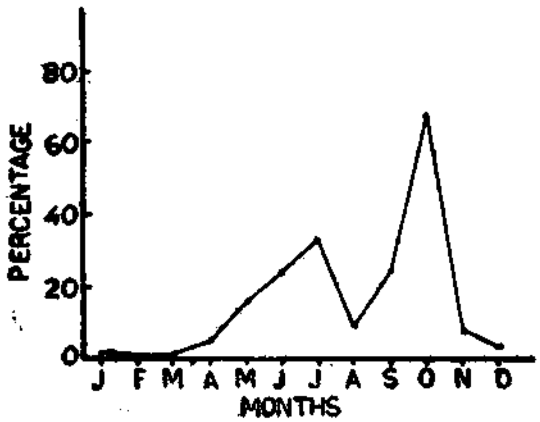


Fig. 1. Seasonal trend of *Stolephorus* catch at Vizhinjam during the period 1965-1978.

*S. buccaneeri* is important (14%). The other species are *S. indicus* (5.0%), *S. andhraensis* (2.0%), *S. commersonii* (0.5%) and *S. macrops* (0.3%). The above data on species composition relates to the period 1970-'78. Further details on the seasonal trend in the catch per unit effort (catch per one trip of the unit) in boat seine, shore seine and gill net for the first four species in the Vizhinjam area are given in Figs. 2 & 3.

The Pelagic Fishery Project of the UNDP at Cochin during 1973-'75 assessed the standing stock of *Stolephorus* biomass in the shelf and slope waters along the southwest coast of India from Ratnagiri to Cape Comorin and in the Gulf of Mannar to range between 500,000 and 1,5000,000 tonnes. Seasonal variations in the area of abundance of the fish indicated a migratory pattern of the *Stolephorus* stock. The fish appears to start a northward migration from the Gulf of Mannar by about September-October and move to north of Quilon by about December and to north of Ratnagiri by about February-March. The stock appears to move towards south and lie between Kasargod and Quilon by about April-May; and by about July-August most of the *Stolephorus* stock has been reported to move into the Gulf of Mannar in the area south and east of Cape Comorin.

*Stolephorus* was mostly observed in shallow areas of 20-50 m depth range. They often occur within 10-15 m off the bottom during day time and begin to ascend and get dispersed in mid-water during night time, while they were found frequently near the coast south of Quilon. They were usually located 8-32 km off shore north of Quilon. The composition of the different species of the *Stolephorus* stock is nearly same as observed at Vizhinjam. *S. heterolobus** was reported to be most abundant in areas with 15-45 m bottom depth and *S. bataviensis* in areas with less than 20 m bottom depth while *S. buccaneeri* was mostly in waters beyond 45 m bottom depth. The last mentioned species was found to be abundant during the period of southwest monsoon, soon after the height of southerly transport of shelf waters, indicating that this species at other times of the year is mostly distributed north of Ratnagiri.

## Observations

### *Capture of live-baitfish using lift nets*

Details of environmental characters of fishing area, gear used, source of illumination, length

* *Stolephorus heterolobus* and *S. devisi* which resemble each other closely are known to occur in the Indian Seas (Ronquillo, 1967; Whitehead, 1968, 1973). But reports of the UNDP mention the occurrence of only *S. heterolobus* in the area of their investigation. At Vizhinjam as well as at other centres along the Indian coast *S. heterolobus* was encountered only rarely in the commercial catches.

