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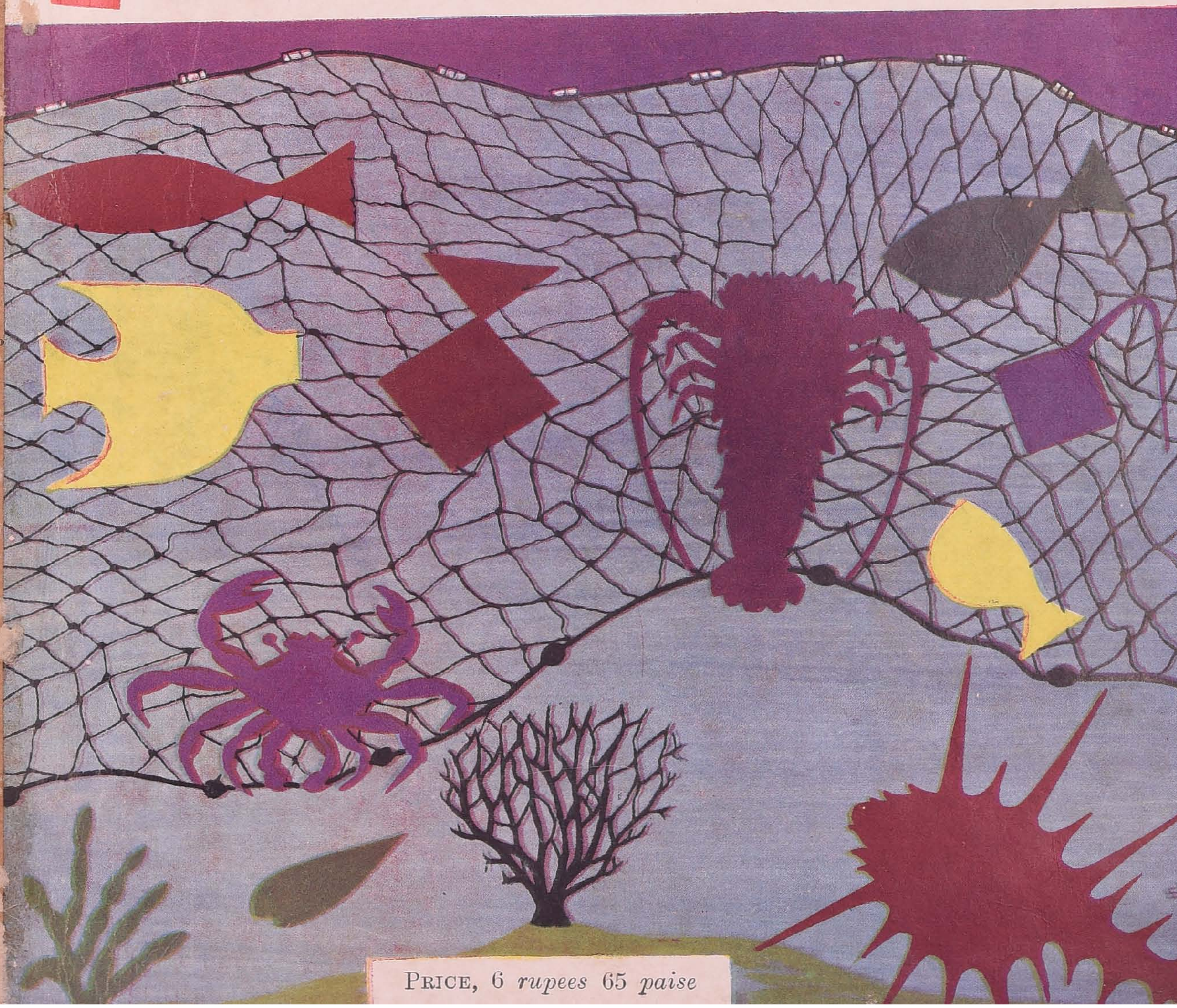

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# MADRAS JOURNAL OF FISHERIES

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# A STUDY OF THE STRUCTURAL COMPONENTS OF THE ADHESIVE DISC OF ECHENEIS (ARTEDI) AND THEIR FUNCTIONS

BY

B. BONNELL AND MRS. K. JEYACHANDRAN.

## PART I.

### Introduction

Interest in the adhesive apparatus of Echeneis fish has been evinced since Aristotle's time, i.e., B.C. 384–322 owing to a report that it was capable of holding back fast moving ships of the time. Gunther (1860) traced the history of the fish. In the nineteenth century after the advent of the theory of evolution Blainville (1822) Kner (1861) Baudelot (1867) Beck (1879) Niemiec (1885) and Storms (1888) studied the apparatus with a view to ascertaining whether it was the modified middle fin of the Teleost. Houy (1909) contributed a valuable paper with histological information as well. The present paper however has become a necessity owing to the discovery that " a curious round ossification ", of Storms (1888) in the posterior end of the disc proper has now been shown to form part of a possible pumping system by Bonnell (1961, 1962, 1964) in " Nature ". Moreover the body is found in different positions in Xray photographs of the living fish taken by the kindness of the Smithsonian Institute, Washington. In following the clue further a very detailed and complete account of all the systems involved has inevitably to be made and published in parts. The last part would contain the functions of the adhesive disc and the discussion of the position that has been taken by the author.

### Material and Methods

In addition to the three very small specimens of Echeneis ranging between 105 mm. and 111 mm. in length supplied by the courtesy of the Smithsonian Institute, Washington, fourteen specimens of Echeneis (remora) ranging between 95 mm. and 137 mm. and one specimen of Osteochir 172 mm. sent from St. Andrews Fisheries Station, New Brunswick, Canada, two specimens of Echeneis 342 mm. and 356 mm. long from the Australian museum Perth, one 148 mm. long from Portonovo by the courtesy of Professor Seshiah, some specimens from the Director of Fisheries Madras, and thirty or more specimens secured locally were available for study. The methods adopted for study were dissections and preparation of the skeleton of large specimens, staining of the entire sucker with Alizarine red and rendering it transparent in glycerine as well as section cutting and staining of smaller forms.

The problem to be finally solved would be whether the mechanical movements vary according as the fish is swimming about or is attached to a place and how the change from one condition to another is harmoniously brought about. Incidentally it would throw light upon whether the apparatus has any other function or functions in addition to that of attachment.

### Externals of the Sucker

The sucker is an oval structure attached to the body in various ways. It has a flap all round freely movable while swimming which is narrow in front broader at the sides and broadest behind. Very fine ciliary sensory organs are present on its dorsal side and there are some special sensory organs arranged not far from the margin each of which appears to be a raised ring from within which a fleshy structure seems to peep out. These probably communicate with the deeper layer while the others with the superficial one.

The central part of the sucker consists of a disc with a small triangular shield at the front end in which there is a depression occupied by a curved finger shaped body the *Tactilodact*. The front edge of this shield is not attached to the skull below. From the posterior apex of the shield a median muscular partition runs backwards connecting the front shield with a much larger posterior shield at the hind end. In this partition smaller finger like bodies are embedded one for each segment which are the *subtactilodacts*.

Every segment has a pair of lamellae which are capable of being raised and which have teeth arranged in three rows along their hind margin. From the cavities in which the lamellae settle two fine grooves lead out which may be called *glyphs*. One of the two glyphs leads outwards and slightly forwards. The other is close to the median muscular partition and leads from the cavity to the next one following it.

This sort of arrangement suggests that the sea water which fills the cavities of the lamellae is driven backwards when the lamellae close. There are 24 pairs of lamellae normally. Out of them 15 are situated on the skull itself and cannot move when the sucker is attached to a place. Since the bones of the skull are immovable all the 15 lamellae are also incapable of movement once attachment has taken place.

The remaining nine pairs of lamellae are not situated on the head but on the five vertebrae following the head. Since each vertebra is capable of moving on the other from side to side, when the portion situated on them is attached although vertical movement is impossible, side to side movement can take place within certain limits. This seems to be the reason why when the fish is attached to a place the fishermen are able to release it by pushing it sideways in the hind region.

Behind the lamellar region the posterior shield is situated. It can move from side to side with the nine pairs of lamellae just anterior to it. The hind part of the shield is not attached to the neck region on its under side because the marginal flap is tucked under it. The ectodermal covering of the entire dorsal side of the adhesive disc is continued below the marginal flaps and continued over the body of the fish. The dorsal side is closely studded with pigment spots which below the flap are fewer in number and widely separated.

### Skeleton of the Sucker

The accompanying (Fig. 1), shows all the skeletal parts separated and mounted in the correct order on black paper except the delicate median *tactilodacts*. The left row represents the dorsal views of the basal plates. The first plate and the last two or three are specially modified. In the normal condition the basal plates overlap to a certain extent. The middle row represents the interneural bones arranged with their hind regions shifted to a side. The right row are of the Lamellar bars arranged in pairs. The lower inner ends are attached to each other by a ligament normally.

### Pyriboss

Starting from the hind end of the disc the first piece is the curious round ossification referred to above. The dorsal view of this body (Fig. 2) which I have called the *Pyriboss* brings out the following points. It has a narrow spout at the front which posteriorly is continued into a groove which in turn opens into the interior of the rounded body by a very large opening. There are two pairs of articulating surfaces at the sides disposed at different angles. In the normal postition the basiarch in front is in contact with the first pair of articulating surfaces. The second pair are free. Innumerable very small protruding tubes closely packed in rows are visible. They seem to be arranged longitudinally in curved rows and have larger outer mouths. These tubes definitely open into the interior of the body which is hollow although the openings are clearer in some cases than in others. The upper surface is flat. As the lower surface extends beyond the upper a dorsal view shows the ventral portion projecting out at the sides. There are some clear small round openings for the blood vessels or nerves to enter.

In the ventral view there is an opening in the anterior region below the very large opening mentioned in the dorsal view. It is very much smaller in size and placed in the anterior part of a shallow depression. In the lateral region small openings for blood vessels and nerves are present. The very small tubes found on the upper side are present in the ventral view as well but in smaller numbers. They are also longitudinally disposed but less closely packed. The dorsal part is mostly hidden when viewed from below and visible only to a very small extent in the hind region.

The side view shows that the dorsal surface is flat while the ventral is rounded. This is but what one would expect because the dorsal surface would have to come in contact with the surface to which it attaches itself but not so with the ventral. Further details of the structure of the Pyriboss are revealed in longitudinal and cross sections, taken with the aid of a microtome.

Figure 3 shows that the walls at the sides are strongly built and that they contain honey comb like cells within which many stained objects are visible. Dr. R.J. Terry, head of the Bilology Department of the University of Texas, South U.S.A., who had the opportunity to examine the slides expressed himself thus, " This structure may be characteristic of the sucker fish only. It is unlike any other vertebrate observed. It seems to be a bed of blood and lymph vessels closely associated yet separated by partitions or septa. Capillaries, arterioles, lymph vessels and vennules are unmistakably present in each of these separate units."

Figure 4 is a longitudinal section of the Pyriboss. In it the front and the hind walls are thick but the upper and lower walls are very thin and probably *yielding*. In which case the contents of the receptacle can be altered in volume. Gaps in the hind wall show that the pulvinus is in continuity with the interior. Changes in the volume can assist drawing in of fluids in one direction and sending them out on the other.

### Basiarch

The next skeletal piece in front is the Basiarch (Fig. 5) which is median in position. The dorsal view shows a process pointing forwards. The arch itself has slight expansions along its margins intended for providing rests for the arch in front. After the two sides of the arch have diverged for a certain distance they curve inwards slightly so that the arch takes on the appearance of a semicircle now trying to close on itself. This curve seems to be scooped out on its dorsal surface which means that it forms a place of rest for some hard part or other. Since the Pyriboss is known to fit into the space formed by the arch it must be resting on this site.

In the ventral view just behind the median prominence pointing forwards the arch is scooped out. It would form a surface below which the front end of the Pyriboss takes shelter when it is fixed in the gap formed by the arch. It would also prevent it from getting through the gap. Houy in his figure has made a mistake in representing the Pyriboss as possessing the large opening in the hind region. In fact however it is in front and the two projections he represents as projecting forwards really project backwards and limit the posterior pair of lateral grooves. The mistake can easily arise if the bones of the posterior shield are disengaged by boiling and then fitted together. Since the Pyriboss have two pairs of lateral grooves it can be fitted into the Basiarch either by the first pair of grooves or the second. But if the bones are separated as the tissues undergo putrification the fact that it is the first pair of grooves that fit into the Basiarch cannot be missed. Moreover only then can the set of four bones functions as a pump.

The Basiarch when looked at from the side shows that the inturned posterior border of the arch bends down and ends in a fat leaf-like plate the front tip of which projects into the space enclosed by the arch. The leaf-like area fits into the lateral grooves of the Pyriboss. The outer margin of the hind region of the arch contains tiers of large openings with smaller openings within them which in their turn have still smaller openings.

**Basilid**

The next piece (Fig. 6) is situated in the front middle line and has escaped attention till now and therefore has not been recorded. I have called it the *basilid.* If it had been noticed this apparently insignificant extremely small piece would have been recognized as a valve. It is a flat plate varying in shape to a considerable extent. In the dorsal view, there is a margin along the outer and lower borders with a very few scattered tubes in them. There is a distinct cleft in the front border intended to accommodate the anterior prominence of the basiarch which in the normal position passes below the lid.

In the ventral view there are two distinct bulges with a channel between them. There are also scattered round openings leading into the cavity formed by the bulges. Some very fine tubes with larger outer openings somewhat similar to those found on the pyriboss are found here also in the marginal region. The lamellar bars on their under sides possess bulges. It is therefore reasonable to consider the basilid as the lamellar bars of that segment which have fused together along the midregion with a groove in between. If the basilid is considered as belonging to the arch in front of it called the *basiplatt,* to distinguish it from the other basal plates of the disc, then the pyriboss must be considered as the modified lamellar bars of the basiarch which have fused along their inner edges leaving a groove in between with a spout in front. If a pair of lamellar bars bend backwards and fuse together and the bars exend only up to the bulges which now have greatly increased in size we shall get a body similar to the pyriboss.

Houy considers the pyriboss as the modified basal plate or stirrup-shaped piece and not of the lamellar bars fused between them because the basilid was not found at all at the time. Infact the pyriboss can be derived either from the basal plate or the lamellar bars. Since the bulges on the basilid have made us decide that it is derived from the lamellar bars, the pyriboss must be derived also from them. The advantage is that only two segments are involved in modification and not three or four if the Basilid is also taken to represent a segment.

**Basiplatt**

The fourth skeletal piece (Fig. 7) which together with the other three occupies the posterior shield of the disc is the basiplatt spelt with a double t to distinguish it from the other basal plates. It has a median front prominence just as the basiarch has, projecting from a central connecting piece from which bridges diverge backwards at an angle and broaden out into larger plates. Slight rims along the front margin and the inner margin of the broad plates afford resting places for the skeletal piece in front and the basiarch behind. A fine curved arch is formed along the lower margin of the middle region which when the basiarch is fitted in position encloses a space over which the basilid rests.

The ventral view shows that there is a small channel or groove formed on the median front prominence which must be a continuation of the channel in the basilid. Along the outer margins of the basiplatt openings that lead into tubes that converge are arranged in tiers.

**Tactilodacts**

All along the middle line there are thin curved rod-like processes the first of which is that of the tactilodact mentioned already as occupying a pit in the front shield. It differs from the others that follow,in that it has flattened bifurcations which touch a prominence on a cup-like skeletal piece below. Muscles are attached on the underside of the bifurcations and to the median bones below the basal plate. By their contraction the structure is raised and the lowering is brought about by the contraction of the connective tissue joining it to the basal plate.

The subtactilodacts have also bifurcations which end in knobs meeting the lamellar bars on their inner lower margins (Fig. 8). They have on either side an elongated tooth even larger than the teeth of the third row of teeth belonging to the lamellar bars. Moreover, they curve inwards and then outwards forming as it were protections to the subtactilodact.

The number of subtactilodacts is less than the number of lamellae because the last lamella has no subtactilodact. If however we consider the main tactilodact as belonging to the first lamella then the last subtactilodact now existing will belong to the last lamella. And this is a perfectly reasonable position to take, if the function of a tactilodact is to raise and lower a lamella. According to this interpretation the subtactilodact found in a lamella is not responsible for raising the lamella on which it is placed but of the next one following. The last lamella therefore does not need a tactilodact as there is no erectile structure behind.

Since these peculiar finger-like bodies have not been mentioned till now all that has been said about them cover new ground.

**Lamellobasal**

Coming now to the other bones that have to be described, the first is the *lamellobasal.* Just as we considered the posterior shield of the disc as being formed of two segments the anterior shield must also be considered as being formed of two fused segments, but one complicate bone. Its dorsal view (Fig. 9) shows that its front end is semicircular in outline and in the very middle of it there is a prominence projecting backwards to which the tactilodact is attached. Behind this are a pair of arches which are separated by a gap. Looking down through this gap we see two pillars supporting the arches converging and joined together below. There is a cup-shaped hollow and the floor of the cup is joined to the front region by a curved connection. Posteriorly there is an elongated spine which is broadened at its front end side ways and in each of the expansions an oval cavity with a callous area in its centre can be noticed. The ventral flattened plates with openings in them are so broad that they with the portions in front can account for two segments.

In a typical segment omitting the very small tactilodacts, the following bones are present: A pair of lamellar bars (Zahn platten of G. Beck; Lames pectines of Niemiec) the basal plate (fussplatt of G. Beck; ostrabeculaire of Niemiec) and interneural spine. The lamellobasa described above is formed by the fusion of two such sets and is the most complicated of all the bones.

In the ventral view (Fig. 10) all around the semicircular front end exceedingly small tubes are closely arranged and point inwards. There is a thickened knob situated at the front end of the middle line which seems to be itself riddled with holes. From this thickened knob a vertical ridge runs along the spine of the internueral bone. The spine itself is broad close to its front end and on it we noticed the callous regions of the dorsal side.

**Lamellar bars**

Behind the Lamellobasal, the lamellar bars are arranged in pairs the number normally is 24. The first pair are shortened and directed outwards and forwards. From this bar a large straight hook or peg projects forwards and inwards. The inner edge of the bar is flattened and ends in two small prominences. The innermost prominence is attached to its compliment on the other side by a ligament. The other has a callous area in its ventral aspect. In the ventral view a large entrance leads into the substance of the bone. The hook itself has several holes which lead into tubes that run across it.

The next pair is more or less like the first with these differences. The hook is at a different angle. On the ventral side the hook has a bulge which is hollow and a bridge connects it with the callous area in the inner edge of the bar. There are two openings one in front and another behind the bridge which are in communication with each other through spaces below the bridge and also with the interior of the bulge. As we proceed further backwards the length of the lamellar bars progressively increase till about the 20th pair and then decrease once again. The angle and curvature of the hook vary from one pair to another. It is possible to insert as many as five bristles from the lower cavity to the upper one, to the hook and the bulge below it. Microtome sections made through the lamellar bar longitudinally and transversely to the axis of the disc show that the bar is hollow and that there are some channels which seem to wind through the bar.

While the front margin of the bar is convex (Figure 11) the hind margin is concave and is grooved in which three rows of teeth are accomodated. The wall separating the teeth from the lamellar bar probably is porous. The first row consists of teeth with a base flat and broad (Fig.8). The next row below consists of longer curved teeth but the basis are not so broad as in the caes of the first row. The third row consists of very long teeth with graceful curvature pointing first outwards next upwards and then backwards. They form the lower most row. All the teeth are set at the proper angle that all the rows meet a surface at the same time.

Sections passing through the lamellae where the teeth are set show that each tooth is surrounded by a space and there is a cavity below it which when filled with fluid would push the tooth out. Houy laboriously explains that the teeth are not true teeth evidently comparing them with our own because he refers to pulp cavity and dentine. They no doubt are solid structures but they do not pass nsensibly into the substance of the bony tooth plate the statement "so that any kind of movement is out of question" quoted from the official translation provided by INSDOC, cannot stand criticism. Moreover when the lamellar bar is boiled the teeth drop out. This cannot happen if the teeth are continuous with the substance of the bone.

Accrodont dentition has been described for lizards where the teeth are solid and continuous with the jaws. It is not only the case that cavities are here present below the teeth, the cavities can be traced to channels in the lamella. My findings are that the teeth are not connected by bone with the lamellar bar and are moved by hydraulic arrangement.

**Basal plates**

Below the lamellar bars the basal plates are arranged along the median line in a series. The first of these which is behind the lamellobasal is relatively smaller and as we move backwards they increase till about the 18th plate and then again decrease in size up to the 24th. A typical basal plate (stirrup shaped bone of Houy) (Fig. 12) consists of a central expansion from which bridges point outwards and meet a very much broadened plate which is marked off into two regions, by a ridge. The part in front is more or less transparent and covers the hind region of the plate in front when the plates are not disturbed as seen from the dorsal view. Towards the inner edge of the ridge a flat projection arises which is of the nature of a clasp. In the normal position the outer part of the lamellar bar passes below the clasp.

The central expansion (Fig. 13) is more or less transparent and has a rounded lobe which articulates with the hind region of the central plate in front. Close to its lower border a transverse slit is present which leads into a conical cavity within which a pair of ligaments arise. The hind margin is prolonged into a pointed process projecting backwards. The other ends of the ligaments meet the lamellar bars towards their inner ends and on their underside. Between the central plates and the lateral plates there is an arched space which serves for the accommodation of the hook of the lamellar bar.

In the ventral view (Fig. 14) the hind part of the lateral plate has innumerable openings along its outer border arranged in tiers which lead into tubes some of which coalesce to form bigger tubes and open finally by small openings along the inner border of the plate. The central expansion has ridges to provide attachment for the muscles joining it with the spine-like bones below.

The first basal plate has the bridge connecting the central expansion with those of the lateral projecting slightly forwards. The posterior part of the lateral plate is very much broader and has the openings arranged in tiers. The clasp of the plate is strongly made. In the dorsal view the slit for the insertion of the ligament is clear and from the central plate a distinct process points backwards.

In the last basal plate (Fig. 15) the lateral portions are very much broader. There is no distinct division of it into transparent and non-transparent portions. In fact the outer margin has openings arranged in tiers almost along its entire length. The clasp is less pronounced and looks more like a spur.

**Basistruts**

Below the basal plates a median row of interneurals are arranged which are the basistruts. The very first basal strut is as we have already mentioned fused with the lamellobasal by its front end. The others are free except for the last two or three of the posterior shield. The dorsal view of a typical free basistrut (Fig. 16) has a prominence in front by means of which it is attached to the central expansion of the Basal plate. It then broadens out into two wings on which there are two depressions with oval callous areas in each of them. Muscles fit into the depressions surrounding the callus and seem to pass between the central expansions of the Basal plates through gaps between them and reach the lamellar bars where similar callus is found. This suggests that the two parts rub against each other and the callus itself is caused by such rubbing.

Behind the wing like expansions there is a slight flattening of the strut which is the part in contact with the median expansion of the Basal plate after which it runs back as an elongated spine. The length of the spine varies with the position it occupies in the disc. In the front region the disc is seated over a cup like depression on the top of the skull and therefore the spines are progressively longer but once the skull region is crossed spines decrease in size until the one at the hind region just before the posterior shield begins, is the shortest. The Basistruts below the posterior shield differ in that their spines are flattened from side to side and they are attached to each other more closely that movement between them is practically nil. The spines of the other Basistruts overlap each other so that three or four of them may appear in a cross section made. Sections also show that a hollow channel is present within the substance of the strut in the anterior flattened portion. Whether these are continuous from spine to spine is not clear.

In the ventral view the prominence in front is distinct and the wing like expansions are convex with no callus in them. In the dorsal view of the same region the callus leads into a funnel shaped portion. The two funnels seem to meet in the centre whether they have any connection with the longitudinal hollow channel is not certain.

While discussing the functioning of the spine like Basistruts Houy maintains that they represent fixed points. This is something that must be carefully noted as it looks as though they are fixed at times and movable at others.

*Summary.*


The present paper supplies the following new information :—

(1) The four skeletal pieces at the hind end are described in greater detail.

(2) For the first time the presence of the Basilid is recognized and described.

(3) The Lamellobasal at the front end has received special attention.

(4) The tactilodact has been described as a separate entity.

(5) The subtactilodacts hitherto unrecognized are emphasised.

(6) More attention is paid to the openings and tubes in all the bones.

(7) In a general way every skeletal element is critically examined.


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*Middle row* :—Basistruts.

*Right row* :—Lamellar bars.

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Fig. 10 .. Lamellobasal (Ventral View), Sp.—Spine. Arrow points to openings arranged in tiers.