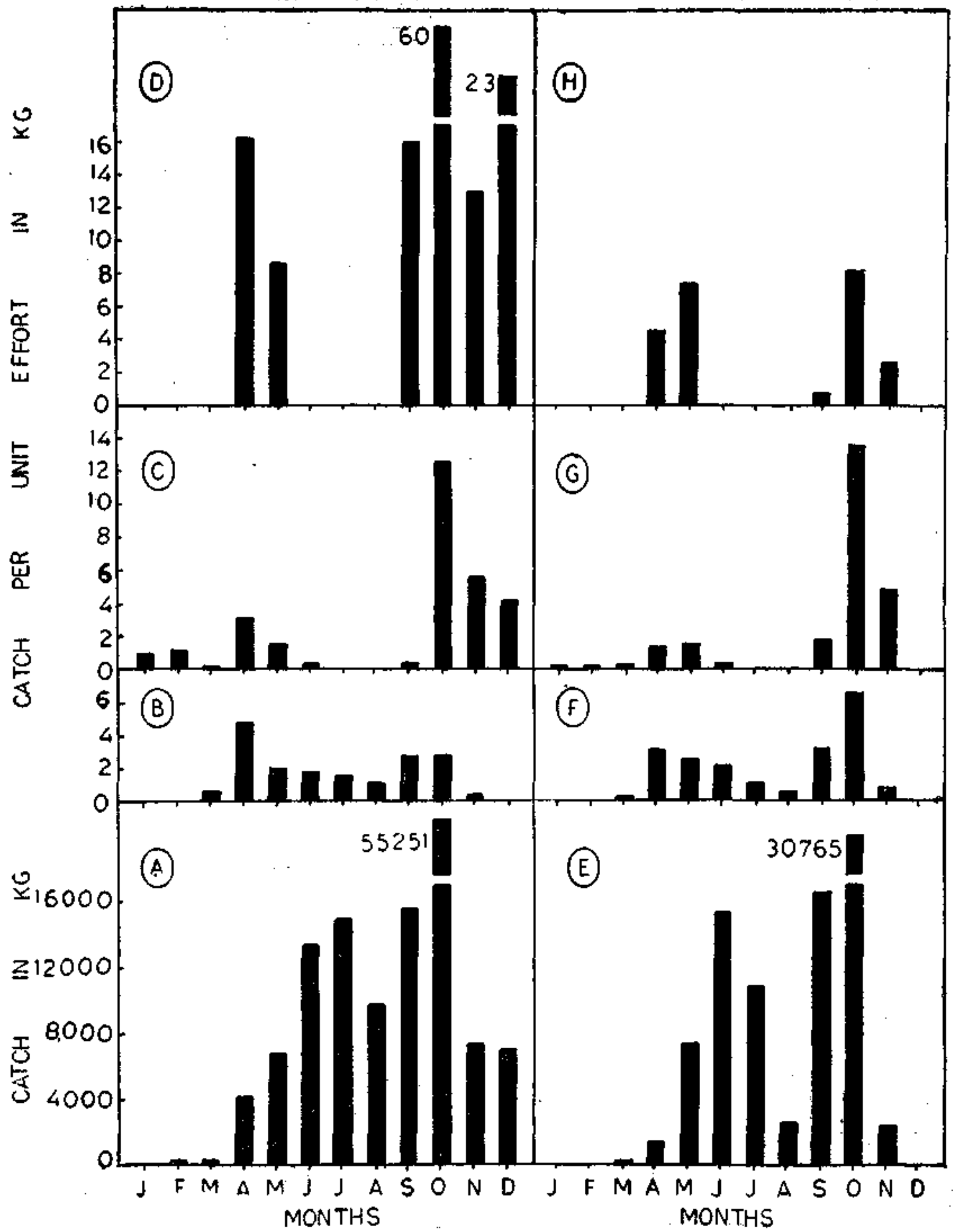


FIG. 2. Seasonal trend in the catch of *S. devisi* (A) and *S. bataviensis* (E) at Vizhinjam; Catch per unit effort (cpue, catch per one drip of the unit) of *S. devisi* in boat seine (B), shore seine (C) and gill net (D); and cpue of *S. bataviensis* in boat seine (F), shore seine (G) and gill net (H).

ranges of fish and squids caught, etc. are given in Table 1. *Loligo singhalensis* and *Sepioteuthis lessoniana* were the dominant species in the catches obtained during night fishing with light the light could not be caught effectively. On account of this, lift net fishing using light inside the bay was found to be more effective.

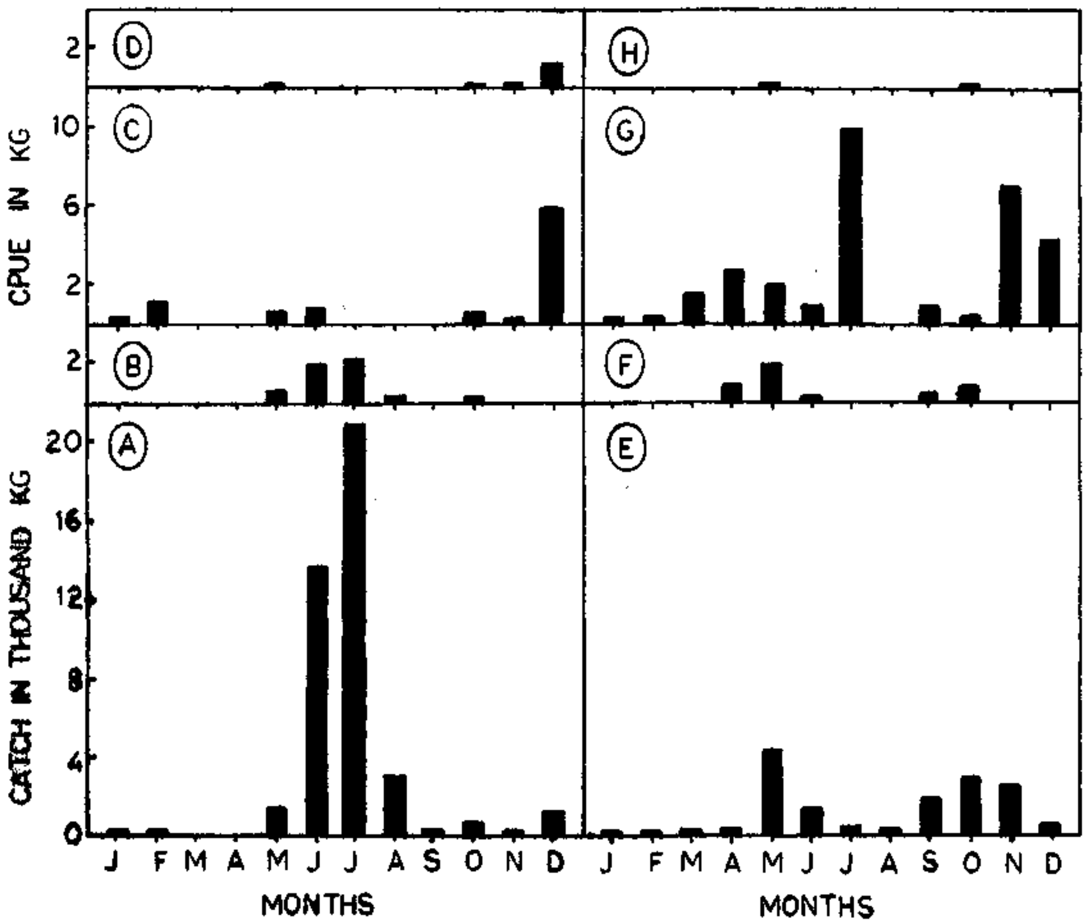


FIG. 3. Seasonal trend in the catch of *S. buccaneeri* (A) and *S. indicus* (E) at Vizhinjam; cpue of *S. buccaneeri* in boat seine (B), shore seine (C) and gill net (D); and cpue of *S. indicus* in boat seine (F), shore seine (G) and gill net (H).

using box-type lift net. The other species obtained in this net were *Pranesus duodecimalis*, *Ambassis gymnocephalus*, *Sardinella gibbosa* and *Hemirhamphus* sp., while *Sardinella longiceps*, *Pranesus duodecimalis* dominated in the conical lift net catches. The foregoing fishes other than *Hemirhamphus* were transferred into cages for rearing purpose. While fishing in the open sea, the lift net was drifted off from beneath the light and hence fish gathered below

*Collections from shore seines and boat seines*

As the fish caught in shore seines are dragged towards the shore over a long distance and in huddled condition, they get injured and hence do not live for more than a few hours after they are collected from the net. Initially *Stolephorus devisi* ranging between 40 and 60 mm collected from shore seines and transported in buckets with sea water and kept in glass aquarium tanks under laboratory conditions

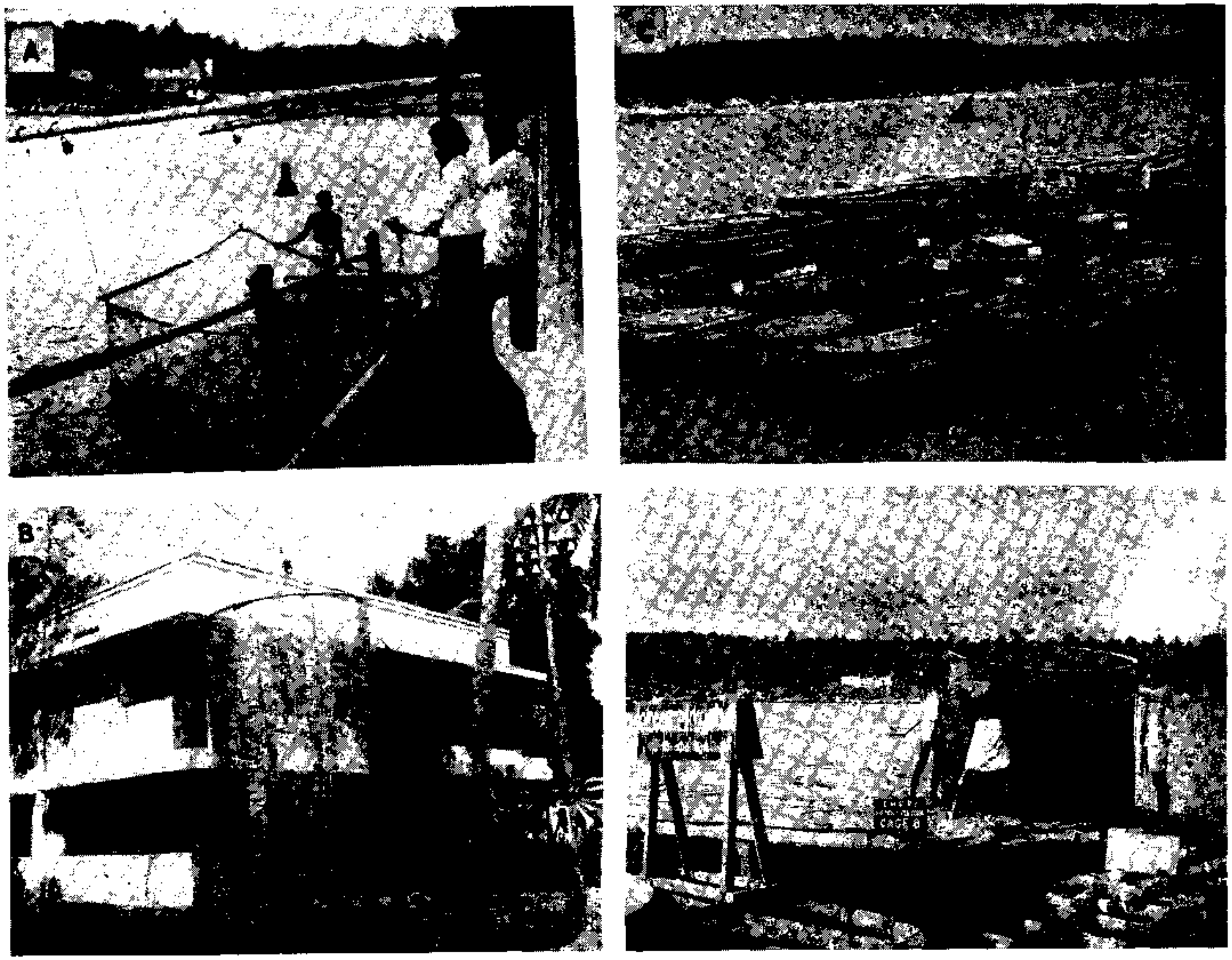


PLATE I. A. Square-type lift net in operation from mechanised boat at Vizhinjam, B. The cage 3.5 × 2.0 m used for rearing anchovies, C. Anchovy culture rafts (in the foreground) and D. The intensity of fouling of the rearing cage after one month of release in water (The upper clear portion of the cage remains above the water).