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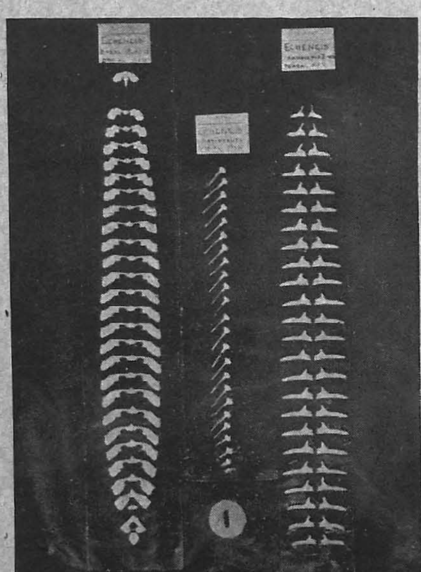


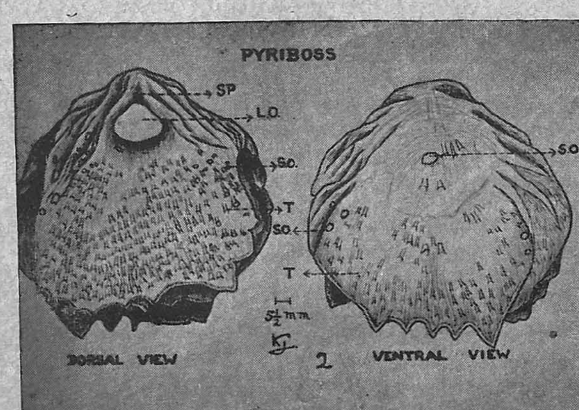

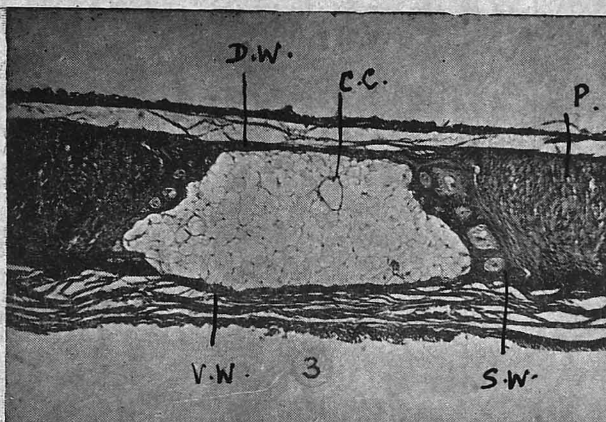
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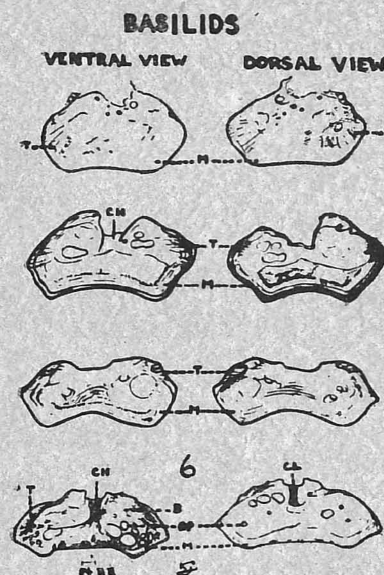
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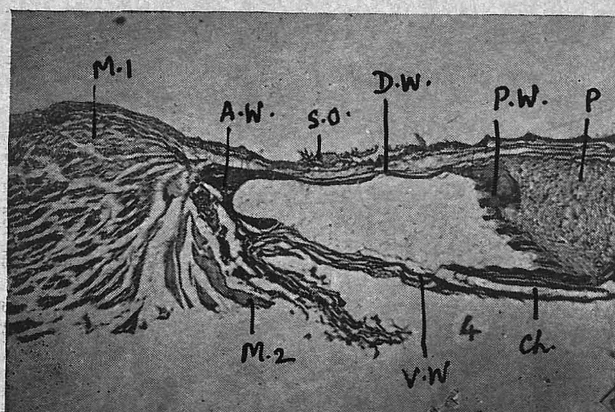
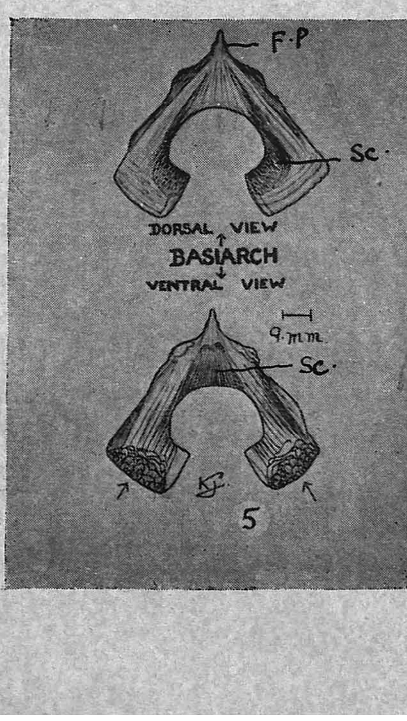
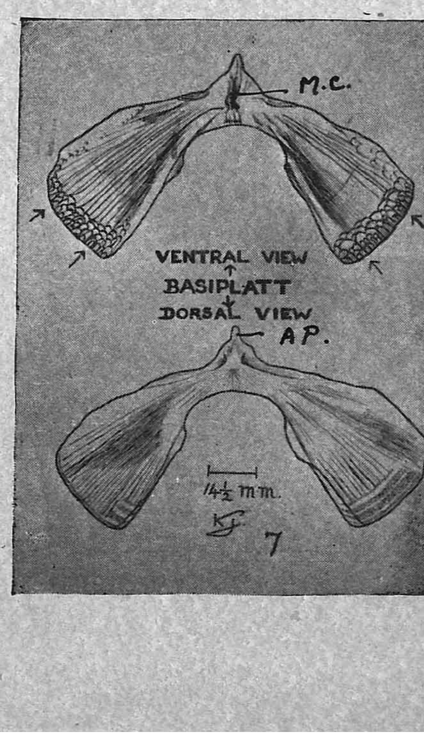
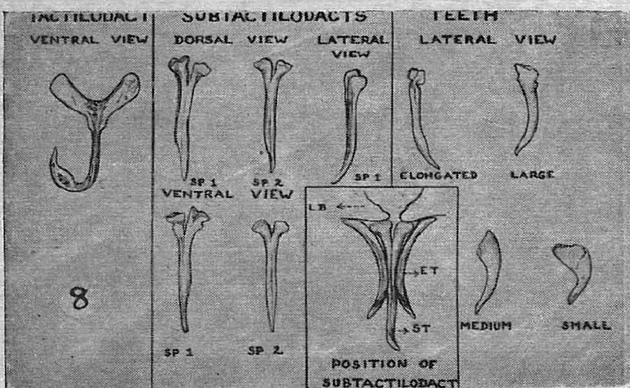
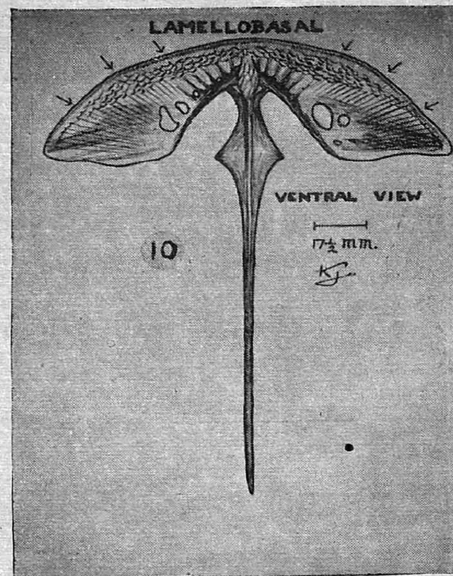
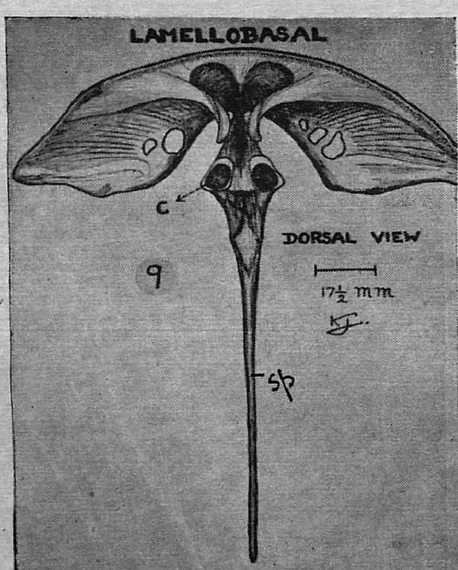

M.1
A.W.
S.O.
D.W.
P.W.
P
M.2
V.W
Ch.
4

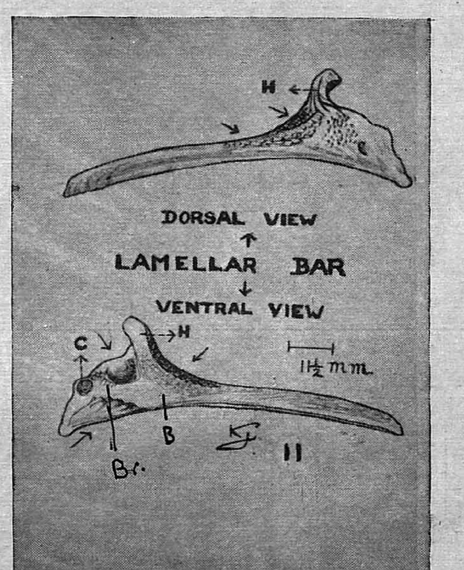

F.P
Sc.
DORSAL VIEW
BASIARCH
VENTRAL VIEW
9 mm
Sc.
5

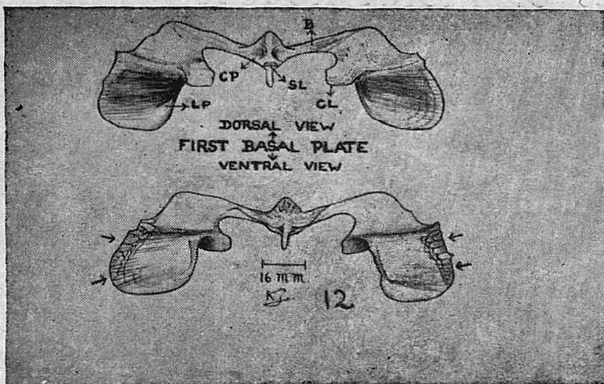

M.C.
VENTRAL VIEW
BASIPLATT
DORSAL VIEW
AP.
14½ mm.
7

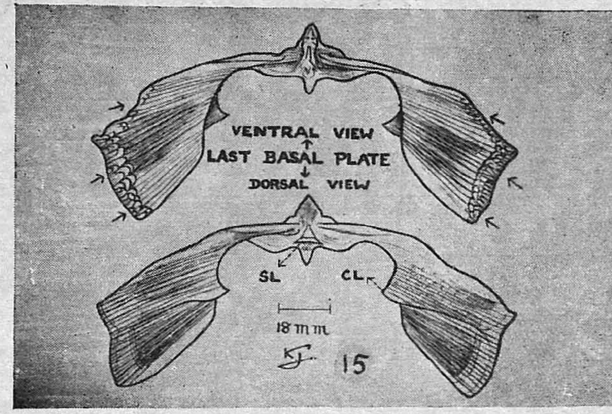

TACTILODACT
VENTRAL VIEW
SUBTACTILODACTS
DORSAL VIEW
LATERAL VIEW
TEETH
LATERAL VIEW
SP 1
SP 2
SP 1
ELONGATED
LARGE
VENTRAL VIEW
LB
ET
ST
MEDIUM
SMALL
8
SP 1
SP 2
POSITION OF SUBTACTILODACT

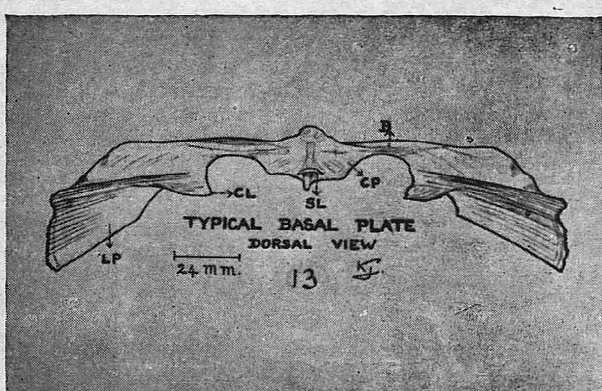

LAMELLOBASAL
VENTRAL VIEW
17½ mm.
10

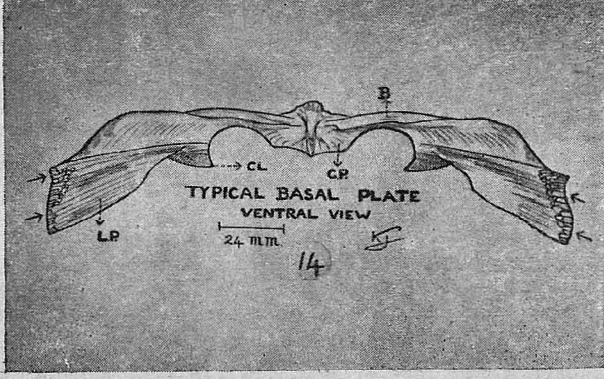

LAMELLOBASAL
C
DORSAL VIEW
9
17½ mm
Sp

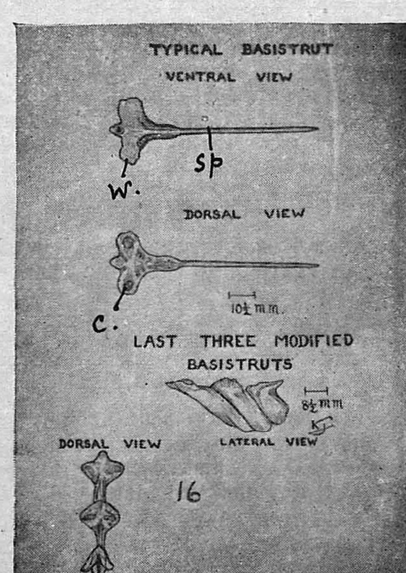

H
DORSAL VIEW
LAMELLAR BAR
VENTRAL VIEW
C
H
1½ mm.
B
Br.
11


B
CP
SL
CL
LP
DORSAL VIEW
FIRST BASAL PLATE
VENTRAL VIEW
16 mm
12


VENTRAL VIEW
LAST BASAL PLATE
DORSAL VIEW
SL
CL
18 mm
15


B
CL
SL
CP
TYPICAL BASAL PLATE
DORSAL VIEW
LP
24 mm.
13


B
CL
CP
TYPICAL BASAL PLATE
VENTRAL VIEW
LP
24 mm.
14


TYPICAL BASISTRUT
VENTRAL VIEW
SP
W.
DORSAL VIEW
C.
10½ mm.
LAST THREE MODIFIED
BASISTRUTS
8½ mm
DORSAL VIEW
LATERAL VIEW
16

# ON THE LARVAL STAGES OF IRONA ROBUSTA

BY

MRS. J. G. ABRAHAM, M.SC.

The marsupium of the female I. robusta is packed with 200—325 larvae. Larvae of both stages (Pullus stadii primii and Pullus stadii secondi) were observed and described here. This is the second detailed description of larvae of any species of Irona.

**Pullus stadii primii**

This larva ranges from 2·75—3·06 mm. in length—

L 2·75×0·83 mm.

Head 0·316 mm.×0·375 mm.

Thorax 1·25 mm.×0·83 mm.

Abdomen 0·75 mm. long.

Telson 0·5 mm.

The larva (Fig. 1) is more than thrice longer than broad measuring 2·75×0·83 mm. and is slightly grey in colour. As in I. far and I. renardi the larva here also look slightly asymmetrical. The cephalon is broader than long and is nearly one fourth the length of the thorax from the broad anterior end of which the antennal pairs are seen. The eyes are narrow 2 mm.×0·1 mm. granular and occupy part of the lateral margin of the cephalon. The thorax is markedly wider than the abdomen but unlike in that of I. far, here the abdomen is much shorter than the thorax. The broadest region of the thorax is at the third, fourth and fifth segment. The last thoracic segment is without limbs as usual and is nearly half the length of the sixth thoracic but broader than the abdominal segments. The Epimera are flabby and not clearly indicated at this stage.

The last two abdominal segments are markedly longer than the proceeding three segments. The Telson is 0·75 mm. long roughly shield shaped with a broader anterior margin and gently rounded posterior margin. There is no sub apical constriction in the Telson as is found in the larva of I. foveolata.

**Appendages**

The antennules (Fig. 2) are eight jointed and blunt tipped. The antennae (Fig. 3) are nine jointed and more pointed at the tip.

The mandible (Fig. 4) is 0·32 mm. long and consists of a three jointed palp and an inner blunt process which develops into the quasi molar of the adult.

The I maxilla (Fig. 5) is about 0·2 mm. long and is a simple appendage with one blunt spine at its tip. The II maxilla (Fig. 6) is 0·15 mm. long is just unequally bilobed with an outer broader and inner narrow lobe, both without spines.

The maxilliped (Fig. 7) is 0·23 mm. long is three jointed of which the second is the largest. The terminal joint bears a tooth. The six pairs of thoracic limbs (Figs. 8—10) are long. Each of the thoracic appendages is provided with long and simple distinct nail or claw. The seventh thoracic segment is without any appendage as usual. The pleopods (Fig. 11) have a two jointed protopodite with the basipodite showing four short rudimentary setae in the beginning stage of development. Pleopods of I stage larvae showed setae in different stages of development. The rami are non-setose just wavy with the outer broader and very slightly longer than the inner one. The Uropods (Fig. 12) are longer than the telson, with a long protopodite, shorter endopodite and much longer exopodite.

**Pullus stadii secondi**

The larva (Fig. 13) has grown to about 3·06 mm. by now. The greyish colour is more prominent. At this stage the head is 0·431×0·562 mm., and broader than long. The most important feature in the head is the eyes. The eyes have become nearly four times broader than in the 1st stage appear much darker in colour, and fill almost the entire length of the lateral margins of the cephalon. The thorax is not so markedly broad as in the I stage larva. The last segment is markedly shorter than the rest. The third and fourth segments are longer than the first two and the fifth, and sixth and the last much shorter than the sixth segment of the first pleon segment. The epimera are flabby and marked faintly on the thoracic region. The uropods are setose with distinct statocyst like organs on their exopodites and the anterior three pairs of thoracic limbs are provided with serrated dactyli, the posterior 3 showing simple claws as in the larva of the first stage.

The antennules (Fig. 14) have become much elongated and are provided with sensory papillae. The terminal joint is provided with a tuft of 8 aesthestasc of which 4 are short and the other 4 are much longer. The outer distal margins of seventh, sixth and third segments of the antennule also bears one short seta each. In addition to the seta, the third segment shows a few hairs. The II antennae (Fig. 15) has slightly increased in length and carries at the distal outer margin of fifth, seventh and eigth segments a seta each. The tip of the distal segment is also setose. The mandible (Fig. 16) does not show much difference from that of first stage larva except in that the simple club shaped structure is slightly getting modified into a quasi molar. The I maxilla (Fig. 17) which was simple in the first stage shows 3–4 teeth at its tip. The *II maxilla* (Fig. 18) at this stage the inner smaller lobe has become more prominent and slightly anterior in position than the outer lobe, and shows 2 sharp slightly curved teeth at its inner margin.

The maxilliped (Fig. 19) does not show much change at all. Most probably the quasi molar of mandible and the teeth of maxillae and maxilliped appear in a later stage in this larva.

The thoracic appendages (Figs. 20—23) show marked difference from the first stage larva. The simple less curved nails of the 1st stage larva have become much elongate and curved showing a very fine narrow pointed tip. Such hooked claws are an adaptation for clinging to any suitable host. In the first 3 pairs, the proximal half of the inner margin of the dactili show 5 to 7 short conical teeth. The dactili of the last three pairs (Figs. 22 and 23) are simple and curved and do not show the serrations. The propodi of the first three pairs and the last show 3 short rather curved teeth in their inner margin. That of the fifth pair (Fig. 22) show two teeth near the dorsal region of the dactylus.

The carpus of the third and sixth (Figs. 21 and 23) show 1 and 2 spines. The merus in sixth pair also shows a spine externally at the distal region (Fig. 23). Such spines in addition to hooked claws seem to be an adaptation for clinging on to a suitable host.

The pleopods (Fig. 24) are all similar. The distal margin of the endopodite shows 7 pinnate setules. The expodite is devoid of such setules.

The uropods (Fig. 25) show a marked change. The endopodite bears 17 pinnate setules of which the two at the outer margin are very much shorter than the rest. The expodite is devoid of setules at the outer margin but bears at its inner margin nine long pinnate setules two simple short setules and one thick inwardly curved spine. Of the nine pinnate setules, the one nearest to the two simple setules is shorter than the other eight.

**Statocysts.**

As in the pullus stadii secondi of I. far the exopodite of the uropods of this II stage larvae show distinct statocysts. They are oval in structure and are present in the middle of the exopodite. They do not seem to open to the exterior but muscle structure seem to pass inwards and support a statolith like mass in the centre. These are never observed in the I stage larva or adult. Evidently they seem to develop at this state of the life history but disappear after they get attached to a host.

In I. renardi eight such pinnate setules and a few thick hairs and a sting are mentioned.

In I. nanoides Stebbing does not mention anything about the number of pinnate setules in the expodites of the uropods.

In the II stage larva of I. far the endopodite shows 15 pinnate setules and exopodite shows 10 such pinnate setules and two straight stings at the distal margin external to these—of which the inner one is longer than the outer.

The larvae of II stage apart from its appearance and size differs from the larva of I stage in the general shape of the body structure of all the cephalic appendages, first 3 pairs of thoracic appendages, the pleopods and uropods and also in the occurrence of statocysts in the exopodite of the uropods.

From 2·5 mms. it grows to 3·75 mms. The shape is much narrower and elongate—the thorax very slightly broader than the abdomen. The larva looks striated transversely faintly. The hitherto scattered pigment cells arrange themselves in transverse rows along the outer and posterior margins of the segments.

*Explanation of figures.*

| *Figure number.* | | |
|---|---|---|
| 1 | Larva I Stage of I. robusta | 5×80 |
| 2 | Antennule | 5×40 |
| 3 | Antenna | 7×40 |
| 4 | Mandible | 7×40 |
| 5 | I Maxilla | 7×40 |
| 6 | II Maxilla | 7×40 |
| 7 | Maxilliped | 15× 8 |
| 8–10 | Thoracic legs First, second and third | 5× 8 |
| 11 | A pleopod of I stage larva | 5× 8 |
| 12 | Uropod | 5× 8 |
| 13 | Larva of II stage | 5× 8 |
| 14 | Antennule | 5×40 |
| 15 | Antenna | |
| 16 | Mandible | 5×40 |
| 17 | I Maxilla | 5×40 |
| 18 | II Maxilla | 5×40 |
| 19 | Maxilliped | 5×40 |
| 20 | I Thoracic leg | 15× 8 |
| 21 | Third Thoracic leg | 15× 8 |
| 22 | Fifth Thoracic leg | 15× 8 |
| 23 | Sixth Thoracic leg | 15× 8 |
| 24 | A pleopod | 5× 8 |
| 25 | Uropod | 5× 8 |

*Key to Lettering.*

| | | |
|---|---|---|
| 1 | A. | Antennule |
| 2 | Ab. | Abdomen |
| 3 | Ant. | Antenna |
| 4 | B. | Basis |
| 5 | C. | Cephalon |
| 6 | Cl. | Claw |
| 7 | Ca. | Carpus |
| 8 | Dt. | Dactylus |
| 9 | E. | Eye |
| 10 | En. | Endopodite |
| 11 | Ex. | Exopodite |
| 12 | Irch. | Ischwin |
| 13 | Mdb. | Mandible |
| 14 | Mc. | Merus |
| 15 | Mx. | I. Maxilla |
| 16 | Mx. II | II Maxilla |
| 17 | Mxp. | Maxilliped |
| 18 | Prt. | Protopodite |
| 19 | Prp. | Propodus |
| 20 | Pl. | Pleopod |
| 21 | Sp. | Spine |
| 22 | T. | Telson |
| 23 | Th. | Thorax |
| 24 | Upd. | Uropod |

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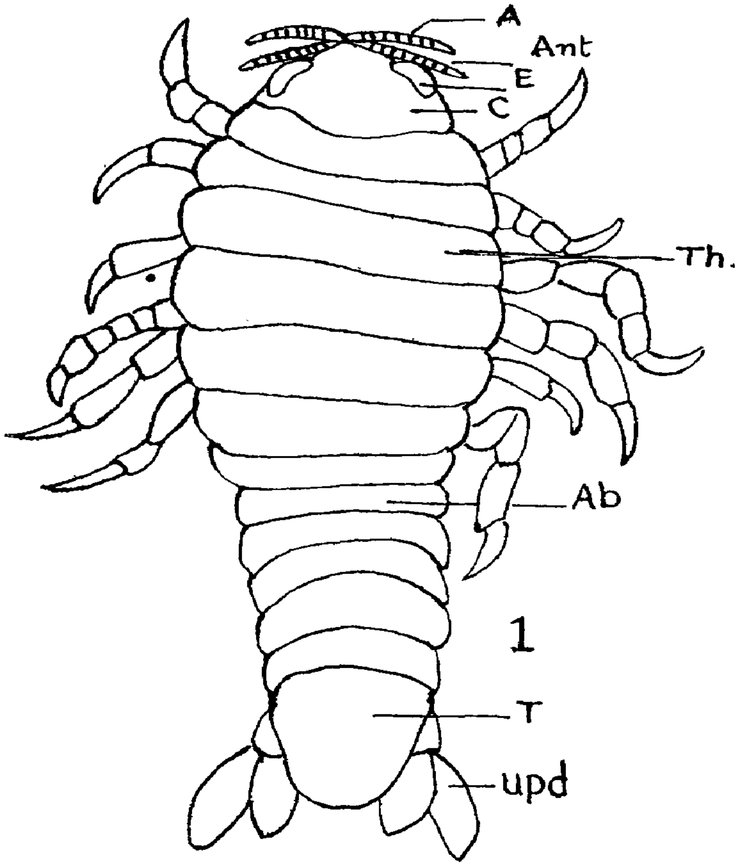
Pl. I