TABLE 1. *Details of capture of live-baitfish from mechanised boat using light and lift nets during March and April 1978*

| Date | Condition of sea | Water temperature (°C) | Depth (metres) | Gear used | Source of light | Place | Time (hrs) | Catch details (Length range in mm is given in brackets) |
|---|---|---|---|---|---|---|---|---|
| 20th/21st March | Calm | 29 | 10-13 | Conical lift net | 500 W | Inside break water area | 2100-0100 | *Sardinella longiceps* (35-48)<br>*Hemirhamphus* sp. (79-250) |
| 21st March | Calm | 29.1 | 10-13 | Conical lift net | ,, | ,, | 1800-2000 | *Sardinella gibbosa* (33-45) |
| | | | | Box type lift net | ,, | ,, | 2000-2400 | *Loligo singhalensis* (60-136)<br>*Sepioteuthis lessoniana* (—)<br>*Ambassis gymnocephalus* (74-86) |
| 30th March | Slightly rough | 29.5 | 20 | Conical lift net | 1000 W | Off Vizhinjam | 2000-2300 | NIL |
| 31st March | ,, | 29 | 20 | ,, | 500 W & 1000 W | ,, | 1830-2330 | NIL |
| 3rd April | Calm | 29.3 | 20 | Box type lift net | ,, | Inside break water area | 1930-2330 | *Pranesus duodecimalis* (33-66)<br>*Sphyraena obtusata* (90-99)<br>*Caranx* sp. (94-95) |
| 4th April | Slightly rough | 29.1-29.5 | 23 | Conical lift net | 500 W | Entrance of Vizhinjam break water area | 1930-2400 | *Sardinella gibbosa* (33-45) |
| | | | | Box type lift net | ,, | | 0300-0600 | *Sepioteuthis lessoniana* (60-95)<br>*Pranesus duodecimalis* (25-76) |
| 5th April | Slightly rough | 29.1-29.3 | 23 | Conical lift net | 500 W | Entrance of Vizhinjam break water area | 2040-2340 | *Pranesus duodecimalis* (29-73) |
| | | | | Box-type lift net | ,, | ,, | 0330-0530 | *Pranesus duodecimalis* (29-73)<br>*Sepioteuthis lessoniana* (85-145)<br>*Hemirhamphus* sp. (89-327)<br>*Sardinella gibbosa* (20-23) |
| 10th April | Calm | 29.5 | 8-13 | Box type lift net | Kerosene pressure lamp | Off Vizhinjam | 2045-2130 | *Loligo singhalensis* (80-125) |
| | | | | | (200 CP) | Inside break water area | 2230-2400 | *Pranesus duodecimalis* (25-71)<br>*Sardinella gibbosa* (15-25)<br>*Hemirhamphus* sp. (69-75)<br>*Caranx* sp. (16-26)<br>*Balistes* sp. (20-22) |

TABLE 1—(*Continued*)

| Date | Condition of sea | Water temperature °C | Depth (metres) | Gear used | Source of light | Place | Time (hrs) | Catch details (Length range in mm is given in brackets) |
|---|---|---|---|---|---|---|---|---|
| 11th April | Slightly rough | 29.1-29.3 | 8 | ,, | ,, | Inside break water area | 0330-0515<br>and<br>2000-2250 | *Sardinella gibbosa* (16-25)<br>*Pranesus duodecimalis* (19-38)<br>*Sepioteuthis lessoniana* (60-76)<br>*Hemirhamphus* sp. (130-239)<br>*Carnax* sp. (17-20)<br>*Balistes* sp. (14-22) |
| 12th April | Calm | 29.1 | 8 | ,, | ,, | ,, | 2000-2330 | *Pranesus duodecimalis* (27-66)<br>*Loligo singhalensis* (45-113)<br>*Hemirhamphus* sp. (46-51) |
| 13th April | ,, | 29-29.1 | 8 | ,, | ,, | ,, | 0345-0600<br>and<br>2030-2250 | *Pranesus duodecimalis* (41-72)<br>*Loligo singhalensis* (48-110)<br>*Hemirhamphus* sp. (45-53) |
| 14th April | ,, | 29.3 | 9 | ,, | ,, | ,, | 0330-0530 | *Loligo singhalensis* (55-110) |
| 24th April | Calm | 29.5 | 9 | Box type lift net | Kerosene pressure lamp (200 CP) | Inside break water area | 2000-2230 | *Pranesus duodecimalis* (34-59)<br>*Loligo singhalensis* (58-98)<br>*Sepioteuthis lessoniana* (50-70)<br>*Sardinella gibbosa* (22-39) |
| 25th April | ,, | 29-29.3 | 9-11 | ,, | ,, | ,, | 0345-0600<br>2000-2250 | *Pranesus duodecimalis* (45-52)<br>*Sardinella gibbosa* (22-35)<br>*Balistes* sp. (30-45) |
| 26th April | Slightly rough | 29.1 | 9 | ,, | ,, | ,, | 2010-2320 | *Pranesus duodecimalis* (30-40)<br>*Sardinella* sp. (23-41)<br>*Sepioteuthis lessoniana* (55-72)<br>*Loligo singhalensis* (54-95) |

lived only for two hours. During the course of the observations *Stolephorus* spp. collected from boat seines alone were found to be suitable for rearing. Hence collections were attempted only from boat seines.

Though a variety of fishes are caught in boat seines, attempts were made to sort out *Stolephorus* spp. from the catches. This was achieved by collecting the fish from the catches dominated by *Stolephorus* spp. The fish were then transferred to the plastic cans filled with sea water by means of buckets making sure that only small quantity of fish was taken out from the net together plenty of water. Though boat seine, when compared with shore seine, was found to be a better source for obtaining live anchovies it has certain inherent drawbacks. For instance, if the anchovies are caught along with large sized predaceous fish, mortality of anchovies would be very high due to injuries. At Vizhinjam the fishery for anchovies by boat seine coincides with the fishery of *Trichiurus* by the same gear, where the latter forms the bulk of the catch and the anchovies thus caught sustain heavy mortality. Even when anchovies form the dominant catch in boat seines, mortality of fish occurs due to the vigorous shaking of the net to remove anchovies entangled in the meshes of the net and the overcrowding of fish in the bag portion of the net during hauling. Hence approximately 20-30% of the fish, depending on the species caught could only be obtained in live condition. Even these fishes are subject to further mortality in due course on account of the shock and injuries they have sustained during capture. *Stolephorus buccaneeri*, *S. bataviensis*, *S. devisi* and *S. indicus* were the species available for observations during the present study. Of these *S. buccaneeri* and *S. bataviensis* alone were available in good quantities during the course of the collections.

*Transportation*

The duration of transportation of fish in cans to culture site ranged between ten minutes to one hour depending on the distance from the fishing site. Observations on the mortality of fish in cans during transportation were made with different densities of fish per can. It was generally observed that when *Stolephorus* catch comprised mainly of *S. buccaneeri* and the fish were handled with utmost care and transported within about half an hour, the mortality was below 5% when about 100 fish of about 75 mm length were carried and when the condition of the sea was not rough. But carrying more fish always resulted in higher mortality due to depletion of dissolved oxygen. For instance, on one occasion about 200 *S. buccaneeri* were introduced into a can with an initial dissolved oxygen concentration of 5.28 ml/litre. After one hour of transportation of fish the dissolved oxygen concentration was found to be 2.64 ml/litre and the mortality of fish was about 80%.

In the case of *S. bataviensis* of 70-90 mm length, mortality was 50-60% during transport lasting for about 30-60 minutes, even when 100 fish were carried per can. Under similar conditions of transport, the mortality was about 90% for *S. indicus* of 120-140 mm length and 50% for *S. devisi* of 60-70 mm length.*

Other small sized fish of *Sardinella* spp., *Ambassis gymnocephalus*, *Pranesus duodecimalis*, *Leiognathus* spp., *Dussumieria* spp. and *Sphyraena* spp. showed eligible mortality during transportation.

* During 1980, in an attempt to reduce the further mortality of *Stolephorus* obtained from boat seine, the fish were transferred immediately to cans with less saline water (60-80% sea water of salinity range 21‰—28‰). Within 20-30 minutes some species of *Stolephorus* were observed to slow down their active, irregular movement and assume a steady, circular movement in the cans. This would indicate that the fish have largely overcome the shock they sustained at capture. Thus the mortality of *S. devisi* in less saline water was approximately one-fifth of that in 100% sea water, where the mortality ranged between 45% and 50% for *S. devisi* and *S. buccaneeri*. But *S. bataviensis* and *S. indicus* showed heavy mortality (85-90%).

*Rearing of* Stolephorus *spp. in cages*

During the present study, observations on rearing were made mainly on *S. buccaneeri* as this was available on many occasions during the period of collections. Other species dealt with were *S. bataviensis*, *S. devisi* and *S. indicus*.

During 1977, collections of *Stolephorus* were made from boat seines operated within the breakwater area and it comprised only of *S. buccaneeri*. About 2,000 *S. buccaneeri* of 40-80 mm length with the modal size at 45-49 mm were stocked in a cage of 4 m height during the last week of June. Mortality of fish was about 80% during the period from the time of capture till stocking; thereafter it was fairly low. Within 2-3 days of captivity mortality came down considerably. Only very few fish were alive by the first week of October '77 and all fish died by the middle of October.

During 1978, collections were made only from boat seines operated off Vizhinjam and inside breakwater. Collections made during middle of July comprised only of *S. buccaneeri*. About 10% mortality was noted during the period from time of capture till stocking. They were stocked in three cages of 3.5 m height at densities of 1,500, 1,500 and 3,500 fish respectively. The initial length ranges of fish stocked were 75-97 mm in the first cage, 52-76 mm in the second and 54-78 mm in the third. On the following day, about 10% of fish was observed in the cages. Thereafter, the mortality was relatively low. However, there was a gradual reduction in the number of fish in the cages during the subsequent three months as a result of which about 200 fish each in the first and the second and about 500 in the third cage only were alive by the last week of October. On 25th October 1978 when fresh collections of *S. bataviensis* were introduced into these cages, all the *S. buccaneeri* present in the cages were found dead on the following day. It would thus appear that *S. buccaneeri* could be kept alive in rearing cages, though with a steady mortality of the fish kept under captivity, for about three months and that addition of fresh fish into a cage that has fish already conditioned to captive environment will bring about mortality of the latter.