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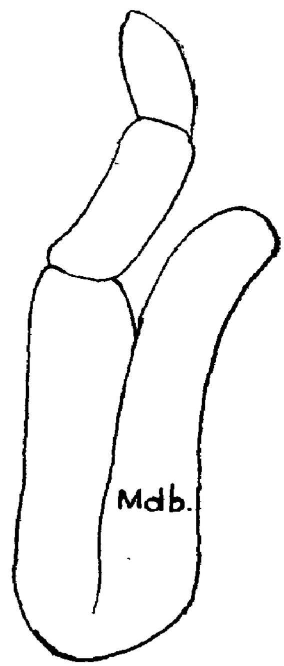


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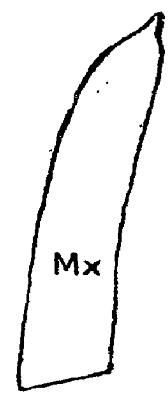


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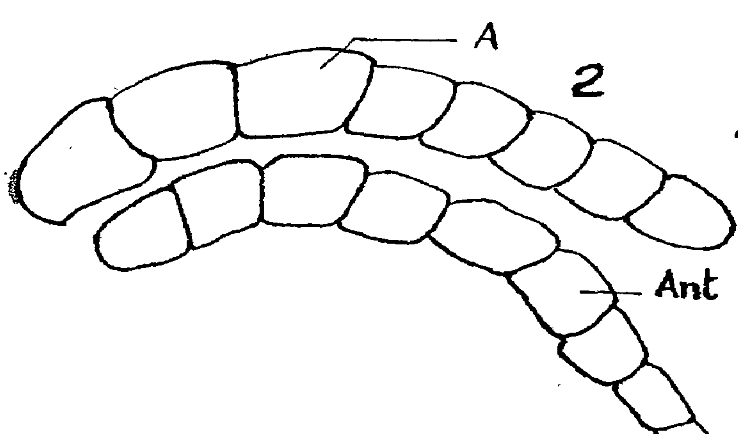


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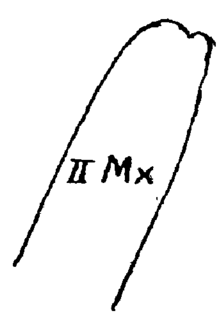


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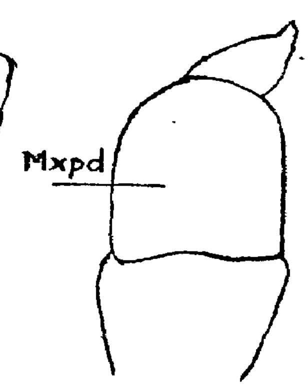


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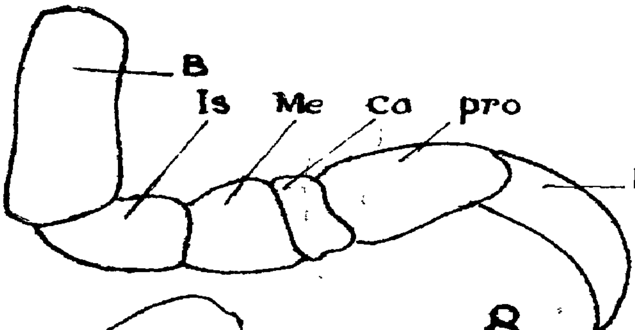


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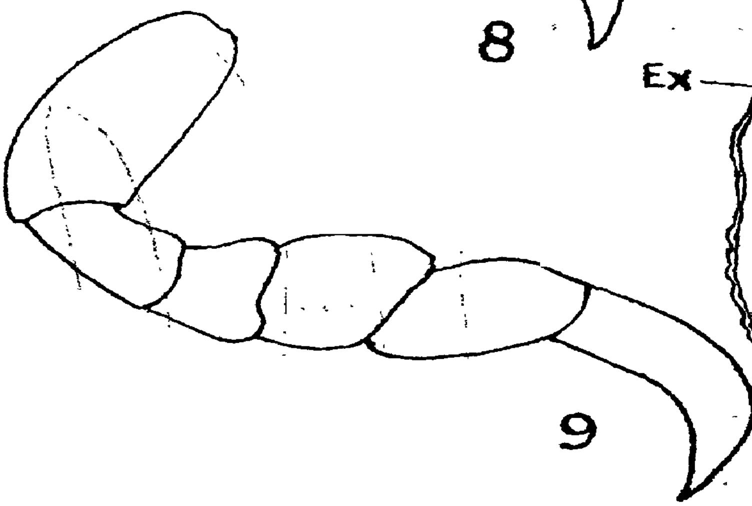

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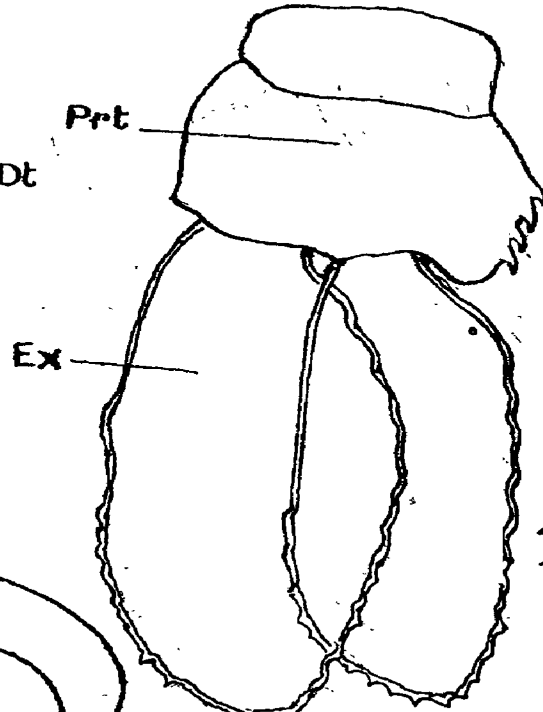


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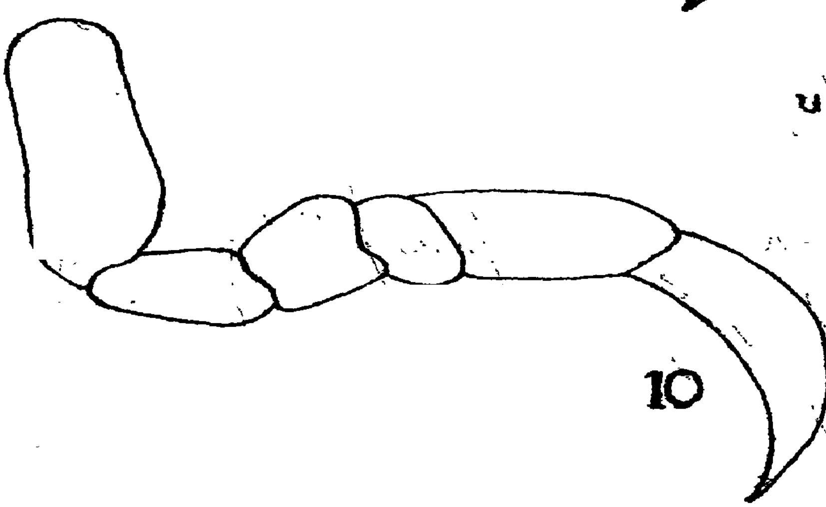

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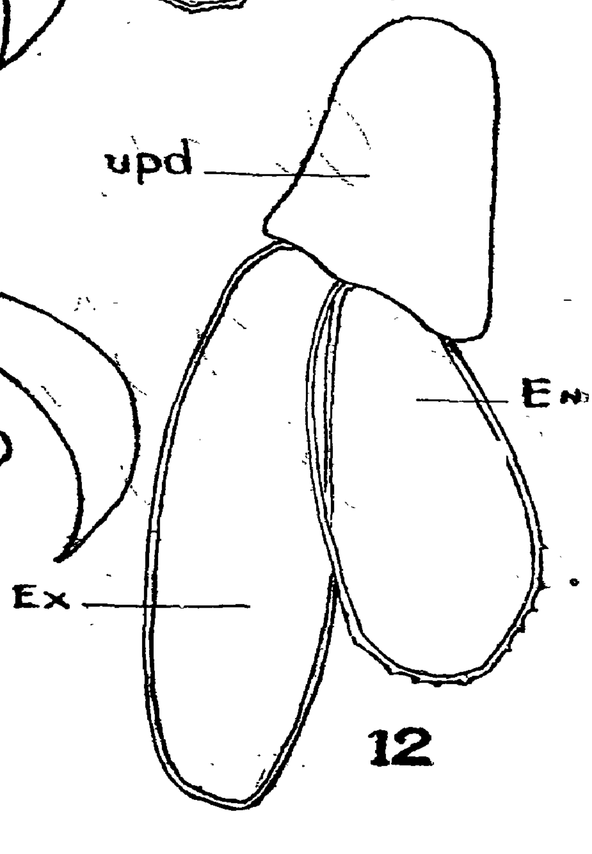


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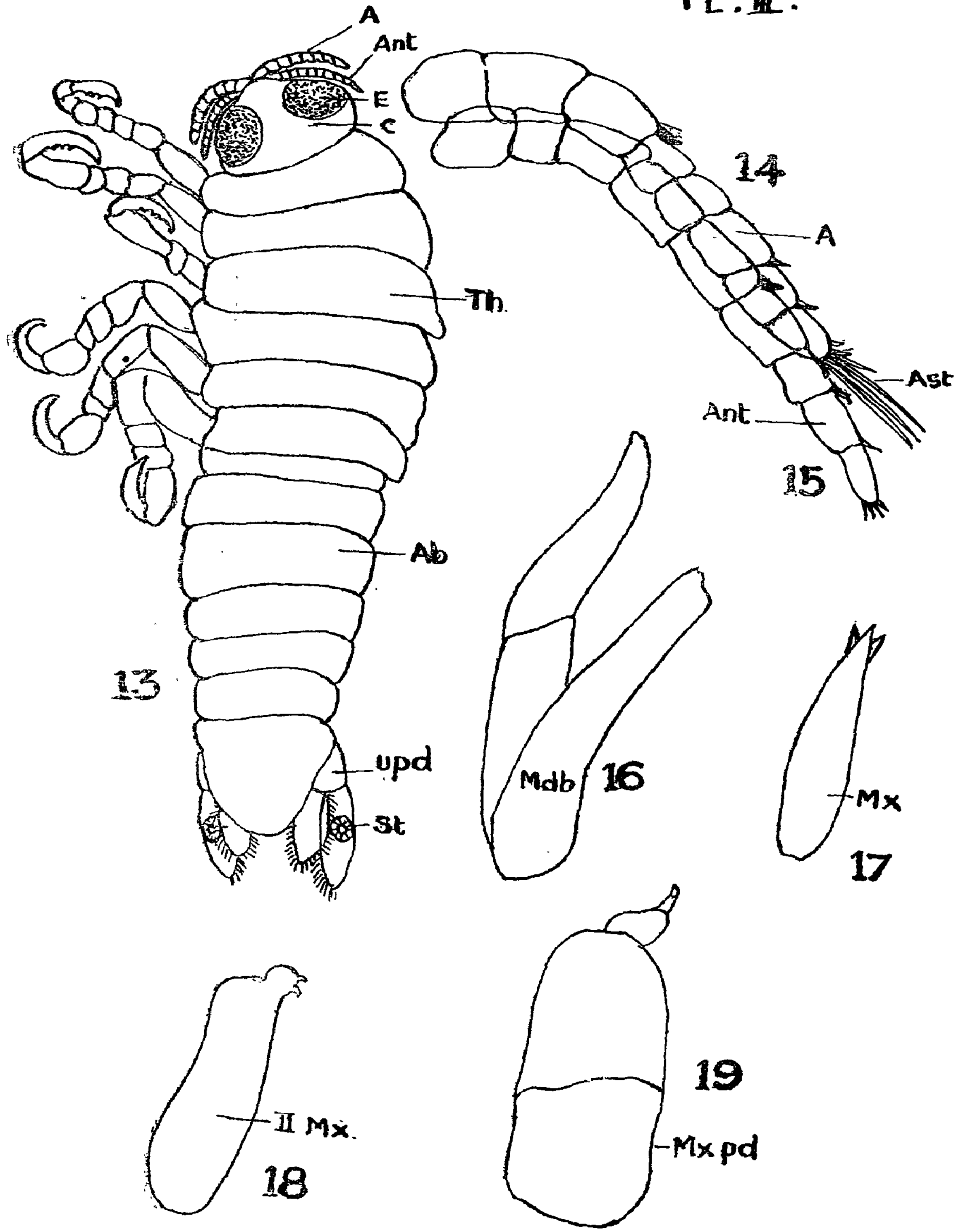
Pl. III.



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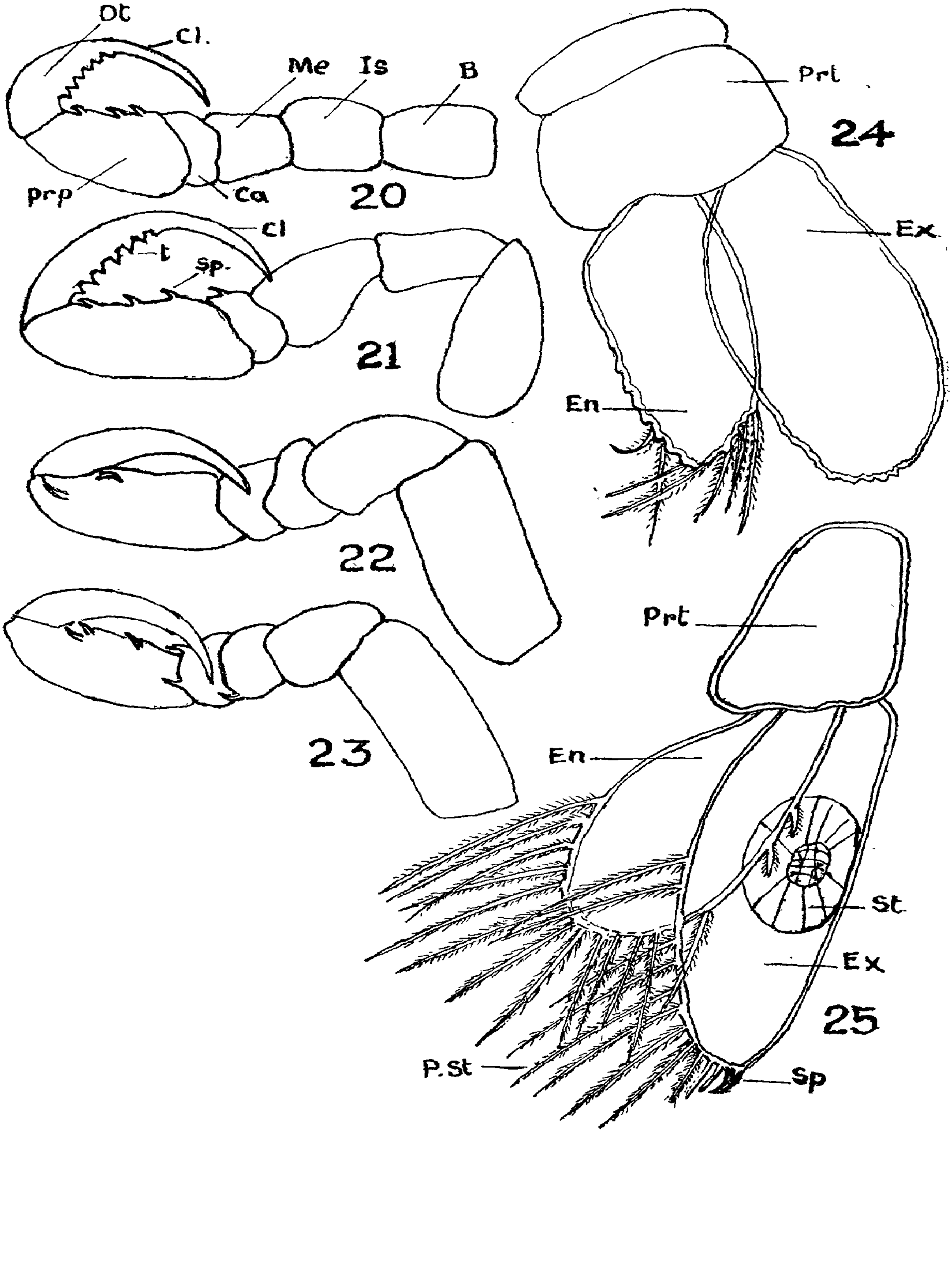
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# USE OF CHLORTETRACYCLINE AS A PRESERVATIVE FOR DRY SALTED FISH-II

BY

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## Introduction

In an earlier communication by one of the present authors (Joseph, K.C., 1962) the results of experiments on the effects of chlortetracycline in prolonging the useful shelf life of four species of dry salted marine fish were reported. The results of similar investigations on six other species of marine food fishes are incorporated in this paper.

The results of studies carried out on the effect of the same antibiotic at lower levels than used in the previous investigations for the preparation of dry-salted Sardines are also presented in this paper.

## Material and Methods

The studies were carried out with the following species of fishes :—(1) Trichiurus savala, (2) Sciæna sp., (3) Lactarius lactarius, (4) Chirocentrus dorab, (5) Serranus sp., (6) Arius sp. and (7) Sardinella sp. The raw material was procured from the freshly landed catches at Cape Comorin. Acronize B1, a product of the American Cyanamid Company was used for the C.T.C. preparations tried in these experiments. The freshly purchased specimens were washed clean, first with sea water, then with fresh water and processed as follows :—

(1) *Trichiurus savala.*—The specimens were slit open along the dorsal side and gutts and gills removed and a few transverse incisions made on both the sides to facilitate penetration of C.T.C. and salt. Those were then cleaned by washing in fresh water and kept immersed in 25 p.p.m. C.T.C. for 5 minutes, drained and salted, the salt : fish proportion being 1: 5 by weight. The salted fish was then kept aside in a closed cistern so as to remain in contact with the self-brine formed for 24 hours. After the curing period of 24 hours, the salted material was removed, drained and dried for three consecutive days in the sun, over bamboo barbecues. A control sample was prepared under identical conditions but for the dip in the C.T.C. solution.

(2) *Sciaena sp.*—The process was the same as for Trichiurus described above, but for the filletting of the specimens by longitudional cuts and the use of a higher salt fish ratio of 1: 4.

(3) *Lactarius.*—The fishes were slit along the dorsal side and gutts and gills removed. No incisions were made on the flesh. Three different salt fish proportions of 1:3, 1:4 and 1:5 were tried. Other details of processing were the same as for Trichiurus already described.

(4) *Chirocentrus dorab.*—The processing was identical in all respects as for Trichiurus.

(5) *Serranus sp.*—The same method of preparation as given above for Sciæna sp. was employed.

(6) *Arius sp.*—This fish was also cured according to the method described for Sciæna.

(7) *Sardines.*—The specimens were cut open along the dorsal line, entrails removed and washed clean. This material was then divided into four lots, one of which was salted to serve as a control sample, the salt:fish ratio being 1:7. The second lot was given a one minute dip in 5 p.p.m., C.T.C. prior to salting in the same ratio of salt:fish mentioned above. Similarly the remaining two portions were given one minute dips on 10 and 15 p.p.m., C.T.C. respectively before salting in the same ratio. The period under cure for all these was 24 hours followed by sun drying for three consecutive days. The entire experiment was duplicated and the products kept in storage in glass-jars with bakelite screw caps up to six months and periodically examined at monthly intervals for organoleptic and chemical characteristics. The chemical and organoleptic tests were conducted employing the same methods as described in the earlier communication (Joseph, K.C., loc cited).

## Results and Conclusions

The results of the periodic analysis are summarised in Tables I to VI respectively for Trichiurus, Sciaena sp., Lactarius Lactarius, Chirocentrus dorab, Serranus sp. and Arius sp., salted after treatment with C.T.C. at 25 p.p.m. concentration. The results of the experiments on Sardines using lower concentrations of 5, 10 and 15 p.p.m., C.T.C. are presented in Table VII.

The earlier finding that the C.T.C. (25 p.p.m.) treated products of dried salted fish remained in excellent condition for three months as against two months only in the case of the untreated control samples of dried salted Lethrinus, Silver bellies and Sardines was further confirmed as a result of the present investigations carried out with Trichiurus savala, Sciæna sp., Lactarius lactarius, Chirocentrus dorab, Serranus sp. and Arius sp. Further, in the case of those fishes for which more than one salt:fish proportions were tried the C.T.C. treated products had always better organoleptic characteristics and chemical qualities than the corresponding control samples of corresponding stages during the period of storage. This showed that the action of C.T.C. in retarding the growth and multiplication of spoilage-causing bacteria was not affected by the concentration of salt present in the cured fish. This view was further confirmed by the figures for total bacterial count estimated in the case of the cured Serranus. Chirocentrus and Arius products. A further close scrutiny of the data reveals that though lower levels of T.V.B.N., T.M.A. and T.B.C. were recorded in the case of C.T.C. treated samples at all stages, their rate of change on storage were found to be more or less of the same order as in the untreated samples. This may probably be due to the removal of most of the C.T.C. penetrated into the flesh by subsequent salting. However the initial reduction in the T.V.B.N., T.M.A. and T.B.C. accomplished by the C.T.C. dip. prior to salting was definitely found to improve the product and enhance its keeping qualities and shelf life.

Experiments on the curing of sardines using C.T.C. at the lower concentrations of 5, 10 and 15 p.p.m. revealed that the use of the antibiotic at 5 and 10 p.p.m. level had practically no effect on the keeping qualities of the cured products. In these cases the samples did not differ very much from the untreated control samples in respect of chemical characteristics. The differences in the average figures for T.V.B.N. and T.M.A.N. for the three series experiments between the treated and untreated samples are noted below :—

| Period of storage in days. | *Concentration of C.T.C. used for immersion.* | | | | | |
|---|---|---|---|---|---|---|
| | *5 p.p.m.* | | *10 p.p.m.* | | *15 p.p.m.* | |
| | *T.V.B.N.* | *T.M.A.N.* | *T.V.B.N.* | *T.M.A.N* | *T.V.B.N.* | *T.M.A.N.* |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| 30 .. .. | 6·5 | 0·25 | 12·75 | 3·25 | 16·0 | 4.25 |
| 90 .. .. | 1·25 | 5·25 | 10·25 | 13·50 | 69·0 | 27·0 |
| 120 .. .. | 1·5 | 2·75 | 8·75 | 9·25 | 53.5 | 25·75 |
| 150 .. .. | 3.25 | 1.75 | 2·25 | 8·50 | 59·25 | 24·50 |
| 180 .. .. | 12·25 | 3·25 | 50·75 | 7.0 | 122.0 | 21·25 |

From these figures it is clear that the samples dipped in 5 p.p.m. and 10 p.p.m. C.T.C. were not better than the control samples. But the samples treated with 15 p.p.m. C.T.C. solution prior to salting exhibited slightly better keeping qualities than the untreated samples. This improvement was however much below what was obtained for the same fish when dipped in 25 p.p.m. C.T.C. (Joseph, K.C., loc. cited). It may therefore be concluded that a dip in 25 p.p.m. C.T.C. prior the salting is beneficial in the salt curing of fish and will improve the quality of the salt cured product and enhance its keeping qualities and shelf life. The method may be safely and profitably adopted in the fish curring industry, as no health hazard is involved, the residual antibiotic being completely destroyed on cooking (Chari, S.T., 1961).

*Acknowledgment.*

We are grateful to the Director of Fisheries, Madras, for his kind permission to publish this paper.

*References.*

1 Chari, S. T. (1961)—" Use of aureomycin in fish preservation and effect of heat on the antibiotic treated fish." Proc. Indian Acad. Sci. 1961, 4, 173–181.

2 Joseph, K. C. (1962)—" Use of Chlortetracycline as a preservative for dry salted fish-I ". Madras Journal of Fisheries, 1962, 1, 129–133.

TABLE I.

*Data on progress of spoilage in Trichiurus Savala cured with salt after treatment with C.T.C.*
*(Salt : Fish 1: 5).*

| *Storage period sample.* | 30 *days.* | | 60 *days.* | | 90 *days.* | | 120 *days.* | | 150 *days.* | | 180 *days.* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *A* | *B* | *A* | *B* | *A* | *B* | *A* | *B* | *A* | *B* | *A* | *B* |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) |
| Moisture (per cent) .. .. | 36·02 | 36·04 | 36·24 | 36·16 | 36·40 | 36·34 | 36·28 | 30·30 | 36·45 | 36·42 | 36·01 | 36·00 |
| TVBN (mgm./cent) .. .. | 94·00 | 82·00 | 102·00 | 84·00 | 117·50 | 97·00 | 122·50 | 101·50 | 133·50 | 107·00 | 162·50 | 132·00 |
| TMAN (mgm./cent) .. .. | 42·00 | 33·50 | 45·00 | 36·00 | 54·50 | 43·00 | 59·00 | 44·50 | 68·00 | 48·00 | 80·50 | 61·00 |
| Organoleptic Test Score (Max. 30). | 30·00 | 30·00 | 29·00 | 30·00 | 29·00 | 30·00 | 28·00 | 29·00 | 25·00 | 28·00 | 23·00 | 26·00 |

*Remarks*—*A* = Control sample.
*B* = Sample treated with C.T.C.

TABLE II.

*Data on progress of spoilage on Sciaena sp. cured with salt after treatment with C.T.C.* (*Salt : Fish* 1 : 4).

| *Storage period sample.* | 30 *days.* | | 60 *days.* | | 90 *days.* | | 120 *days.* | | 150 *days.* | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *A* | *B* | *A* | *B* | *A* | *B* | *A* | *B* | *A* | B |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
| Moisture (per cent) .. .. | 39·75 | 40·02 | 39·60 | 39·84 | 38·40 | 38·64 | 37·43 | 37·37 | 37·18 | 37·17 |
| TVBN (mgm./cent) .. .. | 95·50 | 72·50 | 100·50 | 74·00 | 108·00 | 80·00 | 119·00 | 83·00 | 136·00 | 102·00 |
| TMAN (mgm./cent) .. .. | 37·00 | 34·75 | 39·50 | 35·00 | 41·50 | 36·00 | 58·00 | 38·00 | 75·50 | 59·00 |
| **Organolephic Test Score (Max. 30)** | 30·00 | 30·00 | 30·00 | 30·00 | 29·00 | 30·00 | 27·00 | 29·00 | 26·00 | 28·00 |

*Remarks.*—*A* = Control sample.
*B* = Sample treated with C.T.C.

TABLE III.

*Data on progress of spoilage in Lactarius Lactarius cured with salt after treatment with Chlortetracycline.*

| *Storage period.* | *Sample.* *Salt : Fish.* | *Control.* 1 : 3 | 1 : 4 | 1 : 5 | *C.T.C. Treated.* 1 : 3 | 1 : 4 | 1 : 5 | *Remarks.* |
|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| 30 days .. | Moisture (per cent) .. | 34·43 | 35·05 | 35·23 | 34·61 | 35·12 | 35·17 | .. |
| | TVBN (mgm/cent) .. | 83·5 | 87·0 | 90·0 | 80·0 | 81·0 | 84·5 | .. |
| | TMAN (mgm/cent) .. | 32·5 | 32·0 | 36·5 | 30·5 | 31·0 | 31·5 | .. |
| | Total count (no/gm) .. | 9,300 | 9,500 | 10,100 | 8,700 | 8,100 | 9·000 | .. |
| | Org. Test Score (Max. 30). | 30·0 | 30·0 | 29·0 | 30·0 | 30·0 | 30·0 | .. |
| 60 days .. | Moisture (per cent) .. | 34·60 | 35·06 | 35·20 | 34·84 | 35·10 | 35·12 | .. |
| | TVBN (mgm/cent) .. | 102·0 | 105·5 | 108·0 | 90·5 | 88·5 | 90·0 | .. |
| | TMAN (mgm/cent) .. | 35·0 | 34·5 | 39·0 | 33·5 | 33·0 | 33·5 | .. |
| | Total count (no/gm) .. | 13,000 | 17,000 | 16,000 | 10,000 | 9,000 | 11,000 | .. |
| | Org. Test Score (Max. 30). | 28·0 | 28·0 | 26·0 | 29·0 | 29·0 | 29·0 | .. |
| 90 days .. | Moisture (per cent) .. | 34·84 | 34·91 | 35·13 | 34·80 | 35·35 | 35·02 | .. |
| | TVBN (mgm/cent) .. | 154·0 | 150.5 | 162·0 | 121·0 | 116·5 | 123·0 | .. |
| | TMAN (mgm./cent) .. | 62·5 | 64.0 | 67·5 | 48·0 | 65·0 | 60·5 | .. |
| | Total count (no/gm.) .. | 81,000 | 86,000 | 93,000 | 27,000 | 30,000 | 28,000 | .. |
| | Org. Test Score (Max. 30). | 25·0 | 25·0 | 24·0 | 27·0 | 27·0 | 27·0 | .. |
| 120 days .. | Moisture (per cent) .. | 35·25 | 35·13 | 34·96 | 34·22 | 35·87 | 34·85 | .. |
| | TVBN (mgm /cent) .. | 230·0 | 242·0 | 250·5 | 232·0 | 193·0 | 203·5 | .. |
| | TMAN (mgm/cent) .. | 97·0 | 100·0 | 104·0 | 91·0 | 87·5 | 90·0 | .. |
| | Total count (no/gm) .. | 95,000 | 93,000 | 104,000 | 43,000 | 41,000 | 47,000 | .. |
| | Org. Test Score (Max. 30). | 23·0 | 23·0 | 21·0 | 26·0 | 26·0 | 25·0 | .. |
| 150 days .. | Moistore (per cent) .. | 34·81 | 34·65 | 34·02 | 34·08 | 35·42 | 33·60 | .. |
| | TVBN (mgm/cent) .. | 250·0 | 255·0 | 290·0 | 230·0 | 195·0 | 205·0 | .. |
| | TMAN (mgm/cent) .. | 103·0 | 98·5 | 120·5 | 92·5 | 87·5 | 89·0 | .. |
| | Total count (no/gm) .. | 230,000 | 270,000 | 310,000 | 70,000 | 80,000 | 70,000 | .. |
| | Org. Test Score (Max. 30). | 20·0 | 19·0 | 19·0 | 24·0 | 23·0 | 23·0 | .. |
| 180 days .. | Moisture per cent) .. | 34·84 | 34·73 | 34·09 | 34·30 | 35·50 | 33·55 | .. |
| | TVBN (mgm/cont) .. | 290·00 | 305·0 | 332·5 | 255·0 | 250·0 | 255·0 | .. |
| | TMAN (mgm/cent) .. | 115·0 | 115·5 | 131·0 | 97·5 | 91·0 | 105·0 | .. |
| | Total count (no/gm) .. | 310,000 | 340,000 | 480,000 | 130,000 | 150,000 | 140,000 | .. |
| | Org. Test (Score Max. 30). | 18·0 | 15·0 | 16·0 | 23·0 | 22·0 | 22·0 | .. |

TABLE IV.

*Data on progress of spoilage in Chirocentrus dorab cured with salt after treatment with C.T.C.*

(*Salt : Fish* 1 : 5).

| *Storage period sample.* | 30 *days.* | | 60 *days.* | | 90 *days.* | | 120 *days.* | | 150 *days.* | | 180 *days.* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *A* | *B* | *A* | *B* | *A* | *B* | *A* | *B* | *A* | *B* | *A* | *B* |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) |
| Moisture (per cent) .. .. | 33·26 | 33·16 | 33·09 | 33·28 | 33·34 | 33·67 | 33·30 | 33·21 | 33·42 | 33·37 | 32·59 | 33·22 |
| TVBN (mgm./cent) .. .. | 56·00 | 54·00 | 88·00 | 79·50 | 117·50 | 90·50 | 134·50 | 103·50 | 170·50 | 117·50 | 211·50 | 150·50 |
| TMAN (mgm./cent) .. .. | 24·00 | 23·5 | 35·50 | 32·50 | 43·00 | 38·00 | 45·50 | 38·50 | 61·50 | 53·00 | 66·00 | 62·00 |
| Total count (no/gm.) .. .. | 1,300 | 900 | 49,000 | 13,000 | 57,000 | 17,000 | 80,000 | 40,000 | 1,70,000 | 90,000 | 3,00,000 | 1,20,000 |
| Organoleptic Test Score (Max. 30). | 30 | 30 | 28 | 30 | 26 | 29 | 23 | 27 | 21 | 26 | 19 | 24 |

*Remarks.*—*A* = Control sample.
*B* = Sample treated with C.T.C.

TABLE V.

*Data on progress of spoilage in Serranus sp. cured with salt after treatment with C.T.C.* (*Salt : Fish* 1 : 4).

| *Storage period sample.* | 30 *days.* | | 60 *days.* | | 90 *days.* | | 120 *days.* | | 150 *days.* | | 180 *days.* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *A* | *B* | *A* | *B* | *A* | *B* | *A* | *B* | *A* | *B* | *A* | *B* |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) |
| Moisture (per cent) .. .. | 38·68 | 39·21 | 37·64 | 38·90 | 37·61 | 38·45 | 37·35 | 37·81 | 36·82 | 37·22 | 37·82 | 37·21 |
| TVBN (mgm./cent) .. ... | 97·50 | 90·50 | 174·00 | 142·00 | 232·00 | 166·00 | 280·00 | 175·00 | 343·00 | 271·05 | 365·50 | 284·00 |
| TMAN (mgm./cent) .. .. | 32·00 | 32·00 | 76·00 | 53·50 | 97·50 | 65·50 | 110·50 | 70·50 | 128·50 | 116·00 | 164·50 | 115·50 |
| Total count (no/gm) .. .. | 7,100 | 6,900 | 31,000 | 11,000 | 48,000 | 19,000 | 83,000 | 31,000 | 2,40,000 | 1,30,000 | 3,70,000 | 1,70,000 |
| Organoleptic Test Score (Max. 30). | 30·00 | 30·00 | 26·00 | 28·00 | 23·00 | 28·00 | 20·00 | 26·00 | 17·00 | 23·00 | 16·00 | 22·00 |

*Remarks.*—*A* = Control sample.
*B* = Sample treated with C.T.C.

TABLE VI.

*Data on progress of spoilage in Arius sp. cured with salt after treatment with C.T.C.* (*Salt : Fish* 1 : 4).

| *Storage period. sample.* | 60 *days.* | | 90 *days.* | | 120 *days.* | | 150 *days.* | | 180 *days.* | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *A* | *B* | *A* | *B* | *A* | *B* | *A* | *B* | *A* | *B* |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
| Moisture (per cent) .. .. | 35·97 | 35·41 | 36·13 | 35·59 | 35·61 | 35·30 | 35·34 | 35·08 | 35·41 | 35·72 |
| TVBN (mgm./cent) .. .. | 148·00 | 120·50 | 174·50 | 141·00 | 205·00 | 163·00 | 293·00 | 201.00 | 337·00 | 237·00 |
| TMAN (mgm./cent.) .. .. | 59·00 | 41·00 | 62·00 | 40·05 | 73·00 | 55·00 | 116·00 | 66·50 | 165·00 | 75·50 |
| Total count (no/gm.] .. .. | 24,000 | 9,000 | 13,000 | 13,000 | 67,000 | 22,000 | 260,000 | 60,000 | 4,80,000 | 1,30,000 |
| Organoleptic Test Score (Max. 30). | 27·00 | 28·00 | 25·00 | 28·00 | 22·00 | 27·00 | 20·00 | 25·00 | 17·00 | 22·00 |

*Remarks.*—*A* = Control sample.
*B* = Sample treated with C.T.C.

TABLE VII.

*Data on progress of spoilage in Sardines cured with salt after treatment with C.T.C. (Salt : Fish 1: 7).*

| *Storage period.* | *Sample.* | *Control.* | | *5 p.p.m. C.T.C.* | | *10 p.p.m. C.T.C.* | | *15 p.p.m. C.T.C.* | |
|---|---|---|---|---|---|---|---|---|---|
| | *Experiment No.* | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| 30 days | Moisture (per cent) | 34·65 | 34·42 | 36·73 | 37·01 | 34·42 | 36·13 | 36·13 | 33·99 |
| | TVBN (mgm/cent) | 105·0 | 107·0 | 101·0 | 98·0 | 91·5 | 95·0 | 92·5 | 87·5 |
| | TMAN (mgm/cent) | 26·0 | 24·0 | 27·5 | 23·0 | 20·0 | 23·5 | 20·5 | 21·0 |
| | Org. Test Score (Max. 30) | 29·5 | 29·0 | 29·5 | 30·0 | 30·0 | 30·0 | 30·0 | 30·0 |
| 90 days | Moisture (per cent) | 35·60 | 34·38 | 36·56 | 36·49 | 34·60 | 34·53 | 36·01 | 34·03 |
| | TVBN (mgm/cent) | 180·5 | 178·5 | 177·0 | 179·5 | 171·5 | 167·0 | 117·5 | 103·5 |
| | TMAN (mgm/cent) | 66·5 | 64·0 | 62·5 | 57·5 | 50·0 | 53·5 | 39·5 | 37·0 |
| | Org. Test Score (Max. 30) | 24·0 | 25·0 | 28·0 | 27·0 | 27·0 | 26·0 | 28·0 | 29·0 |
| 120 days | Moisture (per cent) | 35·21 | 34·72 | 36·72 | 36·44 | 35·02 | 35·16 | 35·88 | 34·20 |
| | TVBN (mgm/cent) | 185·0 | 185·0 | 185·0 | 183·0 | 177·5 | 170·0 | 130·0 | 128·0 |
| | TMAN (mgm/cent) | 67·5 | 69·0 | 65·0 | 66·0 | 57·5 | 60·5 | 45·0 | 40·0 |
| | Org. Test Score (Max. 30) | 24·0 | 24·0 | 25·0 | 25·0 | 27·0 | 26·0 | 28·0 | 28·0 |
| 150 days | Moisture (per cent) | 34·26 | 34·40 | 36·57 | 36·59 | 34·81 | 35·01 | 35·81 | 34·35 |
| | TVBN (mgm/cent) | 222·0 | 205·0 | 213·0 | 207·5 | 196·0 | 186·0 | 153·0 | 155·5 |
| | TMAN (mgm cent) | 70·5 | 71·0 | 68·0 | 70·0 | 62·0 | 62·5 | 47·0 | 45·5 |
| | Org. Test Score (Max. 30) | 22·0 | 21·0 | 24·0 | 23·0 | 25·0 | 25·0 | 27·0 | 27·0 |
| 180 days | Moisture (per cent) | 34·69 | 34·64 | 36·38 | 36·61 | 35·02 | 34·96 | 35·78 | 34·43 |
| | TVBN (mgm/cent) | 317·0 | 343·0 | 320·0 | 315·5 | 281·0 | 277·5 | 210·0 | 206·0 |
| | TMAN (mgm/cent) | 75·5 | 83·0 | 80·0 | 85·0 | 70·5 | 74·0 | 56·0 | 60·0 |
| | Org. Test Score (Max. 30) | 19·0 | 19·0 | 21·0 | 21·0 | 22·0 | 21·0 | 23·0 | 24·0 |

# SOME ASPECTS OF THE STRUCTURE, LIFE HISTORY AND PHYSIOLOGY OF NAJAS GRAMINEA DEL., WITH NOTES AS ITS AUTECOLOGY

BY

T. FRANKLIN AND S. ANTONY DOSS.

## Introduction

The paper deals with, a few aspects of the structure and life history of the plant *Najas graminea* Del., with special reference to the environmental conditions such as temperature, edaphic factors, etc. The plant is a common water weed throughout Madras State. It is especially predominant in the tanks and ponds of South Arcot and Tanjore district (e.g., Marakkanam, Veeranam lakes). The materials (*Najas graminea Del.*, and *Najas minor*) were available in plenty in Poongar Swamp near Bhavanisagar Dam. (Coimbatore district). The plant belongs to the family *Najadaceae* of monocotyledons. A very limited description is available for exomorphic and endormorphic characters and its habitat. (Manual of Acquatic plants Norman, C. Fassett 1940). Darlington has worked out the cytology of the plant and found it possesing 'X' as 6 and totally 24 chromosomes.

The genus *Najas* is scattered throughout Madras State. Tle following are the number of species commonly available in the State:—

(1) *Najas indica*—Guindy Park-Madras.

(2) *Najas minor*—Nagari.

(3) *Najas indica*—Government Botonical gardens—Nilgiris.

(4) *Najas minor*-var-spinosa—Tanjore, Mathur village Guindy—Madras.

(5) *Najas graminea*—Marakkanam, Veeranam lakes, Agasthampatti, Thanjavur, Poonagar Swamp—Bhavanisagar.

## Systematic position of the plant

According to Gamble, *Najadaceae* is monogeneric family. The single genus Najas accomodates five species—

(1) *Najas graminea Del*—var—minor Rendle.

(2) *Najas indica*—Chem.

(3) *Najas major*—All var—spinosa.

(4) *Najas lacerata* Rendle.

(5) *Najas falciculata.*—A. Braun.

A. M. Johnson classifies Najadaceae as Naid (Najas, which includes ten species having Worldwide distribution in freshwater.) In the light of modern classification of Hutchinson the family Najadaceae accomodates two orders, namely, *Najadaceae* and *Zannichelliaceae.*

Following Engler A and Prantl. K. (1888), core includes forty species under Najas in his "*Plant Taxonomy*".

Hooker, J. D. (1909) reports 4 species, viz., *Najas major, Najas graminea, Najas minor* and *Najas falciculata.* According to him *Najas tenius. Najas beteromorpha* and *Najas rigida* are the three interminable species.

According to Hooker W.D. (1890) the family contains the following genera.—(1) Triglochin (2) Aponogeton (3) Ruppia (4) Najas (5) Zennichellia (6) Cymodacea (7) Potamogeton.

Mc Lean and Cook say Najadaceae is a monogeneric family containing 35 species of *Najas*. K. Subramaniyam classifies the representatives of Najadaceae according to the shape of the spathe and nature of partition in the antherlobes. The names *Najas* and *Naias* were found to be indentical and so are only synonyms.

## Nature of swamp

Removal of earth for the construction of the reservoir bundh from the part of the Poongar village caused a depression wherein the accumulation of seepage water from the reservoir converted it into an artificial swamp. Layers of lime stone are formed in certain regions along the northern margin of the swamp. The species selected for work is Najas *graminea Del.* At full swamp level, the length of the swamp is about 650 meters and the maximum breadth about 250 meters. The swamp slopes from its margin of about 4′ to a maximum depth of 9′ towards the centre.

## External Morphology of the plant

*Najas graminea* Del. F[1] Aegypte 282—

t. 50; f. 3; 1812 FBI 6; 569, 1893 Rendle in Pflanzeur, 7; 18; f. 5 Q. v; 1901.

The plant *Najas Graminea* Del., is a slender, delicate bright and green acquatic plant. Roots develop at nodes. The plant branches dichotomously. The dichotomous division of the branches are prominent only in *Najas minor.* In *Najas gramineae* the branching is not so frequent. The densly leaved lateral branches and the tips of the main shoot results in a plumose habit of the plant. The average length of the mode of a healthy plant varies from 1·5 cm. to 2·25 cm. in the middle part of the plant, and 0·25 cm. to 0·5 cm. towards the tip. The nodes at the tip are so much aggregated that it is difficult to distinguish the individual nodes. The average length of a healthy plant leaf is about 2·5 cm. The plant flowers and fruits generally from July to August and from November to January after mansoon rains. The plant is both monoecious and dioecious. Separate male and female plants occur along with monoecious species. The plant is normally rooted, the length of the root varies from 16 cms. to 20 cms. when rooted in soil and between 12 cms. to 16 cms. when found floating. The plant when associated with *Chara* sp. is difficult to distinguish under submerged conditions.

*Leaf.*—Leaf margin is toothed variously. The nature of the marginal indentation in *Najas graminea* is clearly seen only while viewed under a dissection microsocope.

But in Najas minor (pres) All however the toothed nature of margin is visible even without microscopic examination. The leaves occur in pairs on the stem and an individual leaf possesses a sheath and a blade. The sheaths bear minute microscopic scales. In *Najas graminea*, the marginal teeth are each composed of only one cell. The teeth that are found in the lower level are broader and slightly shorter than the succeeding ones. The angle of the marginal tooth is always the same as that of the tip of the leaf itself. The length of the sheath varies from 0·35 cm. to 0·25 cm. The leaf at the point of attachment to stem is narrow and measures approximately 0·18 cm. to 0·25 cm. The bi-lobed sheath attaches the leaf with the stem. The breadth of the sheath is nearly 0·08 cm. It is also noted that the sheath of the upper leaves are embraced by the sheath of the lower leaves. Of the members of a pair of leaves, the position of one blade is a little more elevated than the other. The individual leaves are linear and needle like. There is a central thickened layer of cells making it a pseudomidrib. On each side of the midrib there is a zone of about 20 cells. The central midrib is composed of nearly 8 to 9 layer of cells placed one cell beside the other in a linear fashion.

*Roots.*—In most submerged plants, the roots are greatly reduced in size, unbranched and without root hairs. The underground stem is condensed. The exposed nodes develop the adventitious roots which are normally 3·5 cms. to 6·2 cms. long and 0·5 mm. in diameter. They may be longer than this and also thicker under specific environmental conditions. The roots are generally long, whitish and slender and anchor the plant when they come in contact with substratum. If however a fragment of the plant is unable to get hold of substratum, the root is elaborated in length without branching till it gets access to a hold. The course of the root is always negatively geotropic even in those fragments of plants producing such a long root. Those roots which are after a hold may become positively geotropic and again regain normal course. It was interesting to note in the experimental jars devoid of a soil substratum the long white roots in their vain bid to find a hold intertwine themselves. The plants that are rooted in soil develop minute hairs in the roots while those which are not rooted never develop such root-hairs. The roots examined from the specimens which are rooted present crooked appearance with small bends and curves while those of the floating fragments are smooth and straight without curve. The roots of a separated fragment though appear in slender are in reality very rigid. They are not easily softened even if kept in concentrated Acid used for making squash.

*Stem.*—Underground stem and aerial stem are found in the plant. The former is very much reduced and roots are developed in it. The aerial stem is soft and greenish. The ordinary length of the plant varies from 25 cm. to 50 cm. But in some exceptional cases specimens measuring 80 cms. to 100 cms. are also recorded from Poongar swamp. In the case of Najas minor Pers (All F[1]. prfrn 2 : 221, 1785, F.B.I. 6 : 569 1893 Rendle, 14f, 4s. T. 1901 Fluviates minor pers syn 2: 530, 1807, also available in Bhavanisagar) the branchings are prominently dichotamous. The stem is cylindrical, stiff coarse with nodes and internodes. Small needle like structures develop at the nodes from which the runners germinate. The stem of Najas minor is robust and profusely branched. The internodes are 18 mm. to 24 mm. long in the mature regions and 10 mm. to 5 mm. long in the growing apices.

**Anotomy (Native gramine Dael).**

*Transverse section of stem: (Fig. No.* 1).—The transverse section of the stem shows the epidermis, ground tissue and vascular bundle or stele. A hallow is present in the centre of the section.

*Epidermis.*—The epidermal cells of the periphery are not cuticularised and so are able to absorb gases and nutrients directly from the water (John Weaver) (1938). The cells are thin and barrel-shaped with chlorophyll pigments.

*Ground tissue of Cortes.*—The hypodermal cells arranged in two or more layers occur beneath the epidermis. They are composed of thin walled parenchyma. The aerenchyma which are also thin walled connect the hypodermis with the Stele. The ground tissue is fissured into a number of air cavities by the parenchymatous cells that form a diaphragm between the hypodermis and stele. The aerenchyma is responsible for the boyancy of the plant.

*Central cylinder.*—The vascular cylinder is much reduced and endarch. In many plants such as *Najas* and *Elodea.* the fused xylem strands are reduced to a central thin cellular passage, which is surrounded by phloem. Here in Najas graminea the xylem is surrounded by phloem.

*Leaf.*—A transverse section of the leaf (Fig. No. 2) shows the following parts:—

*Epidermis.*—The outer layer is the epidermal layer with numerous disc-shaped chloroplasts. in the cells.

*Mesophyll.*—Shows no differentiation into the spongy and the pallasade tissue.

*Central cylinder.*—In the young leaves vascular tissues are not differentiated. In the mature leaf even the vascular elements are thus very much reduced.

*Root (Transerverse section of Root).*—The adventitious roots and the roots developing from the condensed stems are identical in structure. A transverse section of an adventitious root (Fig. Nos. 3 and 4) shows the following parts :—

*Epidemics.*—Consisting of a single layer of closely arranged barrel shaped cells without the cuticle.

*Ground tissue.*—Consisting of many layers of more or less rounded cells with inter cellular spaces. The inner most layer of the ground tissue envelopes the central cylinder.

*Central cylinder.*—Najas has very simple root of a very simple type in which the phloem is more conspiciqusly developed than the xylem (Agnes Arbur 1920).

*Sex organs—(Male flower).*—Najas graminea Del, occurs both as monoecious and dioecious plants. If monoecious the male flowers are restricted to the tip of the plant and the female flowers to the lower portions of the plant.

The male flowers are strongly pink at the time of emergence which fades in a course of two weeks and ultimately to white. In other species of Najas besides the perianth an outer spathe also envelopes the flower whereas in Najas Graminea Del., such spathe is absent. The male flower is very simple in that the anthers are enclosed in a capsule formed by the closer approximation of the perianth. Hence the sporogenous tissue arises at the tip of the floral axis which develops from one to a four celled structure. The pollen grains of this species are oblong. They measure 10U to 30U in breadth and 30U to 75U in length. The number of pollen in a male flower is infinite and they come out of perianth in thousands as dusts when crushed under microscope. The ripe pollen grains are liberated through an apical dehiscence (Fig. No. 5) of the anthers. The dehiscence of the anther causes the liberation of pollen. Subsequently the perianth falls of. The growth of pollen tube from mature pollen grain is instantaneous which grows to about 100 U in ten minutes in a grain measuring 50U in length. No further growth is observed.

*The female flower.*—The female flower is also as simple and reduced as the male flower. The floral axis develops into an anatropous ovule from below as in the male and envelops the ovary. Thus a pair of integuments are formed. The Najas graminea the ovary terminates into a bifid stigma. The colour of the female flower at the time of formation is pink and turns successively to green, brown and ultimately dark. Such changes in colour appear to be indeces of different stages in maturity.

*Appearance and disappearance of dominance in sex of monoecious plants.*—In monoeciuos plants the occurrence of male and female sex were studied carefully. In the month of August and September the female sex was entirely dominant in monoecious plants. When examined on 11th September 1964, out of 151 plants 150 plants looked as though they were female. Only one plant was monoecious with large numbers of male flowers some strongly pinkish with well developed female flowers. The number of male flowers increased and almost equalled the female flowers by the end of October. In experimental cisterns during the last week of November the female flowers had attained the dark colour, thus indicating that they have already become ripe seeds. In the month of November the malesex was dominant.