*S. bataviensis* was available for rearing thrice during 1978, all from boat seine catches. About 100 fish were collected off Vizhinjam on 28th September 1978 and transported within half an hour to the culture site. About 50% mortality was observed during transportation. The fish stocked in the cage ranged in length from 72-98 mm. All the fish were found dead the following day. Subsequent two collections were made from within the breakwater area. The first one of 800 fish made on 14th October 1978 consisted of *S. bataviensis* (80%) 70-90 mm length and *S. devisi* (20%) 68-76 mm length. The second one of 18,000 fish of 61-90 mm length made on 25th October 1978 consisted of *S. bataviensis* (90%) and a variety of small sized fishes. In both the instances the transportation time was about ten minutes. Mortalities of fish before stocking in the cages were about 20% in the two attempts. The fish collected on 14th October 1978 was stocked in one cage and that collected on 25th October 1978 was stocked in six cages at densities of 5,000, 5,000, 3,000, 3,000, 1,000 and 1,000 respectively. But the fish did not survive for more than six hours.

In 1979 about 4,500 numbers of *Stolephorus* spp. were collected during middle of July from boat seines operated off Vizhinjam and were transported to the culture site within about 45 minutes. At the time of stocking mortality of fish was about 35%. The species composition was as follows: *S. bataviensis* 24%, *S. devisi* 22% and *S. buccaneeri* 54%. This mixed collection was stocked in four cages in densities of about 1,300, 1,200, 450 and 50 respectively. Species-wise stocking of fish was found to be not practicable. The length range of *S. buccaneeri* stocked was 51-79 mm, that of *S. devisi* 52-76 mm and that of *S. bataviensis*

54-73 mm. A sample of anchovies collected from one of the cages after one month of stocking comprised only of *S. buccaneeri.* The length range of fish in the sample was the same as at introduction, but the mean length of the fish increased from 64.71 mm to 66.68 mm. Possibly, more of the smaller fish have died in the mean time. A gradual reduction was observed in the number of fish present in the cages as in the previous years and by the end of October 1979 only very few *S. buccaneeri* were alive.

About 50 numbers of *S. indicus* ranging between 120-140 mm in length collected within the breakwater area on 3rd November 1979, transported within three minutes and stocked separately in one cage did not survive for more than three hours.*

*Rearing of other fish in cages*

Observations were made on *Sardinella longiceps, Ambassis gymnocephalus, Pranesus duodecimalis* and *Sardinella gibbosa* during different periods in the course of study. About 1,000 numbers of *S. longiceps* 60-64 mm modal length incidentally caught along with *S. buccaneeri* during the last week of June 1977 and kept in a cage till second week of November 1977 showed a modal length of 110-114 mm. About 200 numbers of *S. gibbosa* ranging in length 55-70 mm collected from boat seines and stocked on 24th July 1978 were in captivity till 21st September 1978 when they were fished out. The final length range was found to be 80-92 mm.

About 1,150 numbers of *Ambassis gymnocephalus*, 74-88 mm length with a mean length of 80.3 mm were collected by lift nets operated close to the culture rafts on 15th and 16th February 1978 and were immediately stocked in a single cage. Mortality of about 10% was observed during the subsequent ten days period and nil thereafter. They were kept in captivity for about nine months. A sample of fish measured at the close of this period did not show any increase in the mean length. About 3,000 numbers of *Pranesus duodecimalis* of 25-76 mm length collected by lift net from the breakwater area during 3rd-26th April 1978 were stocked in a single cage. Very little mortality was observed during the period of transport and rearing. They were kept in captivity for about five months.

*Feeding of fish kept in captivity*

During July-October 1977, the fish were fed with boiled and ground beef liver as well as with ground dry *Acetes* made into thick paste. Both the feeds were given twice daily and they were accepted by the anchovies and sardines reared in the cages. During 1978, the fish were fed with artificial pelletized feed made from the following: *Acetes* meal (40%), rice bran (20%), black gram (15%), tapioca (11.4%), ground nut oil cake (7.5%), supermindif (comprising a mixture of minerals used for cattle feed) (5%), yeast (1%) and vitablend (consisting of vitamins used for cattle feed) (0.1%). During 1979, the above feed was modified by replacing *Acetes* meal with fish meal. The material cost per kilogram of the above feeds was Rs. 4 and Rs. 3 respectively. The chemical composition of the two feeds are as follows:

| Feed No. | Moisture % | Total ash % | Acid insoluble ash % | Protein % | Starch % | Fat % | Na % mg | K % mg | Ca % mg |
|---|---|---|---|---|---|---|---|---|---|
| 1. | 7.1 | 19.94 | 10.13 | 36.42 | 20.98 | 4.58 | 7.544 | 4.634 | 2.047 |
| 2. | 8.8 | 19.35 | 7.131 | 36.52 | 17.71 | 4.615 | 8.796 | 4.212 | 2.315 |

* During 1980 about 3,000 numbers of *S. devisi* in length range of 58-92 mm (average length 72 mm) were stocked in a cage. The fish were alive with only a little mortality for about a month. Thereafter, a gradual reduction in their number was observed and by the end of the second month all fish were dead.

Fish were fed with artificial feed twice daily approximately 5% of their wet body weight. Though feed was supplied from the time of stocking, fish began to accept the feed from about the third day onwards. From about fifth day onwards the fish were found to come up towards the surface of water as soon as a small quantity of feed was dropped into the cage. Soon after each feeding the stomach of fish was found to be full, with the artificial feed supplied in addition to trace quantities of copepods, diatoms and algae.