*Germination of Najas graminea seeds.*—To germinate Najas graminea seeds in the laboratory and in fields, several experiments were conducted. First the seeds were allowed to germinate in petri-dishes with filter paper in it. Daily water was supplied to the seeds. Thus nearly forty seeds, were kept in four petri-dishes. Care was taken to note that the petri-dishes were always full with water. Similarly two petri-dishes of with soil from the Poongar swamp and another with the soil from one of the experimental cisterns were sowed with seeds and kept irrigated exactly as in the former. There was no sign of germination in the first two months. Only in the third month one seed germinated. The first seed took seventy-two days for germination in ordinary petri-dish with filter paper. Since the day of first germination from eight to twenty-five days four more seeds germinated. Thus altogether gernination of only five seeds took place out of forty. In the sample kept in the soil of the swamp only one germinated exactly on 112th day. It is evident that the seeds of Najas graminea are dormant for nearly three to four months.

The ripe seeds of Najas graminea is dark in colour with lots of ornamentation. It is hard and cannot be easily broken. The size of the seed varies from 1 mm to 1·5 mm. in length and about 1 mm. in breadth. Before germination the seed turns slightly brownish. The beginning of germination is marked first by the formation of the primordial root which is a white knot like structure. Approximately two days after the appearance of the root primordium a faint yellowish white structure measuring about 1·5 mm. identified as the primordial first pair of leaves emerge out of the seeds. Towards the third day elaboration of green pigment over the leaves is complete and elongation take places. The first pair of leaves encloses within it the next immediate pair. On the fourth day the second pair of leaves also emerge out. At this time one of the outer leaves measured 5 mm. and the other 3·5 mm. in length while the second pair of leaves though emerged was still unseparated. On the fifth day further growth in both the leaves and the root was noticed. The members of the first pair of leaves measured 6 mm. and 4 mm. respectively and those of the second pair were each 5 mm. long. The root by this time had grown to about 4·8 mm. in length and already penetrated the filter paper, helping the seedling to stand errect. In prostrate condition the growth of the root is from 20 to 25 mm. After 10 to 15 days of germination 6 or 7 nodes are formed in the plant and by this time another root develops from the second node. The first internode is comparatively longer and the second pair of leaves also much bigger than the preceding pair. The seedling when planted strikes root from the second pair of leaf.

*Growth.*—The growth of Najas graminea Del, is very slow during the first fortnight, after germination. The length of the plant at the end of the first fortnight, is only 2 to 3 cms. with six to seven nodes. The length of an one-month old plant varied from 3·5 cms. to 7 cms. since then the growth rate was comparatively faster, for (e.g.) one and a half month old Najas graminea varied in length from 15 cms. to 21 cms., just looking like adult plants. The seedlings that grew under laboratory conditions were straight without frequent branching. In field where there was intense sunlight and low water level the same batch of seedlings branched frequently. The internodes of the natural plants were smaller than those of the Laboratory plants.

*Development of sex organs.*—The sex organs made their appearance between 35th to 60th day. In the monoecious plants the female sex organs developed first. The female flowers were noted even on the 35th day as a pale green structure. Only after the 45th day it became pinkish colour. In between 35th day and 45th day male flowers were seen emerging at the upper part of the plant. The development of sex organs were noted both in field plants and laboratory plants simultaneously. In limited number of plants observed, those that grew under laboratory condition happened to be dioecious whereas those from the swamp and cisterns were monoecious.

*Pollination and seed formation.*—Pollination takes place under water and seed formation takes a long time. It varies from 60 to 75 days. Evenafter attaining the characteristic dark colour of a mature seed, the seeds do not fall so easily only when completely ripe the seeds fall down. The time thus taken for a seed to fall from the plant from the time of flowering may vary from 90 days to 120 days. However in the laboratory, plants studied in glass jars along with fishes, the frequent movement and disturbances caused by the latter made even some brown seeds to fall. The fallen brown seeds never attained the characteristic dark colour.

*Vegetative reproduction.*—It is very clear that during its life cycle Najas graminea reproduce largely by vegetative method. A fragment of a plant is capable of striking root and leading an independant life. In experimental cisterns and jars broken bits of the plants produced several adventitious roots from the older nodes to strike the soil and establish them. Several experiments were conducted to note the minimum number of leaves and length of plant required to reproduce vegetatively. An independant mature leaf if planted in soil does not produce new plant. Only bits of plants with atleast four leaves and an internode were found capable of sucessfully establishing a new plant. The longer the broken bit, the quicker it establishes itself as a new healthy plant.

*Seed plants and vegetative plants.*—The difference in the growth rate of the seed plants and vegetative plants was not so striking. Bits of seed and vegetative plants were picked up from the experimental cistern. Equal length of material was selected from the tip of the plant in both cases. Individual leaves of both the plants were measured and compared. In this study nearly 4,000 leaves were examined. In each case it was noted that the leaves of the seed plants were on an average 0·523 cms. longer than those of the vegetative plants. The longest leaf of a seed plant measured 3·7 cm.

*Life history of Najas graminea Del.*—The plant Najas graminea germinates during October and November in ponds, puddles, etc., after monsoon rains in Madras State. The plants are restricted to the margins in big lakes and swamps where the depth varies from 3 feet to 5 feet. The plants grow also in the centre of small ponds and puddles of the depth of waterfalls to the above level. The plants growing at a depth of 5 feet grow luxuriantly with long internodes and measure nearly 4 feet to 5 feet. If the water level is in a dangerous condition leading to the possible death of plant, there is an attempt to flower ahead of ordinary plants occuring in optimum depths. Though the ordinary Najas graminea plant in field flowers between 40 to 60 days after its germination there is a general tendency to postpone formation of sex approximately a month which coincides with peak period of formation of flowers.

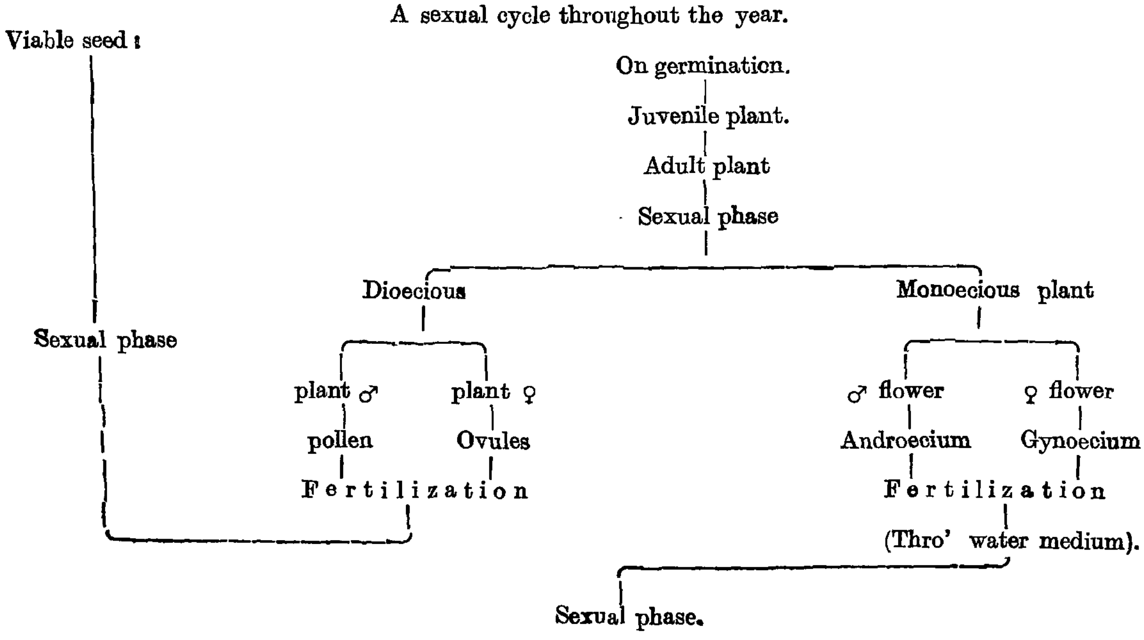
Simultaneous propagation both by seeds as well as by vegetative means is quite common. It becomes difficult at a certain stage to distinguish one from the other. The vegetative plants which got served from the mother plant also bore sex organs many times. But in general reproduction of Najas graminea under optimum conditions is mainly Vegetative. In ponds the number of floating fragments were amazingly high considering the number of plants that grew in them. The vegetative phase dominated the life history of Najas graminea beginning from November to March. By this time the seeds produced by the seed plants undergoing dormancy for about three months also develop into new plants.

*Life history of Najas graminea Del.*

Vegetative phase (A sexual reproduction).

Adult plant : Fragmentation.

A sexual cycle throughout the year.



The germination capacity of seeds is poor. Presence of germinating Najas graminea seeds along the river margin. (River Bhavani about a furlong below the Bhavanisagar Dam) during October and November suggests dispersal through river to ponds and puddles. However absence of adult plants in the river render the possible source of these seeds during monsoon rains which bring them from adjacent pools and swamps. The plant Najas is an annual aquatic herb. However, under optimum conditions the longivity is more. In the experimental cisterns where seasonal variations in the conditions of existence were not much pronounced, the plant grew normally for more than two years.

*Epiphytic algae in Najas graminea Del.*—Nearly eighteen numbers of algae were recorded in the leaves of Najas graminea. They are given below. They are sought out eagerly by fishes with browsing habit. (Cyprinus carpio strain Bangkok.).

*I. Chlorophyceae*—

1. Chlorococcum lummicoler Rab.
2. Closterium lunula (Muelli) Nitzsch.
3. Cosmarium subtumidum Nordst .
4. Oedogomium sp.
5. Crucigenia Morren apiculata (lemm) Schus.

*II. Cynophyceae*—

6. Oscillotoria limosa Ag. ex.Gomont.
7. O. Subbrevis schmid.
8. Nostoc carneum Ag. (Teitler).
9. Microcystis aeruginosa Kuetz.
10. Merismopedia tenuissima Lemm.
11. Anabaena orientalis dexin.
12. Nostoc punctiforme (Kutz) var popularum Geitler.
13. Phormidium ambiguum Gomont.
14. Schizothrix friesaii (Ag.) Com.
15. Rhaphidiospisis curvata Fritsch & Rich.

*III. Bacillariaphyceae*—

16. Cymbella hustedtie Krasske.
17. Navicula simplex Krasske.
18. Gomphonema apiculatum Ehr.
19. Pinnularia viridis (Nitz) ehr.

*General Ecology of the Poongar swamp.*—The swamp lies in the Poongar village facing the left flank of the reservoir bundh at an attitude of about 820 M.S.L. As has been pointed out earlier the swamp depends on the Bhavanisagar reservoir for its water. The supply is effected through seepage. The seepage water is led into the swamp through a small canal running horizontally at right angles to the bundh from the base of the left flank to the swamp. The bed level of the reservoir at the dam site is about 800′ M.S.L. and at full reservoir level it is about 920′ M.S.L. Table No. 1 shows the average rain fall and water level of the reservoir for each month (except July and August) of 1963 and 1964. The average rain fall given in the table pertains only to the local rains in Bhavanisagar. The catchment area of Bhavanisagar reservoir is the Nilgiris. The rivers Bhavani and Moyar draining through the catchment area bring in freshets during both South-West and North-East mansoon rains, into the reservoir. From the table it can be seen that in 1963 the South-West monsoon has failed, bringing down the reservoir level to 889·76′ M.S.L. Local rains in October, November and December of 24·47 mm., 5·74 mm. and 10·4 mm. respectively. North-east, did not have much effect and the level of December had come down to 870·58′ M.S.L. In 1964 by June the level had come down to 843·60′ M.S.L. These conditions adversely affected the swamp to almost a drought. It was reduced to a very small stretch of water of about 1/50th of the original area. These conditions prevailed for about two months and most of the hydrophytes collapsed. The flora encountered in order of dominance are as follows :—

*Chara gymnopitys, Najas graminea Del. Najas minor All, Typha angustata, Bory* and *Chact, Potamogeton indicus, Potamgeton pectinatus Linnes. Ottelia alsinoides Paspaldium punctatum stapf., Limnanthemum cristatum* and *Nymphaea stellata.*

The worst hit were the once profusely growing Najas, Potamogeton and Chara, Typha, being subjected to draught and frequent harvest by local people for making mats though managed to survive because of the underground rhizome. The North-east monsoon rains were timely and heavy as can be seen from the table. The water level by November 1964 was 917·93′ M.S.L. very close to the full reservoir level (920 feet M.S.L.). The swamp also was up to its brim.

It is evident that the water condition of the swamp directly depends mainly on that of the reservoir. It is interesting to see that since the reservoir and the connected fluvial systems do not have any of the hydrophytes present in the swamp, the probable agency which caused their access into it is still vague. According to Vernon W. Proctor 1962 " Oospores of several common North American species of Chara are able to survive a normal passage through the digestive tract of migratory water birds, and that many are dispersed in this manner.... ". That Oospores can be and frequently are carried by one body of water to another seems very probable. In one of his experiments 34 per cent of the spores of Chara Zylanica recovered from the gut of the Mallard duck (Anas platyrhynchos) germinated within two weeks. He considered from 40 per cent to 50 per cent germination normal for non-ingested Chara Zeylanica. A wide array of aquatic birds frequent these swamps. The most prominent in magnitude is an unidentified migratory bird which visits the swamp in February and March for making nests in Typha. Hundreds of nests with eggs and hatching birds are seen during this period. It is probable that such birds by periodically visiting may act as carriers of oospores and seeds of aquatic weeds. The fact that immediately after the filling up of the swamp all species of these water plants once subjected to severe draught bloom up readily must be mainly through seeds which generally keep a fresh even without water. Vegetative propagation may also supplement this to a certain extent.

Chara dominates all of these. According to Vernon W. Proctor (1962) in atleast some species of Chara prolonged dormancy require months before the germination of the Oospores. Even under severe drought both the dormant Oospores as well as the migratory birds appear to assure ready replenishment immediately after the filling up of the swamp. According to Norman C. Fassett, 1945 the Characeae mainly occur in hard water and often have incrustations of lime. In table No. 2 are given the free carbondioxide carbonate and bicarbonate values of the water besides temperature for each month of 1964 except July and August. There was no free carbondioxide. The bicarbonate increased from 418 P.P.M. in January to 687 P.P.M. in June Table I. This gradual increase in bicarbonate corresponded to the decrease in the water level of the swamp which was regulated by the water conditions of the reservoir (Table 2). The high bicarbonate content with decrease in the water level of the swamp is explained by the large scale death of Chara resulting in its non-utilisation. In September 1964, the bicarbonate was reduced to 115·3 P.P.M. and towards December it was only 50 P.P.M. This period coincides with the full level of swamp and the profuse growth of Chara. Cattails are the first invaders in a newly excavated pool (Norman C. Fassett 1940). Typha angustata might have been the first occupant when the swamp was newly formed in 1956 and 1957. In the course of a week or two of the filling up of the swamp the first vegetation to be seen in dense growth externally is Typha angustata. The extensive spreading up of underground stem can remain dormant markedly adopting the plant for survival once again when water is full.

Potamogeton pectinatus with narrowly linear leaves is submerged while Potamogeton indicus with eliptic Ovate leaves is floating. While the former is pre-dominant the latter is highly sporadic in this water piece. Both this species with special means of vegetative propagation are adapted to swamps of Poongar type. Potamogeton indicus grow from the rhizome of previous season and Potamogeton pectinatus forms tubers which appear to give rise to new plants in the succeeding season. (V. Singh-1964). In both cases propagation through seeds appear to play the dominant roll.

Limnanthemum Cristatum is available in this swamp only in the deepest portions (the original three wells which got submerged after the formation of the swamp) and also in the north-eastern margin by the side of the outlet. In the deeper portions other weeds are hardly present and in the vicinity of the outlet they are very sporadic. Eva mitra (1955) observed that new plants developing from floating rhisomes which get severred from the mother plant before attaching themselves to the soil, while deprived of the opportunity of coming into contact with the bottom mud, decayed within six days and sank to the bottom by about the 20th day. It is highly probable that the reason why Limnanthemum Cristatum is not found in the other areas of the swamp is be cause of the thick bed of Chara and Ottelia at the bottom. Najas and Potamogeton in the column afford very little chance for the new plants which accidently get detached by mechanical means to strike root easily and develop.

Najas graminea and Hydrilla verticillata overgrew to the extent of floating in nursery ponds and attracting a particular species of Trichoptera during August and September (Family Phryganeidae) which deposited their eggs over them. The larvae cuts stems and leaves and utilise them to make their cases. Hundreds of these larvae were found moving with their cases. It is interesting to note that the most common weed Hydrilla verticillata is totally absent though it grows in experimental cistern and in the slow-flowing canal supplying the Agricultural Research Station. Era Mitra observed this plant in some tanks of Calcutta inclose association with vallisinaria spiralis and Cerataphyllum demersum. In such cases the weeds were completely devastated in two weeks. During induced breeding of cyprinus carpio (Var.Bangkok) a weedy bed hydrilla or vallisnaria is commonly prepared inside the happa for the deposition of eggs. Najas can also be safely used for this purpose. It was found that grass carps preferred Hydrilla to Najas when both of them were present in the ponds. But when the former was absent they took to Najas sp. readily. A few specimens of Labeo fimbriatus examined from Veeranam lake (South Arcot district) had Najas in plenty in their guts. The acquatic herb-eating fishes of Bhavanisagar are Barbus carnaticus and very occasionally Barbus hexogonolepsis. But they are absent in the swamps and as such have no control over the growth of Najas.

*Summary.*

1. Morphology of the plant is described.
2. Anatomy of the plant is worked and described.
3. Dominance of sex in monoecious plant in different periods of life history is described.
4. Life history of the plant is worked.
5. General ecology of Poongar swamp with Najas graminea is desecribed.

*Acknowledgment.*

The authors are much indebted to Sri A. Sreenivasan, Assistant Director of Fisheries (Hydrology) for suggestion of this problem, his guidance and interest at every step of this investigation and constructive criticism. Suggestion and help from colleagues, Messrs. M. Devaraj, V. Natarajan, and assistance in soil and water analysis by R. Soundararajan is gratefully acknowledged.

TABLE No. I.

| *Months.* | *Average rainfall,* 1963. | *Average rainfall,* 1964. | *Humidity,* 1963. | *Humidity,* 1964. | *Average water level of the reservoir.* 1963. | 1964. |
|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| | (MILLE METRE) | | (PER CENT.) | | | |
| January .. .. .. | 0·49 | .. | 73·9 | 79·3 | 913·28 | 877·15 |
| February .. .. .. | 0·26 | .. | 73·7 | 79·4 | 907·39 | 867·96 |
| March .. .. .. | 2·90 | 0·77 | 77·9 | 85·1 | 903·29 | 855·26 |
| April .. .. .. | 2·11 | 1·01 | 77·2 | 75·6 | 897·22 | 846·91 |
| May .. .. .. | 4·08 | 10·7 | 70·9 | 69·9 | 900·82 | 847·73 |
| June .. .. .. | .. | 0·77 | 68·7 | 68·3 | 900·43 | 843·60 |
| July .. .. .. | .. | .. | 79·4 | 79·1 | .. | .. |
| August .. .. .. | .. | .. | 77·7 | 81·3 | .. | .. |
| September .. .. | 3·19 | 3·21 | 73·6 | 67·6 | 889·76 | 914·61 |
| October .. .. .. | 24·47 | 77·7 | 82·4 | 77·2 | 881·24 | 912·74 |
| November .. .. | 5·74 | 13·3 | 85·2 | 77·4 | 880·80 | 917·93 |
| December .. .. .. | 10·4 | .. | 87·4 | 66·29 | 870·58 | 916·29 |

TABLE No. II.

*Water Analysis* 1964 *at Poongar swamp.*

| *Months.* | *Temperature.* | *Free* $Co_2$ *ppm.* | $Co_3$ *ppm.* | $H\ Co_3$ *ppm.* |
|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) |
| January .. .. | 26·0 | .. | 29·00 | 418·00 |
| February .. .. | 30·2 | .. | 15·00 | 485·00 |
| March .. .. .. | 30·0 | .. | 14·00 | 492·00 |
| April .. .. .. | 32·0 | .. | 20·00 | 590·00 |
| May .. .. .. | 32·0 | .. | 40·00 | 665·0 |
| June .. .. .. | 30·0 | .. | 54·00 | 687·00 |
| July .. .. .. | .. | .. | .. | .. |
| August .. .. .. | .. | .. | .. | .. |
| September .. .. | 28·5 | .. | 21·0 | 115·3 |
| October .. .. .. | 28·5 | .. | 22·0 | 116·7 |
| November .. .. | .. | .. | .. | .. |
| December .. .. | 29·8 | .. | 55·0 | 55·0 |

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Najas graminea Del., (Stamen or Androecium)

Fig. No. 5 Front View (i)

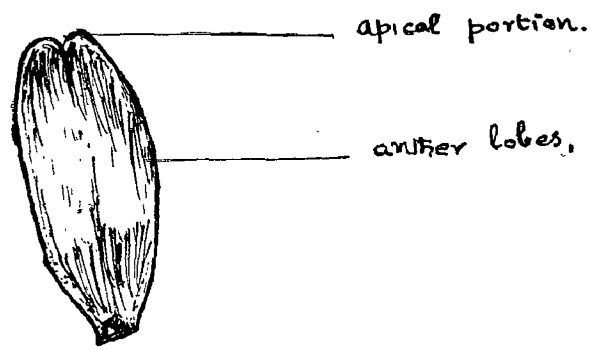



Fig. No. 6 Side View of Stamen. (ii)

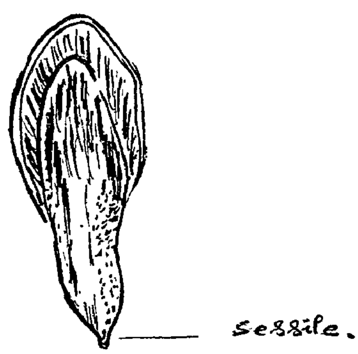
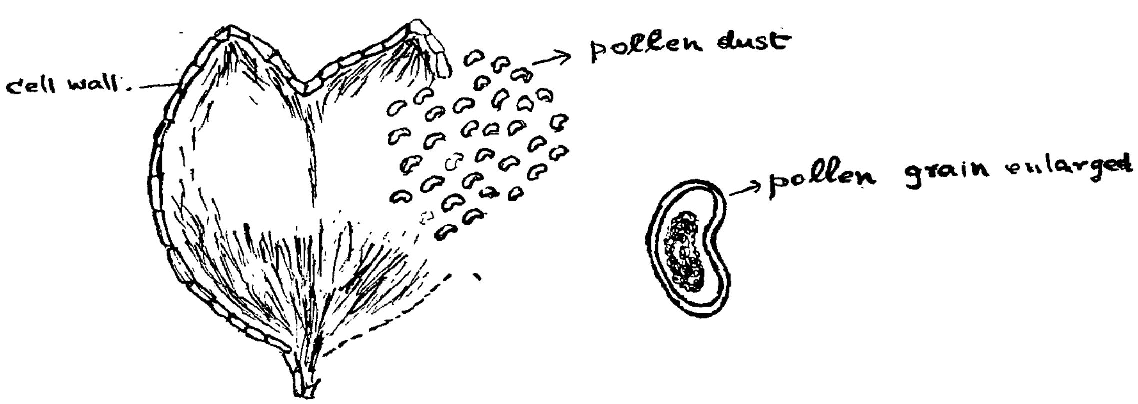
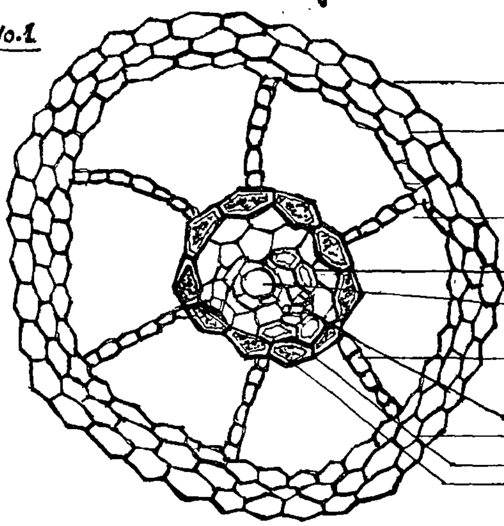



Fig. No. 7 Crushed anther



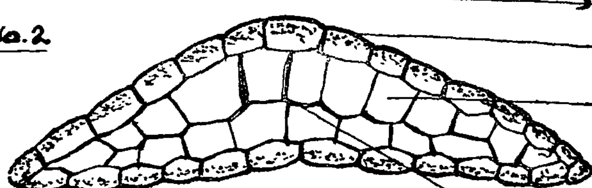
## Najas graminea Del., Transverse Section of the Stem.

Fig. No.1



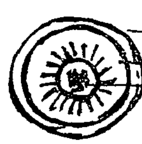

## Cross Section of the Leaf (High Power)

Fig. No.2



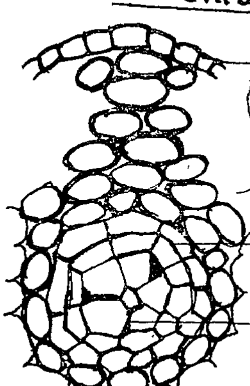

## Transverse section of Root

Fig. No.3.




## To enlarge a portion of a Root,

Fig. No.4.



# TILAPIA MOSSAMBICA: ITS ECOLOGY AND STATUS IN MADRAS STATE, INDIA

BY

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*Tilapia mossambica*, Peters, the cichlid fish, made a controversial entry into Madras and remains a controversial fish throughout the world. Chacko and Devadas (1953) claimed they were the first to bring the fish from Ceylon to Madras but Panikkar and Tampi (1954) had imported them earlier from Bangkok for experimental work at the Central Marine Fisheries Institute at Mandapam. At a time when fish culturists all the world over were after a fish that would be of immense use in increasing the protein output by maximal production, *Tilapia mossambica* came into the picture from obscurity. It raised very high hopes as seen from the assertion of Kelly (1957)—" The quest of fishery workers of various countries for a fish of fast growth rate, large reproductive capabilities, and a palatableness suitable for wide human consumption has apparently been satisfied to a great extent by this fish". The Government of India was cautious in the introduction of this fish and restricted its spread initially to areas South of Vaigai River (Madurai district) and excluded its spreading in the great rivers of the north where carp culture was important and lucrative. The State Government of Madras, through its Fisheries department introduced this fish with great hopes and spread it through the ength and breadth of the State, even north of Vaigai river. Here a review is made and the position of *Tilapia mossambica*, in Madras State for the past ten years. It is not proposed to review the earlier literature on the subject since the review of Chimitz (1955) (1957) has already furnished an excellent bibilography. The experience of the Madras State Fisheries department in the culture of *Tilapia* in various types of waters is presented here, along with brief notes on the hydrobiological conditions of these waters.

## Historical

Though the Central Marine Fisheries Institute, first brought *Tilapia mossambica* to India for experimental purposes, the State Fisheries department of Madras were the first to introduce the fish for commercial culture. The results of research done on the food and association of *Tilapia mossambica* in Madras, have been published (Menon and Murthi, 1956) and Menon *et al* (1959). The observations were made in a controlled fish farm at Chetput and a polluted body of water in Thanjavur. These observations were of a short-term nature.

## Status of Tilapia in Madras Ponds

Almost all the ponds maintained by the State Fisheries department have been stocked with *Tilapia mossambica* along with Carps and *Chanos chanos*. Based on a study of these ponds for over eight years, it was found that it is difficult to classify waters as " Tilapia water " and " non-Tilapia water ", on the basis of hydrobiological factors. Hence we have arbitrarily divided these waters into three categories based only on the average size of *Tilapia mossambica* obtained from these ponds—

(1) ponds yielding very small sized *Tilapia*, smaller than 100 g. each.

(2) ponds yielding medium sized marketable *Tilapia* 100 to 300 g. and

(3) ponds or other waters yielding *Tilapia* of weight 300 g and over.

(1) *Ponds yielding small Tilapia.*—In Table I, the name and the hydrological conditions of ponds belonging to this category is furnished. The temperature of surface water in these ponds varies from 27·4 to 32·0°C the pH value from 7·5 to 9·6 the methyl orange alkalinity (expressed as $HCO_3$) 71·0 to 292·8 the chloride content from 48 to 536, the hardness from 60 to 274, calcium 47 ro 86·2 mg/l and the electrical conductivity from 380 to 2,125 micromho. The dissolved oxygen varied from zero to 23·0 mg/l but mostly it ranged from 0·5 to 5·0 mg/l. It is thus seen that small sized *Tilapia* are produced under wide hydrological conditions. The pH value of all the waters is on the alkaline side but mostly it is below 8·5. The temperature is fairly high. The methyl orange alkalinity is generally high, so also the electrical conductivity with a few exceptions, the water was hard. The low oxygen content of these waters is striking. Over-crowding by myriads of small sized *Tilapia* (respiration of small fishes is higher than that of larger ones) could be an important factor in the depletion of oxygen. Resistance to low oxygen tension by small *Tilapia* has been noted by us on many occasions.

(2) *Ponds yielding medium sized Tilapis.*—The surface temperature of the water of these ponds is not different from the ponds in Category (I). The range of temperature is 27·2 to 32·0. The pH value of these ponds ranged from 7·2 to 9·6: the methyl orange alkalinity ranged from 45·8 to 552·5 (as $HCO_3$) but in general it was between 150 to 200 mg/l. The Chloride content varied from 16·0 to 536 but the majority of the ponds were in the range 60 to 250 mg/l. The calcium content ranged from 3·1 to 98·6 and the hardness from 60 to 274·0. The conductivity of the water of these ponds ranged from 375 to 2,650 micromho. The dissolved oxygen of these ponds is generally adequate but in a few cases very low or absent.

(3) *Waters yielding large-sized Tilapia.*—The surface temperature of these waters is generally lower than those of the two previous categories of waters, exceptions being small ponds. Most of the waters in this group are large pieces of wild waters such as irrigation tanks (minor reservoirs) and large impoundments (major reservoir). The pH value of the waters ranges from a low value of 6·5 in an upland lake (Yercaud) to a high value of 9·5 in

some eutrophic ponds. The methyl orange alkalinity of this group is in many cases lower than that of the previous group, so also the electrical conductivity. The chloride content, hardness and calcium content also were lower.

It is seen that ponds in which small sized *Tilapia* dominate are small and less than 4·0 acres but with a depth comparatively greater than the ponds of group (II). Ponds in the latter group have a greater area than those of group (I) though a few are small also. Only in the larger pieces of water in group (III) we find *Tilapia* also of larger sizes. In wild waters, *Tilapia* grows to a larger size than it does in small artificial ponds. Spatial factors, thus seem to influence the size of *Tilapia*. Kenny (1960) noted that "in small over crowded ponds fish (*Tilapia*) matured and produced off spring in three months".

Majority of ponds in group (I) have very heavy blooms of algae. In these tanks, undigested algae as faecal pelletes of *Tilapia* were a common sight. Hickling (1961) and Fish (1951, 1955) had in fact found that some species of *Tilapia* do not digest blue green algae. However it is possible that this partially digested material can act either as manure for the pond or as food for other fishes. It is known that ammonia produced metabolically in ponds over-populated by fish has a depressing effect on growth (Kawamoto, 1959). Menon *et al* (1959) admit that "if *Tilapia* is left uncropped or un-controlled, a certain amount of population pressure sets in creating conditions of such alarming nature as smaller and still smaller generation succeeding one another".

**Mutual inter-action of Tilapia mossambica with other species.**

There are conflicting findings on the effect of *Tilapia* on other species such as carps in the same eco-system.

In the ponds of Chingleput district with heavy blooms of algae in which *Chanos* were stocked along with *Tilapia*, the recovery of *Chanos* was negligible and the growth was very poor. The exploitable size of *Chanos* in these ponds, viz., Thimmarajakulam, Veppunkulam, Karpoorachettikulam, Rangaswamykulam, etc., since 1958 was less than 100·0 g. though in such waters resembling temple tanks (Ganapathi, 1940) the growth of *Chanos* should be atleast 500·0 g. per year. In Karpoorachettikulam *Chanos* was attaining size of nearly 1·0 kg up to August 1956, but subsequently, on the introduction of *Tilapia* the average size was 45 g. and the largest Chanos was not more than 100 g. The weight of *Tilapia* in the first six months after introduction was about 200·0 g. but subsequently the average weight of these went down to less than 45·0 g. Prior to stocking with *Tilapia* the weight of *Chanos* caught in these ponds was as much as 900·0 g. each. In Veppankulam pond, the average weight of *Tilapia* was 135·0 in 1958–59 and 1959–60, 100·0 g during 1960–61 and was less than 75·0 g. in 1961–62. Uncontrolled breeding is the cause. In this pond, *Etroplus suratensis* another chchlid fish failed to show up in catches after the introduction of *Tilapia*. In Chettikulam from which Chacko and Ganapathi (1950) reported phenomenal growth of *Catla catla*, *Tilapia* of average size 250·0—330·0 g. were exploited in 1958–59 but the average size of *Chanos* went down to 100·0 g. The average size of *Tilapia* also dwindled to 80·0 g. This pond, because of good phyto-plankton bloom including the presence of filamentous algae was best suited for *Chanos*. More than 50 per cent of the Catches of this pond are *Tilapia*. In Sarvatheertham, a temple pond, the size of *Chanos* was 800·0 g but after the introduction of *Tilapia* the size of *Chanos* went down to 65·0 g. *Tilapia* first introduced in May 1958, bred in August, same year. In Vellore Fort Moat the average weight of *Tilapia* was 240—310 g. in 1957–58, but in 1959–60, it had dwindled to 170—270·0 g. In Poondi fish farm ponds where *Tilapia* were grown *Notopterus notopterus* the size of the former was 26·2—26·8 cms. (206 to 280·0 g.) in 1958. In five months the growth was 50·0 to 100·0 g In Vellaikulam pond, Arni, the size of *Tilapia* exploited ranged from 38 to 90·0 g. but growth of *Catla* was very poor—230·0 g. The Quarry pools of Virudhunagar were once a good biotope for the culture of *Chanos* and carps since they resembled temple tanks. But in Quarry Pool 2, which was shallow the catches were mainly small sized *Tilapia*. In the deeper Pool 3, *Chanos* grow to 1 lb. and *Catla* to 16—20 lb. each though *Tilapia* were also present. (This was a large pond 6·6 acres in extent.) In the two departmental ponds in Karunguzhi small-sized *Tilapia* were the main fishery. In the departmental pond, Valaiveesiteppam in Madurai town, a small half acre pond with dense algal bloom only small sized *Tilapia* were available in plenty, the stocked *Chanos* not showing up in catches. In Ayyankulam, Thanjavur, in which *Chanos* was thriving well, growth of this fish declined after stocking with *Tilapia*. Even the growth of major carps such as *Catla catla*, *Labeo fimbriatus* and *Cirrhina mrigala* was adversely affected. *Tilapia* itself had shown good growth the average size being (25–28 cms.) 340·0 g during 1957–58 but subsequently the size dwindled. The K. factor was 1·4—1·6 in 1957–58. In the Fort Moat pond at Arni, *Tilapia* stocking has adversely affected the growth of *Chanos*. The growth of *Catla catla*, *Labeo* sp. and *Cirrhina* was also poor. *Tilapia* of sizes 16·5 cms. to 20·5 cms. and weight 75·0—155·0 g. were exploited in this pond. In Teppakulam, Sivaganga, a typical temple pond with a permanent bloom of *Microcystis aeruginosa* the average size of *Tilapia* was 100·0—110·0 g. but that of *Chanos* was less than 200·0 g. though this should grow to at least 500·0 g in a year. In the Anjaneyarkulam in Villupuram, a very productive water, the average exploited size of *Tilapia* was 80·0—160·0 g. but the size of *Chanos*, was only less than 225·0 g. In Theerthankulam, Tindivanam, the stocked *Tilapia* has so increased in population that its average exploited size gradually came down from 160·0 to 50·0 g. *Catla* which was growing fast in this pond, prior to the introduction of *Tilapia* is showing poor growth —270·0 g. in a year and the growth of *Chanos* is also poor 225·0—260·0 g. each. Kalukatti tank in Karaikudi is another glaring example of a pond rich in plankton (0·6 c.c./1) showing poor results after *Tilapia* stocking. Though initially higher yield of *Tilapia* was obtained, year by year the size of *Tilapia* went down till the average weight was less than 30·0 g. The largest sized *Tilapia* from this pond weighed only 60·0 g. This pond not only showed very bad growth and survival of *Chanos* but even the growth of *Catla* and *Labeo* and *Cirrhina* sp. was drastically reduced. Mariamman teppam in Madurai is a standing example of the failure of *Tilapia* in sustaining the yield of fish. This is a very productive pond, abounding in plankton. This was one of the demonstrating ponds for the culture of *Chanos*, which was showing good returns, the growth reaching at least 450·0 g. a year. But as a result of stocking *Tilapia*, growth and survival of *Chanos* was badly affected. *Tilapia* multiplied so profusely that one could collect a glass of water from this pond and get thousands of *Tilapia* fry. Even major carps were badly affected. In the sewage fish farm ponds in Madurai, *Tilapia* continuously multiplied and got overcrowded with size not more than 22·0 cms. (100·0 g. maximum). *Chanos* hardly grew well in this water with very heavy blooms of phytoplankton, their size remaining 2·2 cms. (28·0 g.). The balance of evidence clearly shows that introduction of *Tilapia* has positively ruined *Chanos* culture and has in many cases decisively affected carp-culture. In Bhavanisagar fish farm breeders of *Cyprinus carpio* of weights above 1·0 kg. were stocked after draining the pond, clearing *Tilapia* and refilling. But *Tilapia* which entered through inlet waters multiplied soon and it was seen that the food was attacked by the myriads of small *Tilapia* and the carps rarely approached it, resulting in their impoverished growth. Thus even small-sized *Tilapia* could affect the larger sized fishes. In a temple pond in Coimbatore town, the mirror carp *Cy. carpio* were introduced in September 1956, where within a few months they grew to 500·0 g. each and in a year they had increased in weight to 1000·0—1200·0 g. But, unwisely *Tilapia* were introduced during 1958 resulting in their uncontrolled multiplication. In June 1961, *C. carpio* 250 numbers were stocked at a size of 25·0 g. average size. After 13 months they were still 125·0—175·0 g. each and after 23 months they were of the same size though they attained maturity. *Tilapia* were all less than 60·0 g. each in a temple pond in Avanashi, the mirror carp *Cyprinus carpio* had grown to 400·0 g. in four months but subsequently growth was arrested by *Tilapia*. Growth of *Chanos* was very poor. Yashouv (1958) noted in Israel that in mixed cultivation with carp, *Tilapia mossambica* disturbs the development of carp.

Tilapia in relation to predators, is, however, controlled. In all the departmental ponds studied, it was noted that wherever predatory species such as murrels (*Channa marulius*, *C. striatus*, etc.) the gobie (*Glossogobius giurius*), the fresh water shark (*Wallagonia attu*) the feather back (*Notopterus notopterus*) were present, the uncontrolled breeding of *Tilapia* was checked and the size of *Tilapia* improved. In some of the ponds predators entered naturally and in some others they were deliberately introduced to control *Tilapia*. Menon *et al* (1959) have clearly established that better growth of *Tilapia* occurs when a predator like murrel was present in the pond. They also cite examples to show that in the presence of predators like *Notopterus notopterus*, *Sacchobranchus fossilis* and *Glassogobius giuris*, *Tilapia* was found to grow better. Hickling (1963) indicates that stocking with predators and population control will give larger sizes and yields.

In Webster Moat, Tanjore, which is the most productive pond in this State (Sreenivasan, 1962) some predators such as murrels (the snake head) were present. Due to the presence of some deep pits in this shallow pond, they escaped capture but they kept down the populations of *Tilapia*. Initially, during the earlier years 1956–57, the average weight of *Tilapia* was 540·0 g. but subsequently this declined to 280·0 g. But generally the weight range was stabilised at 120·0 g. to 330·0 g. (18·0—29·0 cms.). In this pond, carp culture was not affected and species such as *Catla*, *Rohu*, *mrigal*, *Cirrhina cirrhosa*, *Labeo* sp. thrived and grew well to large sizes. In the West Moat pond in Tanjore, *Wallago* were present—even those of weight 10·0 kg. In this pond also generally *Tilapia* were above 100·0 g. in weight, ranging from 112·0 to 238·0 g. Here too carp culture was not affected by *Tilapia*. *Rohu–mrigal* and *Catla* were raised as breeders from this pond. It was in Sengulam pond. Mannargudi that best growth of *Tilapia* was noted. During 1957–58 the average weight of exploited *Tilapia* was over 400·0 g. (34·5—38·5 cms.). Presently *Tilapia* of sizes 150·0—325·0 g. (18·0—26·0 cms.) are being caught. In this pond also carps have fared well and their growth had been good. In Ayyangulam Pond, *Tilapia* of sizes 25·0 to 29·0 cms. (330·0 to 400·0 g.) were common during 1957–58 but now the size has decreased.

Though ponds in Chingleput district have been the haven of small sized *Tilapia* an exception is the Fort Moat pond of 7·0 acres in which the murrels thrive. In this pond, plankton did not occur as a permanent bloom but only as seasonal bloom. The water is disturbed by continuous inflow and outflow. The average size of *Tilapia* exploited is 31·32 cms. (500·0—550·0 g.). *Catla*, *Rohu*, *Mrigal* the major carps grow well in this pond and this is used as a breeder pond for them. "Manthai Oorani" pond in Vadugapatti (Madurai district) was also one of the ponds where *Tilapia population* was restricted and the size was over 200·0 g. each. In North Arcot district in the following ponds, controlled population of *Tilapia* yielded exploitable sizes over 100·0 g. each—in Ayyankulam (Tiruvannamalai) murrels were present and there was continuous disturbance of the water by people bathing and washing clothes in all areas of the pond, the depth of which was 3·8 m. The dominant bloom of this pond was of *Cyanophyceae*. The exploited size of *Tilapia* was 20—23·5 cms. (175·0—225·0 g.) growth of carps—*Catla*, *Mrigal Cy. carpio, etc.*, were good and *Chanos* also grew well. In Ellaipillayarkoil pond also presence of murrels kept down the numbers of *Tilapia* 75—115·0 sizes taken. In Samedankulam pond, Cheyyar, the exploited size of *Tilapia* ranged from 15—21·5 cms. (125—170·0 g.). Breeding was restricted, since the bottom was firm. In the departmental pond in Chengam, where murrels and gobies were present, *Tilapia* were of size 19—24 cms. (125—145 g.). In Vellore Fort Moat pond, a deep polluted water with heavy bloom of *Microcystis* and where predatory species such as *murrels*, *gobies notopterus* and *Sacchobranchus* were present, *Tilapia* had never been a pest. In Teppakulam pond, Kulithalai, where the murrels exist and breed the average size of *Tilapia* is over 500·0 g. though a few are 250·0 g. also. *Catla* grows well in this pond which has no ostensible bloom of algae but has submerged and emergent weeds and periphyton. In Tirumakulam, Madurai, also *Tilapia* exploited are of large size 21—26 cms. (200·0—325·0 g.), in contrast to Mariamman Teppam in the same city. In Sivaganga teppakulam pond, *Murrels*, *Tilapia*, *Catla* *Chanos* and *Labeo* spp. were introduced. This typical temple pond has a dense bloom of algae and mollusca. *Catla* grows well (2·5 kg.) but *Chanos* was only of size 200 g. *Tilapia* were controlled and their average weight was 110·0 g. A very striking example of the role of predators in the control of murrel was seen in Chakkadi Oorani in Sivaganga. This was a shallow pond with good zooplankton population. *Tilapia* and murrels alone were stocked. The size of *Tilapia* was 150—220·0 g. and the yield of *murrels* was very high. However, the largest sized *Tilapia* obtained from small ponds was from Saravana Poigai, a pond in Valliyoor (Tirunelveli district), a typical temple pond. Here the normal size of *Tilapia* were 27—35 cms. (320·0—680·0 g.) more often 650·0—680·0 g. It is inexplicable that another pond just 20 m. away from this, yields *Tilapia* of size 100·0—200·0 g. only.

### Tilapia at high elevations

At higher elevations, due to lower temperature, breeding of *Tilapia* has not been profuse. In the Shevroy Hills (elevation 1,500 m.) temperature ranging from 20—26°C, *Tilapia* was first introduced in Yercaud lake in September 1957 bred within five months (in February 1958). This lake has a permanent but mild bloom of blue green algae. The *Tilapia* grew well, the average exploited size always being over 300·0 g. and mostly about 450·0 g. *Tilapia* of sizes 750·0 g. are also sometimes recorded. At the same elevation *Tilapia* were introduced in the Cauvery Peak Estate ponds where they were grown in monospecies culture. Here also they attained large size of 300·0—700·0 g. average weight but never got over populated. In the Mohanad pond which had an over growth of *Najas*, large *Tilapia* of sizes 1·0 to 1·2 kg. were common. *Ophiocephalus punctatus* were also present. Temperature was 26·6°C. Perhaps the lower temperature regulated precocious spawning. This is confirmed by Criddland (1962) in laboratory experiment. Kemp (1960) recorded a growth of 168·0 g (23·0 cms.) for *Tilapia* in five months in a pond at an elevation of 1,600 m. in New Guinea. In Kodaikanal lake (elevation about 2,400 m.), *Tilapia* were introduced into two small ponds. The temperature here did not exceed 22·0°C. and was about 16·0°C *Tilapia* did not grow and did not also multiply under these conditions. It failed to survive in waters in Ooty (elevation 2,500m.).

### Tilapia in Reservoirs

In rivers and large reservoirs, *Tilapia* has not posed any serious problem. Because of fluctuating water levels the breeding " pits " of *Tilapia* are affected. Further, being a slow growing species, predators make a meal of them. In most of these waters, *notopterus*, *Wallago*, *eels* and Cat fishes are present and they check the multiplication of *Tilapia*. Heavy stocking with *Tilapia* has been made in Vaigai, Sathanur, Amaravathy, Krishnagiri and Manimuthar Reservoirs. In Vaigai Reservoir, *Tilapia* forms a major fishery in the gillnet catches and by numbers constituted about 40 per cent of the catches during 1961–62, and 1962–63. By weight 25—50 per cent of the catches were *Tilapia*. The associates were the indegenous *Labeo contius*, *Barbus* spp. *Eels*, *Callichrous* sp, *murrels*, Cat fishes, *Wallago* and the introduced *Catla*, *Labeo fimbriatus*, *Cyprinus carpio*, etc. Plenty of *Tilapia* fry are collected downstream—those breeding in the pools. In Manimuthar and Amaravathy Reservoirs, the gillnet catches show up *Tilapia* of sizes 400·0—1,000·0 g (some time 1·5 kg. also). In Sathanur and Krishnagiri Reservoirs, *Tilapia* ou sizes 500·0 g. are common. In large irrigation sources like Odathurai tank (180 acres) with continuous inflow, outflow, *Tilapia* are not stunted but grow to a marketable size and over 250 g. It is probable that the receding water levels in sharply fluctuating reservoirs affect the breeding pits. In Vaigai, large breeding pits with a diameter of 1·0 m. and more and depth of 0·5 m. are exposed when water level falls off.

### Growth Rate.

Many workers wrongly consider *Tilapia* to be a fast growing species. Kelly (1957) thinks that a growth of 84·0 g. is 18 weeks (240 g.year) is fast and Raskemp (1960) considers 85—120 g in 8 months to be fast. Ling (1957) reported a growth of 200·0 g. in 1½ years in Thailand. Leroux (1961) found *Tilapia* to grow to only 12·5 cm. in the first year in Transvasal. Chacko and Krishnamoorthy (1954) who found it to grow to 22·0 cms. (110·0—140·0 g.) in eight months consider *Tilapia mossambica* a fast grower. Hickling (1962) cites that this fish grows to 200·0 to 290·0 g. in 320 days. The largest size noted in Lake Kariba was 32·0 cms. In Avanashi temple tank, *Tilapia* was first stocked in November 1957 had grown to 280·0 g. in eight months the next weight group being 110·0 g. All this shows that a fish growing to not more than 250·0 g. a year has been considered a rapid growing species. Even minor carps like *Cirrhina reba* grow larger in size in a year. Major carps like *Catla*, *rohu*, *Mrigal* attain at least six times this weight in a year in unfertilized waters. So also are *Cyprinus carpio*, *L. fimbriatus* and *C. cirrhosa*. *Chanos* grows much better than *Tilapia* and is much less of a nuisance. Neither is *Tilapia* a sport fish like the mahseers or *Barbus carnaticus* which though their growth is slow attain large sizes. Wells (1952) reported a growth of 32 oz. (900·0 g.) in the first year but this seems doubtful. In phosphate fertilized ponds, Hickling (1960) obtained a growth of 1 lb. in eight months but these were hybrid all-male *Tilapia mossambica*. Naumov (1961) cites that *Tilapia* grows well in brackish water, reaching 850 g. but this seems doubtful. In Egypt, the first year growth of *Tilapia mossambica* was only 60 g. (Koura and El Bolock 1958), which is certainly very poor when compared with its growth in our waters.

### Tilapia and Control of Algae

Vaas (1947) found *Tilapia mossambica* lived mainly on Phytoplankton and epihytic algae. Swingle (1957) noted that *Tilapia mossambica* was promising for control of filamentous algae such as *Pithophora* and that they also consumed *potamogeton*. Hickling (1961) states that *Tilapia mossambica* feeds mainly on green filamentas algae but not blue green algae and that other *Tilapia* species cleared a pond of Enhydrias weeds. Chacko and Krishnamoorthy (1952) applaud the "algicidal and mosquitocidal propensities" of this fish. Heard (1960), however, after studying four ponds concluded "its usefulness in controlling algae is undetermined". This seems to be the correct appraisal. In a small cement cistern containing *Tilapia mossambica* in Bhavanisagar, *Hydrilla* disappeared and this was erroneously considered to be due to *Tilapia* but on many subsequent occasions this phenomenon was not at all noted. In natural ponds also *Tilapia* was not noted to reduce the intensity of *Hydrilla* weed. In a large number of ponds with blooms of blue green algae where *Tilapia* were teeming in thousands, those algae were not controlled. In such ponds, one could invariably see undigested faecal pallets of these algae.