*Environmental factors of the rearing cages*

The ranges of dissolved oxygen, salinity and temperature of the surface waters of the rearing cages during the periods were 3.38-5.07 ml/litre, 33.60‰-34.8‰ and 21.2°C-26.3°C for *S. buccaneeri* and *S. devisi*; 3.38-7.55 ml/litre, 33.5‰-35.30‰ and 21.2°C-29.8°C for *Pranesus duodecimalis*, and 3.17-7.55 ml litre, 24.40‰-35.50‰ and 21.2°C-29.8°C for *Ambassis gymnocephalus*. *Stolephorus buccaneeri* kept in laboratory tanks exhibited normal activity at a lower salinity of 17.5‰ for five days after which the experiment was terminated.

During the course of rearing fish in the cages, the cages were found to be fouled by a variety of fauna and flora (Plate I D). They were algae, mussels, pearl oysters, sea anemones, gastropods, ascidians, starfishes, sea urchins and polyzoans. Settlements and occurrence of these organisms were found to be intense on the inner surface of the cage than on the other surface and more on the upper two metres depth of the cage from the surface than further below. Anchovies swimming close to the walls of the cages in their normal milling pattern are injured when they come in contact with the shelled molluscs, sea urchins and sea anemones etc. Depletion in the dissolved oxygen of the water inside the cages could have resulted from the restricted circulation of water due to clogging of the meshes of the cage and consumption of oxygen by the fouling organisms. The unconsumed feed and excreta of the fishes that accumulates at the bottom of the cages were also found to foul the cages and pollute the water inside. Occurrence of a variety of fish such as serranids, theraponids, siganids, lutianids, gobiids, chaetodontids etc., and crabs in the cages (which would have entered into them through the meshes of the netting as eggs and early larvae) could have caused severe competition for food and space in the cages and some of them would have caused mortality by preying on the stocked fish, as cages were suspended in water for over three months. Entry of crabs through the gap between the lid and the rim of the cage was prevented by covering the space with net material. Though periodical cleaning of the rearing cage is necessary to ensure free circulation of water in the cage, it is not advisable to do so when the fish is in it since this would kill the fish. Hence cages should be suspended on rafts not much in advance of stocking of fish.

## General Considerations and Conclusions

Tunas represent an extensive fishery resource in the oceanic region currently underfished partly due to insufficient supplies of live-bait. About 230 species of fish representing 34 families have been used as live-bait in the pole and line fishing to capture skipjack tuna throughout the Pacific, Atlantic and Indian Oceans with varying degrees of success and many other species were no doubt employed as live-baitfish but not reported in literature (Baldwin, 1975). Whereas anchovies (Engraulidae) and sardines (Clupeidae) are widely used as bait fish in the Pacific and Atlantic Oceans (Baldwin, 1975), percoid fishes represented by families Pomacentridae, Caeciodidae, Apogonidae and Labridae in Minicoy (Jones, 1958) and the red fish *Dipterygonotus leucogrammicus* (Emmelichthyidae) in Sri Lanka (Sivasubramaniam, 1965) are the main groups traditionally used in the Indian Ocean.

The most desirable characteristics of a good baitfish according to Baldwin (1975), Yuen (1977) and Smith (1977) are : (1) highly reflective lateral surface, (2) surface swimming with rapid erratic motion, (3) a tendency to return to the vessel when broadcast, (4) length below 15 cm, preferably 6-8 mm length with elongate body, (5) relative abundance, availability to the fishery and the ease with which it can be handled and (6) hardness and survival for extended periods in captivity. Baldwin (1977) remarks that 'Without question, the anchovies (Engraulidae) provide the greatest source of desirable baitfishes... However, their survival in bait wells, depending upon the species involved, may be from excellent to poor'. The most important anchovies used as live-bait in different geographical areas are : the anchoveta *Cetengraulis mysticetus* in the tropical Pacific Ocean from Mexico to Peru ; the northern anchovy *Engraulis mordax* off California ; the southern anchovy *E. ringens* in the eastern Pacific Ocean ; *E. japonicus* in the Southern region of Japan upto Taiwan ; the nehu *Stolephorus purpureus* in the Hawaiian Islands (Yoshida *et al*., 1977 ; Baldwin, 1977).

Several other species of *Stolephorus* are being used as baitfish in the tropical Pacific, west of Hawaii. They are *S. buccaneeri*, *S. heterolobus*, *S. devisi*, *S. bataviensis*, *S. indicus* and *S. commersonii*. Though all these species have a high tuna attractability their survival in captivity was found to be poor, daily mortality rates as high as 50% being not uncommon. On some occasions *S. buccaneeri* and *S. heterolobus* alone have shown fairly good survival rate in captivity (Baldwin, 1977). The last mentioned two species as well as *S. devisi* are highly prized as baitfish in Palau, Fiji, Ponape and Papua New Guinea (Uchida, 1970 ; Wilson, 1977 ; Smith, 1977 ; Kearney *et al*., 1972 ; Hida, 1971 ; Lee, 1973). Information on the evaluation of these species as livebait, their habitat and capture methods in Western Pacific Ocean have been compiled and published by Shomura (1977).

The present investigations indicate that compared with sardines (*Sardinella longiceps* and *S. gibbosa*), the silverside (*Pranesus duodecimalis*) and the glassy perch (*Ambassis gymnocephalus*), the *Stolephorus* anchovies are delicate to deal with. Mortality of anchovies is high on capture and it continues at a reduced rate throughout the period of captivity. Compared with *S. bataviensis*, *S. indicus* and *S. devisi*, the round head anchovy *S. buccaneeri* was found to be more hardy. Detailed work, however, is required to determine the shock intensity, injury and mortality that the fish sustain on capture, the daily rates of mortality of fish in captivity, as well as the optimum density of stocking of fish. Regardless of these considerations *Stolephorus buccaneeri* was found to survive in captivity for about three months, *S. bataviensis* for six hours and *S. indicus* for three hours*. Among the other fish, *Ambassis gymnocephalus* survived in captivity for nine months, *Pranesus duodecimalis* for five months, *Sardinella longiceps* for four months and *S. gibbosa* for two months.