**Tilapia—Present Experience—A Review**

There existed two views on the question of suitability of *Tilapia* for culture. The pro-*Tilapia* views were mainly of those whose interest was in raising fish protein [illegible] in under-developed countries and make it available at cheap prices. They had to take into account vital factors such as tolerance of wide range of temperature and salinity, resistence to low oxygen tensions, ability to breed in confined waters, and non-fastidious feeding habits. The answer was found in *Tilapia*. Raskamp (1960) advocated large scale distribution of *Tilapia* in Netherlands New Guinea. Swingle (1960) found a high production of *Tilapia* ranging from 1,477—4,384 lb./acre in Alabama ponds mostly of undersized fishes. Likewise Kenny (1960) obtained yields of 1,700 kg./acre in West Indies but these were of sizes 2—10 cms. He suggested stocking of the tarpon (*Megalops* sp.) to control *Tilapia*. Heard (1960) however recorded a low production of 95·8 lb./acre in lakes and had this to say "the use of *Tilapia* in established lakes with balanced fish populations and stable fishing pressure may be somewhat limited". Ling (1957) while advocating the good qualities of *Tilapia* suggested the use of snakehead (murrel) and other predators to control it. Schuster (1952) declared that "natural regeneration high productivity, resistance to disease, and good feeding habits are factors which make *Tilapia* an attractive fish". His statement that "in tambaks......there also seems to be a possibility of growing *Tilapia* with *Chanos*", cannot be applied to ponds in Madras where *Chanos* culture has been ruined by the later intruder. Hickling (1962) remarks that "*Tilapia* is much less valuable than the beautiful white milk fish" Vaas and Hofstede (1952) found that in unmanured ponds, *Tilapia* interfered with Carp. In the philippines the competition which *Tilapia* offered to *Chanos* made its introduction a controversial issue (Anon, 1956). Yashouv (1958) found that *Tilapia* interfered with growth of carp but recommended its growth as secondary crop. Sarig (1955) also recorded the delaying of growth of carp in the presence of *Tilapia*. A very revealing situation has been presented by Ponguswana (1957) in Thailand. He obtained in Bangkhen Farm ponds yield of 5,600 kg. per acre per year of *Tilapia* with manuring but only 305 kg. out of this (5·5 per cent) consisted of fish of average weight 150·0 g. So he declared "obviously a big tonnage of thin fish with a large proportion of inedible material would be less valuable than a somewhat smaller crop in good condition". Swingle (1960) had a better idea of the utility of *Tilapia mossambica* when he stated "this species may have use as a forage fish for raising various predatory fishes and prevention of overcrowding would be a problem in its management". Wunder (1960) found that in Egyptian rice fields *Tilapia mossambica* had not shown any useful results. Chacko and Krishnamoorthy (1954) in India state that *Tilapia* co-existed with many carps, *Chanos*, *C. carpio*, etc., without detriment to them in Chetput pond but the observations were made only for the first year after the introduction. The conclusion of Menon *et al* (1959) that "*Tilapia* have not shown any deleterious effect on the indigenous carps" are based on inadequate ovbservations and are erroneous. Panikkar and Tampi (1954) however furnished evidence from other countries to prove the detrimental effects. Panikkar's (1952) warning "we are now not in a position to recommend the introduction of these species (*Tilapia*) without ruling out the indigenous species and without making sure that these species are not likely to affect local ecological conditions and cause adverse effect", should have been paid due attention. Frequent reproduction, breeding when small, and mouth breeding, result in large number of small fish which compete with adults for plankton and limit the development of large fish (Hickling, 1963). Periodical cropping by intensive fishing yielded a very high production—experienced in the ponds at Pudukkottai. Introduction of *Tilapia* resulted in lower yields year by year. But, for four months from April to July 1964, intensive fishing was done with spectacular results. In these four months the weight of fish exploited was more than double the average annual catch for the previous five years. The yield for these four months were as follows:—

| *Name of pond.* | *Yield kg./ha. (4 months).* |
|---|---|
| Kumundan Kulam .. | 1,850 |
| Kilnainar eri .. .. | 1,820 |
| Palaniandi Oorani .. | 2,770 |
| Pallavankulam .. .. | 1,220 |
| Malnainar eri .. .. | 1,553 |

There was another pond with a permanent turbidity giving very low yields but when *Tilapia* was cropped intensively, it yielded 540 kg./ha in four months. Two other ponds in the same town yielded 830 and 880 kg./ha. respectively in four months which was two to three times the previous annual yield. Intensive removal of marketable fish will thus lead to high yields of *Tilapia*. In Indonesian ponds polluted heavily by organic matter, a yield of 7,000 kg./ha. has been obtained with *Tilapia* (Huet, 1956). This author also considers the introduction of *Tilapia mossambica* in stagnant waters, a success. He says it possesses the advantage of reducing floating algae. The general yield is reported to be 500 to 1,000 kg./ha. In Israel, Yashouv (1958) records that continuous thinning gives a yield of 600 — 1,200 kg./ha. of *Tilapia mossambica*. Johnson (1959) records yields of 1,000 lb. acre / year of *Tilapia* in Mauritius when all male fish were stocked and liberal application of manure and fertilizer was made. He also stressed the need for population control. However, from our experience of *Tilapia* in impoundments, it is evident that they grow well to large sizes in these without becoming "runted". In all the reservoirs where these have been stocked, they have not affected the carp fishery or the other indegenous fishery. Cautious introductions of *Tilapia* in such impoundments could be undertaken. So also in waters in sub-tropical climates—at elevations of 3,000—4,500 feet.

**Certain Physiological aspects of Tilapia Mossambica**

Oxygen consumption by *Tilapia* was found to be high, the lowest value being 0·43 mg./hr./g. of body weight for fingerlings of weight 17·0 g and 2·0 mg./hr./g of body weight for fry of size 0·1 g. Under the influence of 30 p.p.m. Veronal this could be reduced by 40 per cent. Direct transfer of *Tilapia* from fresh water to 2 per cent, NaCl medium did not affect the fish but if the concentration was 2·5 per cent Nacl the fish died. Even a short acclimitization to 1 per cent NaCl and transfer to 2·5 per cent Nacl resulted in its survival in the latter medium. *Tilapia* fry were not affected when the temperature of water was brought down from 28·0°C to 20·0°C but when it was brought down 15°C, suddenly all the fry died. The asphyxial level for *Tilapia* in sealed vessels was found to be 0·6 mg./l for large ones and 0·85 mg./l for fry. But in open vessels *Tilapia*, fingerlings withstood very low concentrations of oxygen for a number of days. They survived 0·2 mg./l for 10 days.

*Tilapia* was resistant to a large number of inorganic Chemical poisons. The LC 100 is given below: Sodium cyanide 0·4 p.p.m., calcium hypochlorite 4·0 p.p.m., copper sulphate 5·0 p.p.m., sodium arsenite 60·0 p.p.m. (T.L.m. 56 p.p.m.) sodium hypocholorite 7 per cent solu tion, 400·0 p.p.m. and sodium sulphite 1,000·0 p.p.m. The LC 100 for certain organic chemicals is given below:—

Endrin 20 per cent 0·012 p.p.m. (T.L.m. 0·009 p.p.m.) Dieldrix, 0·06—0·08 p.p.m.(T.L.m. 0·05), Aldrix 40 per cent 0·05 p.p.m. (0·035 T.L.m.) chlordane, 0·07 p.p.m. (T.L.m. 0·055), Toxaphene 0·05 p.p.m. chloramine T. 28·0 p.p.m. Selective killing of *Tilapia* from ponds is thus rendered difficult because of its greater resistance to the toxicants. But it is less resistance to parathion than other fishes Lc 100 being 8·0 p.p.m. (T.L.m. 5·0 p.p.m.).

**Utility of Tilapia**

In our ponds in Madras State, the initial higher yields of *Tilapia* were followed by lower yields in subsequent years. During the earlier years *Tilapia* was liked by the population, but subsequently with the decrease in size of *Tilapia* marketed, it has become the most un-popular fish and in fact even hostility to it has developed. Though *Tilapia* of sizes 250·0 g and over still attract good market, small-sized ones are sold for a song. In Madurai, 100 lb. of this would hardly fetch Rs. 2 (U.S. 40 c.). In Pudukkottai we found that 62 lb. of *Tilapia* was sold for just Rs. 2·75 , in the departmental pond in Madurai, though *Tilapia* production increase year by year for a few years the money value decreased year by year (Table II). The glut of small-sized *Tilapia* in Madurai led to some experiments on its conversion to fish meal. This fetched a higher price than fresh *Tilapia*. It would be interesting and useful to study the utility of *Tilapia* for making fish pastes or fish hydrolysates. In Manakudic backwaters *Tilapia* were introduced in 1958 and are thriving well. This should prove very useful as live bait for off-shore fishing in this area. From impounded waters with fluctuating water levels with inflow-outflow of water and in which indigenous predators exist, *Tilapia* could be stocked with advantage and harvested at large size of 0·5 to 1·0 kg. or more in gill nets.

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*Summary.*

Introduction of *Tilapia mossambica* in Madras had very adversely affected carp culture and chanos culture in ponds. Population explosion and the consequent pressure for space and food reduce the size of *Tilapia*. In wild waters where indigenous predators such as notopterus, murrels, gobies, Wallago, etc., exist *Tilapia* of larger sizes are obtained because of population control. In large irrigation tanks and impoundments *Tilapia* grow to a large size and contribute to a large percentage of catches. Even in small ponds, intensive cropping up results in high yields of fish—*Tilapia*, as in Pudukkottai. In waters with overcrowded *Tilapia* populations, the oxygen tension is low. They do not seem to digest *Microcystis*, the predominent blue green algae in ponds.

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TABLE I.—*Hydrological conditions of ponds yielding* Tilapia *of less than 100 g. weight each.*

| *Name of pond.* | *Location.* | *Area.* | *Temperature °C.* | *pH.* | *Dissolved oxygen mg./l.* | *$HCO_3$ alkalinity mg./l.* | *Electrical conductivity.* | *Hardness ppm.* | *Calcium mg./l.* | *Chloride mg./l.* |
|---|---|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
| Hanumantharayan temple tank. | Coimbatore .. .. | 0·2 | 33·0—26·5 | 8·5—9·0 | 15·2—8·8 | 274—259 | 800—775 | 186 | .. | 84·0—98·0 |
| Relief tank .. .. | Pennagaram .. .. | 0·5 | 30·2—28·4 | 7·6 | 9·8 | 153·6 | 370 | ND | 22·5 | 56·0 |
| Valaiveesi Teppam .. | Madurai City .. | 0·75 | 29·8 | 8·5 | 4·9 | 500·2 | 1,750 | ND | 92·6 | 100·0 |
| Sewage Fish farm .. | Madurai City .. | 0·1 | 33·8—35·8 | 9·0—9·6 | 16·6—30·0 | 312·1—54·9 | 1,895—1,750 | ND | 98·2—37·1 | 330·0—375·0 |
| K. K. Perumal Tank .. | Ponneri Town .. | 1·0 | 34·8 | 8·7 | 16·5 | 48·8 | 400 | .. | 48·2 | ND |
| Y.M.C.A. Pond .. | Madras City .. .. | 1·0 | 30·6 | 8·9 | 3·8 | 262·3 | 1,950 | .. | 54·6 | 376·0 |
| Kosavankulam .. .. | Karunkuzhi .. .. | 0·5 | 31·6 | 9·6 | 9·1 | 122·0 | 1,180 | .. | 25·7 | 196·0 |
| Vellaikulam .. .. | Kancheepuram .. | 3·0 | 27·0 | 8·5 | 5·0 | 247·1 | 805 | .. | 65·3 | 94·0 |
| Sarvatheertham .. .. | Kancheepuram .. | 4·0 | 31·6 | 8·9 | 9·5 | 98·5 | 460 | .. | 33·6 | 86· |
| Chettikulam .. .. | Kancheepuram .. | 2·5 | 31·8 | 9·6 | 38·8 | 33·6 | 495 | .. | 33·2 | 95·0 |
| Thimmarajakulam .. | Chingleput .. .. | 1·5 | 31·2 | 8·4 | 8·2 | 149·5 | 630 | .. | 45·4 | 58·0 |
| Karpoorachettikulam .. | Chingleput .. .. | 1·5 | 28·0 | 7·9 | 2·6 | 250·1 | 820 | .. | 50·8 | 250·0 |
| Veppankulam .. .. | Chingleput .. .. | 1·0 | 27·2 | 8·8 | 0·6 | 103·7 | 500 | .. | 0·0 | 300·0 |
| Theerthankulam.. .. | Tindivanam .. .. | 3·0 | 29·2 | 7·3 | 3·4 | 54·9 | 625 | 188 | 38·7 | 174·0 |
| Vellaikulam .. .. | Arni .. .. | 0·11 | 31·4 | 8·6 | 7·4 | 91·5 | 320 | 76 | ND | 52·0 |
| Fort Moat .. .. | Arni .. .. | 6·0 | 29·8—28·4 | 9·3 | 4·8—5·2 | 106·8—78·1 | 610 | 150 | 25·5 | 160·0 |
| Kallukatti tank .. .. | Karaikudi .. .. | 0·5 | 29·2—35·4 | 7·1—9·6 | 0·0—17·3 | 164·8—51·0 | 475 | 120 | 26·2 | 96·0—111·6 |
| Quarry Pool No. II .. | Virudhunagar .. | 0·66 | 31·8 | 9·2 | 3·2 | 326·14 | 3,000 | 340 | 34·1 | 916·0 |
| Quarry Pool No. III .. | Virudhunagar .. | 3·0 | 32·0 | 8·3 | 6·0 | 219·6 | 725 | 134 | 34·1 | 130·0 |
| Ayyankulam .. .. | Thanjavur .. .. | 2·0 | 29·2 | 7·5 | 0·0 | 219·6 | 490 | 104 | 52·1 | 91·0 |
| Anjaneyar Temple tank. | Villupuram .. .. | 4·0 | 34·4 | 8·3 | 4·0 | 372·1 | 1,075 | 164 | 42·7 | 181·0 |
| Sekkadikulam .. .. | Adirampatnam .. | 3·7 | 28·4 | 8·3 | 1·5 | 378·2 | 1,275 | 124 | 80·2 | 274·0 |
| Melnainareri .. .. | Pudukkottai .. .. | 2·0 | 35·4 | 7·9 | 0·0 | 85·4 | 2,100 | 280 | 44·1 | 564·0 |
| Sakkarai Theertham .. | Tiruvannamalai .. | 0·5 | 32·4 | 7·4 | 10·4 | 128·1 | 380·0 | 96·0 | 24·6 | 50·0 |
| Temple tank .. .. | Avanashi .. .. | 0·5 | 28·6—29·6 | 8·1—8·6 | 1·0—6·2 | 445—415 | .. | .. | .. | 36·0 |

TABLE 11.—*Hydrological conditions of ponds yielding medium sized* **tilapia** *(weighing over 100 g. but less than 300 g.)*

| *Name of pond.* (1) | *Location.* (2) | *Area.* (3) | *Temperature °C.* (4) | *pH.* (5) | *Dissolved oxygen mg./l.* (6) | *$HCO_3$ alkalinity mg./l.* (7) | *Electrical conductivity.* (8) | *Hardness ppm.* (9) | *Calcium mg./l.* (10) | *Chloride mg./l.* (11) |
|---|---|---|---|---|---|---|---|---|---|---|
| Pillaikulam | Adirampatnam | 6·6 | 28·6 | 8·6 | 0·8 | 420·9 | 1,350 | 116 | 86·2 | 272 |
| Kumudamkulam | Pudukkottai | 1·5 | 29·0 | 9·1 | 0·8 | 45·8 | 38·5 | 72 | 92·2 | 82 |
| Tirumakulam | Madurai | 4 | 30·4 | 8·0 | 4·6 | 201·3 | 620 | ND | 98·6 | 47·0 |
| Mariamman Teppam | Madurai | 17 | 30·4 | 9·6 | 1·8 | 256·2 | 2,650 | .. | 61·1 | 298 |
| Tirukkulam | Sirkazhi | 1·2 | 30·0 | 7·5 | 0·5 | 189·1 | 380 | 92 | 4·7 | 48 |
| West Moat | Thanjavur | 2·0 | 28·2 | 7·5 | 0·7 | 183 | 375 | .. | .. | .. |
| Webster Moat | Thanjavur | 4·0 | 29·0—28·0 | 8·8—7·9 | 0·01—0·1 | 219·6—289·0 | 825—695 | 170 | 61·5 | 180 |
| Teppukulam | Sivaganga | 6·0 | 32·0 | 8·8 | 1·3—0·0 | 103·7—201 | .. | 80 | 34·1 | 160 |
| Chekkadikulam | Sivaganga | 2·0 | 29·2 | 8·3 | 2·9 | 231·8 | 900 | 148 | 21·0 | 230 |
| Quarry Pool No. 1 | Virudhunagar | 0·48 | 31·2 | 9·0 | 9·8 | 167·8 | 2,125 | 70·0 | 44·1 | 536 |
| Sampadayankulam | Cheyyar | 0·50 | 30·0 | 7·2 | 4·0 | 61·0 | 145 | 60·0 | ND | 16·0 |
| Ayyankulam | Tiruvannamalai | 3·27 | 31·6—29·0 | 7·6—9·6 | 15·6—4·6 | 122—201<br>225·7 | 1,510—1,350 | 274—102 | 43·6—45·4 | 302—315<br>220 |
| Tamaraikulam | Tiruvannamalai | 20·0 | 28·6—27·4<br>27·2 | 8·4—8·5<br>8·3 | 3·2—5·0 | 204·3—292·8<br>161·7 | 800—1,025 | 134—122<br>30·0 | 28·1—36·1 | 124—104 |
| Sandaimedu Pond | Chengam | 1·0 | 29·0 | 7·7 | 2·1 | 183·0 | 470 | 96·0 | 24·0 | 60·0 |
| Periatheppam | Valliyoor | 2·0 | 31·8 | 7·6 | 23·0 | 161·7 | 425 | 72 | 17·0 | 61·0 |
| Thattankulam | Karunguzhi | 1·90 | 31·8 | 9·6 | 7·0 | 152·5 | 1,250 | .. | 23·6 | 290·0 |
| Chennamalleswarar Temple tank. | Madras | 0·5 | 28·4 | 8·4 | ND. | 152·5 | .. | .. | .. | .. |
| Vellore Fort Moat | Vellore | 12·0 | .. | .. | .. | .. | .. | .. | .. | .. |
| Pachemuthunadar Pond. | Nagapattinam | 2·0 | 30·8 | 9·6 | 8·4 | 552·5 | 1,850 | 446 | 311 | 360 |

TABLE III.—*Hydrological conditions of ponds yielding large sized* Tilapia (*over 300g. in weight*).

| *Name of pond.* | *Location.* | *Area. (acres.)* | *Deph.* *Max.* | *Deph.* *Min.* | *Temperature °C.* | *pH.* | *Dissolved oxygen mg./l.* | *HCO3 alkalinity mg./l.* | *Electrical conductivity.* | *Hardness ppm.* | *Calcium mg./l.* | *Chloride mg./l.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) |
| Saravana Poigai .. .. | Valliyoor .. .. | 0·5 | 15 | 5 | 32·6 | 9·5 | 16·4 | 71·0 | 390 | 80 | 9·5 | 95 |
| Mandai Oorani .. .. | Vadugapatti .. | 1·0 | 8 | 2 | 32·4 | 8·5 | 17·4 | 195·2 | 580 | 150 | 52·1 | 72 |
| Teppakulam .. .. | Kulithalai .. .. | 1·67 | 8 | 2 | 31·4 | 7·3 | 1·1 | 311·1 | 680 | 181 | 43·1 | 78 |
| Sengulam .. .. | Mannargudi .. | 3·5 | 10 | 4 | 29·8—29·8 32·2 | 8·7—7·3 | 6·5—5·6 | 280·6—176·9 | 890 | 170 | 46·1—19·6 | 156—28·0 |
| Fort Moat .. .. | Chingleput .. .. | 7·0 | 12 | 3 | 28·2 | 9·5 | 6·2 | 82·4 | 255 | 130 | 22·5 | 120 |
| Cauvery Peak Pond .. | Shevroy's Yercaud. | 1·0 | 6 | 4 | 25·8—26·4 | 6·5—9·3 | 11·5—9·0 | 21·4—74·1 | .. | .. | .. | 12—14 |
| Ananthasagaram Reservoir | Mettupalayam .. | 1·60 | 10 | 2 | 24·6 | 8·3 | 5·6 | 262·3 | 525 | .. | 31·6 | .. |
| Yercaud Lake .. .. | Shevroys' Yercaud. | 22·0 | 18 | 12 | 22·0—25·2 | 8·6—8·8 | 9·0—13·0 | 40·3—15·3 | 130·12 | 52 | Tr. 12·0 | 26·0 |
| Odathurai Reservoir .. | Odathurai .. .. | 1·90 | 18 | 6 | 25·4 | 8·7 | 6·6 | 271·5 | 525 | 28·40 | 41·6 | 64·0 |
| Manimuthar Reservoir .. | .... | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| Amaravathy Reservoir .. | Kallapuram .. | 2,100 | 112 | 45 | 24·6 | 7·6 | 8·4 | 25 | 40 | 48 | Tr. | 7·0 |
| Sathanur Reservoir .. | Sathanur .. .. | 3,100 | 99 | 34 | 30·4 | 8·8 | 7·6 | 177·0 | 320—580 | 114—264 | 31·1 | 34·0—60·0 |
| Vaigai Reservoir.. .. | Vaigai .. .. | 5,980 | 96 | 26 | 26·4 | 7·8 | 6·7 | 51·9 | 125—140 | 65—114 | 17·5 | 8—20 |
| Krishnagiri .. .. | Muthur .. .. | 3,080 | 52 | 17 | 26·0—29·0 | 7·5—8·5 | 6·0—7·8 | 250—460 | 500 | 76—138 | 33·6 | 35—50 |

TABLE IV.

*Fish yield and its money value is some ponds where* Tilapia *is the predominent species.*

| Year. (1) | Fish yield (2) LB. | Amount realized by sale. (3) RS. |
|---|---|---|
| *Mariamman Teppam—* | | |
| 1956–57 .. .. .. .. | 30,497 | 11,225 |
| 1957–58 .. .. .. .. | 25,397 | 6,138 |
| 1958–59 .. .. .. .. | 26,717 | 3,280 |
| 1959–60 .. .. .. .. | 37,356 | 1,537 |
| 1960–61 .. .. .. .. | 8,471 | 940 |
| 1961–62 .. .. .. .. | 15,469 | 860 |
| 1962–63 .. .. .. .. | 24,649 | 1,035 |
| *Pudukkottai tanks.—* | | |
| 1954–55 .. .. .. .. | 2,115 | 779 |
| 1955–56 .. .. .. .. | 2,468 | 864 |
| 1956–57 .. .. .. .. | 5,351 | 1,833 |
| 1957–58 .. .. .. .. | 5,385 | 1,306 |
| 1958–59 .. .. .. .. | 6 233 | 1,765 |
| 1959–60 .. .. .. .. | 6,766 | 1,582 |
| 1960–61 .. .. .. .. | 5,263 | 1,277 |
| 1961–62 .. .. .. .. | 9,102 | 327 |
| 1962–63 .. .. .. .. | 7,196 | 583 |

TABLE V.

*Total yield of fish and weight of* Tilapia *in some ponds, lake and impoundments.*

| Year. (1) | Total fish yield. (2) LB. | Yield of Tilapia. (3) LB. | Numbers Tilapia. (4) |
|---|---|---|---|
| *Odathurai tank—* | | | |
| 1957–58 .. .. | 6,265 | Not known. | .. |
| 1958–59 .. .. | 7,886 | Do, | .. |
| 1959–60 .. .. | 7,681 | Do, | .. |
| 1960–61 .. .. | 14,029 | 6,043 | .. |
| 1961–62 .. .. | 9,843 | 4,857 | .. |
| 1962–63 .. .. | 11,531 | 4,868 | .. |
| *Ananthasagaram tank—* | | | |
| 1957–58 .. .. | 657 | 138 | .. |
| 1958–59 .. .. | 3,732 | 2,765 | .. |
| 1959–60 .. .. | 4,176 | Not known. | .. |
| 1960–61 .. .. | 7,529 | Do. | .. |
| 1961–62 .. .. | 8,242 | 7,954 | .. |
| 1962–63 .. .. | 5,110 | 2,954 | .. |
| *Kallukatti Pond—* | | | |
| 1959–60 .. .. | 1,712 | 1,706 | .. |
| 1960–61 .. .. | 1,735 | 1,707 | .. |
| 1961–62 .. .. | 499 | 417 | .. |
| 1962–63 .. .. | 1,778 | 1,208 | .. |

TABLE V—*cont*

*Total yield of fish and weight of* Tilapia *in some ponds, lake and impoundments*—cont.

| Year. (1) | Total fish yeild. (2) LB. | Yeild of Tilapia. (3) EB | Numbers Tilapia. (4) |
|---|---|---|---|
| *Theerthankulam Pond.—* | | | |
| 1956–57 .. .. | .. | Nil. | .. |
| 1957–58 .. .. | 2,637 | .. | .. |
| 1958–59 .. .. | 2,445 | 138 | .. |
| 1959–60 .. .. | 1,193 | 86 | .. |
| 1960–61 .. .. | 961 | 372 | .. |
| 1961–62 .. .. | .. | 289 | .. |
| *Veppankulam (Chingleput)—* | | | |
| 1958–59 .. .. | 144 | 144 | 419 |
| 1959–60 .. .. | 393 | 393 | 1,120 |
| 1960–61 .. .. | 225 | 225 | 933 |
| 1961–62 .. .. | 420 | 410 | 2,455 |

TABLE VI.