Of prime importance to secure large quantity of baitfish are the effective methods of capture that do not cause any injury to the fish. Bag type of seines would cause injury to the fish caught in them and this would lead to large-scale mortality of fish. Hence lift net and purse seine seem to be the more effective gear for capturing live-bait. But capturing fish such as *S. buccaneeri* which is known to occur far below the surface and largely in the open sea would pose problems. As the anchovies have been found to perform diurnal vertical migrations, fishing using night lights might be helpful. But as mentioned earlier, lift netting is ineffective in the open sea.

Mortality of fish is the major problem for the utilization of *Stolephorus* as live-bait. It occurs at several stages namely (1) at capture,

* During 1980, *S. devisi* was found to survive in captivity for about two months.

(2) during transfer of fish from the capturing net to transporting equipment, (3) during the period of transportation and (4) during the period of stocking in the cages. Injury caused to the fish during capture would lead to large scale mortality later (delayed mortality). Since different species of *Stolephorus* exhibit varying degrees of hardness, mortality of fish varies with the species composition of the collection. For example, boat seine collections yielded the highest rate of survival as much as 20-30% of the fish caught in respect of *S. buccaneeri*, but yielded much less in respect of other species of *Stolephorus*. Random movement of fish, as opposed to milling in compact circles, in the restrictive captive situation is yet another factor that induces mortality of anchovies. Due to this disorientation, the fish hit one against another, often injuring themselves and also waste excessive energy. Provision of circular current and oxygen concentration upto saturation may be helpful in restoring the milling pattern. The presence of hardy and non-predatory schooling fish in the same environment may enhance survival by possibly promoting earlier milling pattern of the captive anchovies.

Smith (1977) considered mortality of anchovy live-bait to be due to causes such as injury caused by net abrasions or contact with other individuals, with resultant loss of scales and mucus; and due to stress or shock reaction induced by the trauma of capture and handling. Shock rather than physical injury has been implicated as the major killer.

Mortality of live-bait that occurs at different stages could perhaps be minimised by taking the following precautions: capturing fish by lift nets or encircling nets; allowing the fish to swim from one captive condition to another; keeping fish in water of lower salinity soon after capture; maintaining the dissolved oxygen of holding tank or bait well water at saturation level; installing in the holding tank or bait well a device that would suck in or help in the removal of scales and mucus that get dispersed in the holding medium; removing predators from the bait wells, retaining only hardy species that would promote early milling of anchovies; avoiding addition of new stock of fish into a holding tank that has already conditioned fish in it; holding baitfish in pens prior to transporting them; and avoiding transportation of live bait in rough weather and for long distances (Struhsaker *et al.*, 1975; Shomura, 1977).

The foregoing observations and general considerations suggest that any attempt to utilise the *Stolephorus* resources of the Indian seas should be directed towards utilising *S. buccaneeri*. But this fish accounts for only about 14% of the anchovy resource. However, the possibility of this species being available in larger quantities in the shelf waters north of Ratnagiri remains to be investigated. This also calls for a detailed study of the biological and fisheries characteristics of this anchovy. From what is known at present *S. buccaneeri* occurs in the inshore waters of Southwest Coast during the period of southwest monsoon, soon after the height of southerly transport of shelf waters and mostly remains offshore beyond 45 metres depth zone during rest of the period. During the monsoon period the average monthly cpue of this species in boat seine at Vizhinjam varied between 0.43 kg and 2.26 kg. Lewis (1977) states that the catches of this species tend to be either too large (upto 500 kg) or quite small.

From the observations of Smith (1977) on the survival of *S. devisi* and *S. heterolobus* it would appear that this species complex accounting for about 47% of the anchovy catch along the West Coast could also be utilised for stocking for live-bait purpose. This raises the possibility of attempting to utilise about 60% of the anchovy resource available along the West Coast for this purpose.

Though *S. buccaneeri* has been found to remain in captivity for about three months there is a gradual mortality of fish in captivity. Further it is still not clear as to the period over which at least 50% of the stocked fish would remain alive.* Observations of Smith (1977) indicate that *S. devisi* and *S. heterolobus* could be held in captivity for 14-16 days before cumulative mortality reaches 50%. Applying this criterion, it would appear that the foregoing three hardy species of *Stolephorus* cannot be stocked much in advance of tuna fishing season, which in Minicoy (Lakshadweep) lasts from November to April; nor fish collected in distant grounds could be transported to the Lakshadweep.

* *S. devisi* was found to remain in captivity for about two months.

Information on the anchovy resources around the Lakshadweep is totally lacking. There is thus an urgent need to explore how the resources of *S. buccaneeri, S. heterolobus* and *S. devisi* are distributed in the oceanic waters of the West Coast. Establishment of the necessary infrastructure for capture and holding of anchovies and other desirable baitfish such as *Spratelloides delicatulus*, whose potential as live-bait has been pointed out by Jones (1960 a, b), in suitable localities in the Lakshadweep and introduction of *Herklotsichthys punctatus*, which is abundant in the Andaman waters, into this area would go a long way to increase live-bait fish supplies for the tuna live-bait fishing in the Lakshadweep.

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