*Data on the fish yield and* Tilapia *catches in some ponds.*

| Year. (1) | Total fish yields. (2) LB. | Tilapia. Total Weight per year. (3) LB. | Tilapia. Number. (4) | Tilapia. Average weight. (5) LB. |
|---|---|---|---|---|
| *Yercaud lake (upland lake)—* | | | | |
| 1956–57 .. .. | 524 | Nil. | Nil. | Nil. |
| 1957–58 .. .. | 484 | 1 | 494* | .. |
| 1958–59 .. .. | 756 | 304·5 | 841 | 0·36 |
| 1959–60 .. .. | 890 | 698·5 | 1,871 | 0·37 |
| 1960–61 .. .. | 300 | 273 | 716 | 0·38 |
| 1961–62 .. .. | 497 | 203 | 283 | 0·72 |
| 1962–63 .. .. | 538 | 315 | 419 | 0·75 |
| *Ayyankulam (Tiruvannamalai)—* | | | | |
| 1958–59 .. .. | 2,878¾ | 303¾ | 1,835 | 0·17 |
| 1959–60 .. .. | 4,860 | 4,589 | 28,299 | 0·16 |
| 1960–61 .. .. | 8,160 | 6,527 | 39,952 | 0·16 |
| 1961–62 .. .. | 3,841 | 1,997 | 16,654 | 0·12 |
| 1962–63 .. .. | 4,191 | 1,504 | 8,581 | 0·17 |
| *Tamaraikulam (Tiruvannamalai)—* | | | | |
| 1958–59 .. .. | 5,021 | 912 | 5,862 | 0·15 |
| 1959–60 .. .. | 5,703 | 3,902 | 24,067 | 0·16 |
| 1960–61 .. .. | 3,227 | 1,659 | 10,069 | 0·17 |
| 1961–62 .. .. | 2,921 | 2,500 | 14,910 | 0·17 |
| 1962–63 .. .. | 3,768 | 1,686 | 9,960 | 0·17 |

* Fingerlings.

# A NOTE ON THE PRESERVATIVE ACTION OF ACETIC ACID APPLIED AS A SPRAY OVER SALTED FISH

BY

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## Introduction.

Though a variety of chemical preservatives and anti-oxidants have been permitted in food preservation, very little use of these have so far been made in fish preservation especially in preparing salted and dried fish. The literature concerning chemical preservation of fish has been reviewed recently by Tarr (1961). The use of inorganic and organic acids to control bacterial spoilage of fish was suggested by Nadeau (1939). The recent works of Sen *et. al.* (1961) and Suryanarayana Rao and Valsan (1962) have indicated the usefulness of Sodium propionate and propionic acid as effective chemical adjuncts for extending storage life of salted and dried mackeral. Bersamin *et. al.* (1961) found Sarbistat useful in preventing the growth of yeasts and moulds among the common dried fishery products such as *Sardinella* and *Decapterus* species. Nicholson (1930), found that the addition of one part of acetic acid to 250 parts of boric acid would improve the preservative action of the latter. Aiso (1951), Tetsumoto *et. al.* (1953) and Tarr *et. al.* (1950) found 0·1 to 0·5 per cent Dehydro-acetic acid incorporated in flesh slightly effective in inhabiting bacterial spoilage of fish. Similar observations with monobromacetic acid were made by Tarr *et. al.* (1950) and Rowan *et. al.* (1953). The use of Vinegar in the preparation of fish pickles in our houses is well known. Experiments were therefore conducted by the present authors to find out the effect of a spray of one per cent acetic acid over salted fish before drying on the qualities of the salt-cured fish. The results of these experiment are discuss in this communication.

## Material and methods.

The investigations were carried out with two varieties of marine fishes. *Lactarius sp.* and *Dussumieria sp.* The specimens for the investigation were obtained fresh from the local landings and were split along the ventral side and guts removed. These were then washed and salted. The salt : fish ratio for *Lactarius sp.* was 1 : 4 and that for *Dussumieria sp.* 1 : 8 by weight.

The salted fish was then divided into two lots. Of these one lot was allowed to remain overnight in a tub so as to be in contact with the self-brine formed. After curing, the fish was dried in the sun for three days. The other half of the salted fish was sprayed with a solution of one per cent acetic acid using a fine sprayer immediately after salting. Further processing was done by the same method described above. The dried fish was stored in glass containers with lids and examined at monthly intervals for a storage period of up to six months. Moisture was determined as per A.O.A.C. (1958) method. T.V.B.N. and T.M.A.N. were estimated by the micro diffusion method of Conway (1947) and the organoleptic rating of the products was done as per scoring system of Venkataraman and Vasavan (1955).

## Results and Discussions.

The analytical data on the progress of spoilage in the two sets of samples for *Lactarius sp.* and *Dussumieria sp.* are shown in Tables I and II respectively in annexure.

It will be seen from these data that as far as the chemical indices of spoilage, viz., T.V.B.N., and T.M.A.N., were concerned the acetic acid treatment did not appear to have effected any improvement. But based on organoleptic tests, the acetic acid treated samples scored a higher rating than the corresponding control samples. The acetic acid treated samples were more attractive in appearance and had better flavour than the untreated control samples, the difference between the two samples becoming more marked from the third month onwards. This may be due to the fact that since acetic acid was applied only as a spray, it did not penetrate the flesh deep enough to effect uniform improvement in the quality of the product. Probably the effectiveness of the chemical was restricted to the fish surface only and the apparent better appearance gave a misleading idea of the real quality of the fish. However the usefulness of acetic acid in preservation of salted fish products has been indicated by Notevarp *et. al.* (1934). Similar observations and limited protection against moulds by propionic acid have also been reported by Valsan *et. al.* (1961).

*Acknowledgment.*

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TABLE I.

*Showing data on the progress of spoilage in salted Dussumieria sp. sprayed with Acetic acid prior to curing.*

| Sample. | Period of storage. | | | | | |
|---|---|---|---|---|---|---|
| | One month. | | Two months. | | Three months. | |
| | A | B | A | B | A | B |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Moisture (per cent) .. .. | 36·01 | 36·88 | 36·18 | 36·75 | 36·28 | 37·63 |
| T.V.B.N. (mgm./cent) .. .. | 87·5 | 90·0 | 112·0 | 112·5 | 163·0 | 172·0 |
| T.M.A.N. (mgm./cent) .. .. | 21·0 | 20·0 | 27·5 | 30·0 | 44·0 | 43·5 |
| Organolephic Test score (Max. 30) | 30·0 | 30·0 | 28·0 | 28·0 | 23·0 | 29·0 |

| Sample. | Period of storage. | | | | | | Remarks. |
|---|---|---|---|---|---|---|---|
| | Four months. | | Five months. | | Six months. | | |
| | A | B | A | B | A | B | |
| (1) | (8) | (9) | (10) | (11) | (12) | (13) | (14) |
| Moisture (per cent) .. .. | 35·30 | 37·50 | 37·09 | 37·60 | 37·08 | 37·62 | *A*=Control sample. |
| T.V.B.N. (mgm./cent) .. .. | 271·0 | 287·5 | 375·0 | 329·0 | 398·0 | 397·0 | |
| T.M.A.N. (mgm./cent) .. .. | 62·0 | 65·0 | 77·0 | 82·5 | 116·5 | 109·5 | *B*=Acetic acid treated sample. |
| Organolephic Test score (Max. 30) | 20·0 | 24·0 | 18·0 | 21·0 | 12·0 | 13·0 | |

TABLE II.

*Showing data on the progress of spoilage in salted Lactarius sp. sprayed with Acetic acid prior to curing.*

| Sample. | Period of storage. One month. A | B | Two months. A | B | Three months. A | B |
|---|---|---|---|---|---|---|
| (1) | (1) | (2) | (3) | (5) | (6) | (7) |
| Moisture (per cent) .. .. | 37·36 | 38·16 | 37·34 | 38·21 | 37·72 | 38·39 |
| T.V.B.N. (mgm./cent) .. .. | 120·0 | 118·0 | 145·0 | 141·0 | 171·0 | 163·0 |
| T.M.A.N. (mgm./cent) .. .. | 27·5 | 28·0 | 38·0 | 35·0 | 40·0 | 38·0 |
| Organolephic Test Score (Max. 30) | 29·0 | 29·0 | 26·0 | 27·0 | 22·0 | 25·0 |

| Sample. | Period of storage. Four months. A | B | Five months. A | B | Six months. A | B | Remarks. |
|---|---|---|---|---|---|---|---|
| | (8) | (9) | (10) | (11) | (12) | (13) | (14) |
| Moisture (per cent) .. .. | 38·18 | 38·27 | 38·69 | 38·26 | 38·68 | 38·22 | *A* = Control sample. |
| T.V.B.N. (mgm./cent) .. .. | 262·0 | 260·0 | 383·0 | 382·0 | 420·5 | 402·5 | |
| T.M.A.N. (mgm./cent) .. .. | 55·0 | 50·0 | 95·0 | 91·5 | 117·0 | 110·5 | *B* = Acetic acid treated sample. |
| Organolephic Test Score (Max. 30) | 18·0 | 23·0 | 16·0 | 20·0 | 12·0 | 14·0 | |

# ON THE EFFICIENCY OF THE "METTUR RANGOON" NETS IN THE BHAVANISAGAR RESERVOIR.

BY

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Multipurpose artificial impoundments are potential sources of fish production. There are many such in *India* and almost all of them without exception have been taken up for fish culture. An understanding of the existing fishery before impoundment, the trend in recruitment of the indigenous fishery after the formation of the water spread, the programme of introduction of exotic fishes, study of the breeding grounds, productivity and biomass variations over different seasons in relation to water exchange are all factors that decide the fishery wealth of these artificial impoundments and are to be constantly studied. The Hydrobiological station at Bhavanisagar is investigating on these lines so that a management policy could be laid out for each type of our reservoirs (Ranganathan *et al* 1963 and Sreenivasan 1964). A simultaneous analysis of the fishing efficiency with different gear is equally essential for a study of the trend of the unit catch effort and also for evolving the best fishing gear.

It is generally felt that the technique employed by the inland fishermen in Madras State for exploiting the major reservoirs like Mettur and Bhavanisagar are capable of further improvement. Yet no better solution than the " Rangoon " net of Mettur has been suggested as an effective alternative especially when the bottom is uneven, full of rocks and submerged trees. Gulbadmov (1961) in his report to the Government of India on " Improvement of Fishing Techniques in Inland Reservoirs of India " considers the nets used by the Mettur and Bhavanisagar fishermen capable of improvement and recommends even a gradual substitution of his new " Sebgul " I or II. His comparison of the average catch of a fisherman at Mettur with that of his " Sebgul " net is incomplete, in that data are not available with reference to water level and seasons of the fishery. Even if Mettur Fishermen have no technical background, their instinctive acumen are so much that they have evolved the best mesh size to suit each fishery as evidenced by the nets used in 1964 and 1965 for catching the 20 to 25 kgs. *Catla*, and 14 to 16 kgs. *Mrigal*. It is highly doubtful if " Sebgul net ' II with 3·5 bar will ever catch *Cirrhina cirrhosa*, and *Barbus dubius* since the biggest of the former in Mettur is of 4·0 kgs. and is caught only in the 2″ and 2½″ mesh, the fish being definitely small for 3·5″ to 5″ nets. *Barbus dubius* of more than 1·0 kg. has never occured in Mettur in recent years and the biggest size of 3 to 5 kg . are always caught in 2½″ mesh bar in Bhavanisagar. It was therefore felt by us that a complete account of fishing operations in a reservoir will be of value so that comparative studies could be instituted elsewhere to evolve the efficient methods in reservoir fishing.

Bhavanisagar, a reservoir of 30 square miles in Madras State is formed as a result of the damming of the Bhavani and Moyar Rivers draining from the Nilgiris plateau. A fairly accurate idea of the water line at different contours and the nature of the bed is available (Ranganathan *et al* 1963). The FRL contour line is +915′ and capable of being raised to +920′ while the bed level of the river at the Dam site is +797′. Typical of artificial impoundments, the submerged bed is very uneven, strewn with rocks, boulders and even small hillocks all over. Submerged basements of villages, complete fort with a temple and forests strewn with big trees especially in the area drained by the now submerged Bhavani are characteristic of the bottom. (Photos) Seining of any sort is hence impossible.

The reservoir was developed for its fishery from the year 1952 by conserving the indigenous fishery of *Barbus dubius*, *Macrones aor*, *Wallagonia attu* and *Labeo bata*. These fisheries are now well established in this reservoir. *Labeo calbasu*, *Catla catla*, *Cirrhina mrigala* and *Labeo rohita* were systematically stocked. Of these *Labeo calbasu* has got established well while the others are yet to be established. *Barbus dubius* breeds between September and November migrating for a short distance up the Bhavani and the peak fishery is around these months. *Macrones aor* dominates the catches between December and May, a period of their gonadial maturation and local migration especially in the Moyar side. *Labeo calbasu* along with *Wallagonia attu* and the carps *Catla*, *Mrigal*, *Rohu* and *Labeo fimbriatus* are always to be anticipated when freshes appear especially in the Bhavani side. It is now possible to pin point the movement of each fishery with reference to breeding or feeding migration and this has enabled us to operate the fishing units to the best advantage.

Reduced to terms of the unit effort the results of 1964 fishing in Bhavanisagar reservoir is reflected in Table 1. The average daily landing of each unit in 1964 was 46·35 *kgs*. The other limiting factors in addition to the fishing efficiency of the gear are the water level, the rate and nature of inflow and outflow and turbidity. The unit effort was calculated on the basis of total number of units employed each month. Thus during January 1964, three units operated each day for 31 days (93 units in January). Each unit consisted of one coracle, a basket shaped craft lined by hide and operated by two fishermen, 20 " Rangoon " nets consisting of ten 2½″, Five 2″ and five *catla* nets of 4″ meshes prescribed as optimum. The standardized specifications of these nets are given in Table 2 (*a*). Before the nets were operated care was taken to give the correct co-efficient of 50 per cent hanging. The loose hanging and slipping were avoided by tying the knot at every 24″ in the float line. The initial cost of rigging one unit was around Rs. 1,000, Rs. 900 for nets and Rs. 100 for the coracle. The fishermen were paid each Rs. 70 a month and the expenditure on each unit a year is $140 \times 12 = 1{,}680 + 1{,}000 = 2{,}680$ rupees. The fish were disposed of at the rate of 92 Paise per kilogram and each unit earned on an average of Rs. 10,000 a year during the period under discussion. In addition, during the months of May to July the fishing effort was increased as can be seen from the table by engaging some units of the Mettur fishermen. There was not so much of net standardization with Mettur fishermen as in the department. The nets used in general by them were of the specifications given in Table 2 (*b*).

The overall result of fishing in 1964 involving a total unit effort of 1920 was the landings of 89 tons of fish (Table 3). Each unit effort of fishing costs the Government Rs. 8 aggregating to Rs. 16,000 and the total revenue on account of sale at 92 paise was Rs. 87,200. The species anticipated to form the main fishery based on hydrobiological studies were truely reflected in the catches, . Thus 19,673 *Barbus dubius* (24,173 kgs.) 3,213 *Labeo calbasu* (11,274 kgs.) 2,319 *Wallagonia attu* (9,071 kgs.) and 10,695 *Macrones aor* (18,959 kgs.) accounted for the more dominant catches. There was a significant increase in catches during May, June and July in the low level conditions of 846 feet to 871 feet level influenced by occasional floods. When water level conditions become stable, the increase in catches of *Barbus dubius* from November to December is on account of the return of spent voraciously feeding spawners. Such observations were made on *Macrones aor*, the season for large scale fishing being around the breeding months of November to March. *Labeo bata* was successfully fished with 2″ mesh nets in May (1,057 fish weighing 1,109 kgs.) and December (1,383 fish weighing 1,042 kgs.) during their upward breeding migration consequent on sporadic floods. The fishery was followed by a large scale breeding of the fish about 10 to 15 miles above the place of capture as was confirmed by a heavy collection of spawn of the same species A major carp fishery of *Labeo calbasu, Catla catla, Cirrhina mrigala Labeo bata* and *Labeo fimbriatus* was anticipated and achieved between May and June.

Sudden floods and heavy winds affected adversely the catches especially during May and June. The general practice of the fishermen was to relay the nets which got rolled immediately after the wind or flood. Two sets of 5 experimental nets were operated under identical conditions, the first one using the ordinary nets and attending to relaying after wind and flood. In the second set the nets were framed, barrel shaped thermacole floats at a distance of 3 metres in the float line and small stone sinkers in lead line were used. This effectively prevented the rolling of nets. The comparative results are shown in Table 4 (a and b). During the month of June one set of ordinary nets landed 858 fishes weighing 2,374 kgs. as against 3,271 fishes weighing 8,127 landed by the same number of nets rigged with floats and sinkers. The results in May were still better. 5,259 fishes weighing 10,301 kgs. were accounted for by the improved nets compared to 1,143 fish weighing 2,586 kgs. from the nets handicapped by rolling on account of winds and floods. The catch of the bigger sized fish by ordinary nets is significant. Once the conditions became normal as regards flow and wind there was no appreciable difference in the landings between the " Sebgul " nets and the Mettur net with advance care on framing and felling.

The results of the study made in regard to the species of fish caught in relation to the mesh of the net is indicated in the Table 5. *Catla catla* weighing 10 to 17 kgs., *Cirrhina mrigala* weighing 10 to 14 kgs. and *Labeo callasu* 8 to 12 kgs. and *Wallagonia attu* 10 to 20 kgs. were always caught in the Catla net of 4″ mesh. 2½″ mesh yielded the maximum catches in Bhavanisagar Reservoir accounting for the *Barbus dubius*, *Macrones aor*, *Labeo kontius*, *Wallagonia attu* and *Labeo calbasu* and the 2″ mesh landed *Labeo bata* and the two-year old *Barbus dubius* and *Labeo kontius*. The use of the 2″ net must be with reference to *Labeo bata* only, otherwise if they are used indiscriminately the smaller sized *Labeo calbasu*, *Catla catla* and *Cirrhina mrigala* are liable to be captured. These observations are of practical value in deciding the mesh for each type of fishery in a reservoir in relation to size of the fish.

Intensification of efforts are always called for when best fishing conditions prevail. Low level with flux of even little flood water is one. The results of one such fishing in low level of ·844·90 and one in high levels of F.R.L.+915·60 contour level, in the same place using the same number of nets but with mesh to suit the fishery of that period is given in Table 6 and 7. The catch per unit effort was high in March and April, due to the persistant low level condition (859·06′ to 844·06). The unit effort catch of 233 kgs. and 130 kgs. in March and April is explained by the fact that this is the period of maximum catch of *Macrones aor* and also due to use of new Catla and Rangoon nets supplied in March 1964 accounting for a catch of *Catla catla*. *Labeo calbasu* and *Barbus dubius*. Six days fishing near Kothikombu yielded 1,823 fish weighing 4,422·5 kgs. at 844.90 feet level while in the same place at 915·60 feet level yield was only 1,732 fishes weighing 2,439·5 kgs. Comparative catch data under the same level conditions but in different area are given in table 7 and 8. Six days in the Moyar side (Table 8) resulted in the capture of 1,465 fishes weighing 1,933·00 kgs. The submerged Bhavani area yielded (*see* Table 7) 1,732 fishes weighing 2,439 kg.

A map of the Bhavanisagar reservoir, indicating the best fishing area under different contour levels, the nature and season of the fishery is appended.

### *Acknowledgement.*

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### *Discussion.*

Interesting data of practical value have been obtained in analysing the fishing results in the Bhavanisagar reservoir, Madras State.

During 1964 a total quantity of 89 metric tons of fish were landed involving 1920 unit effort of fishing. Each unit effort is one day's fishing with one coracle, 2 fishermen and between 1,000 to 1,250 metres of " Rangoon net ". Each unit effort costs nearly Rs. 8. The total fishing expenditure on account of these efforts was Rs. 16,000 nearly, while the receipt by way of the sale of fish was Rs. 87,000.

Maximum efficiency was assured by giving a 50 per cent hanging and avoiding slipping at the head rope by binding at regular intervals.

The hydrobiological investigations gave accurate idea of the fisheries in general and areas of congregation on account of breeding and feeding migrations. Nets were always laid at places best suited taking into account the results of the above study.

An attempt has been made to standardise the nets so that all workers can compare their results. This will help in ultimately bringing a standard to define each unit effort, for multipurpose reservoirs in India.

Any appreciable superiority of the ' Sebgul ' nets over the Rangoon nets cannot be established on ordinary days. Floats on the head rope and sinkers at the bottom prevented rolling of the nets during floods and winds, thus saving the trouble of attending to relaying often.

The results of fishing under low and high level conditions and the richness of the Bhavani fishing ground over Moyar area are all given in different tables.

Further experiments on fishing with drift nets at different depths, with electrical lights using different colours and fishing with current are to be tried. Till such time as the efficiency of the above experiments are proved beyond doubt, Rangoon nets properly hanged are the best for artificial impoundments in river basins characterised by uneven bottom and submerged fishing obstacles.

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# FISHING CENTRES IN BHAVANISAGAR RESERVOIR FOR THE YEAR 1964.

(Illustrations to Figure.)

## GROUP A.

*Bhavani side.*

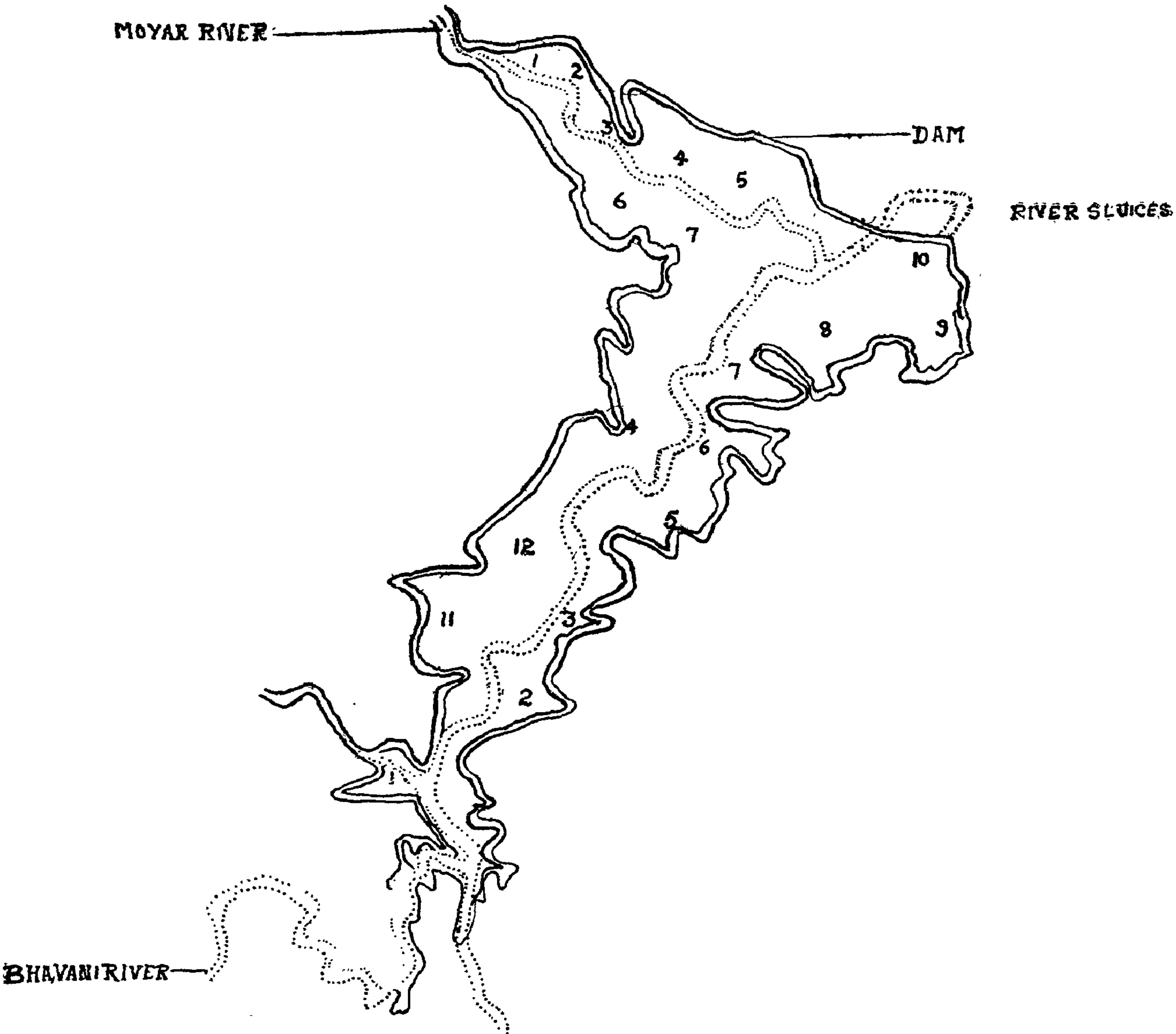
| *Fishing Centres.* | *Specifications of nets recommended for use.* | *Nature of fishery.* |
| --- | --- | --- |
| 1 Emanpatti chalai | 25 per cent of the nets 4″ Catla, 25 per cent 2″ mesh for *Labeo bata* and 50 per cent Rangoon nets 2½″ mesh. | *Barbus dubius, Wallagonia attu, Labeo calibasu, Labeo bata, Catla catla, Cirrhinai mrigala, Macrones aor* in order of importance. |
| 2 Thattapallam | .... | .... |
| 3 Kothikombu | .... | .... |
| 4 Dananaykankottai | Centres 1 and 2, 11 and 12 functional in between 890′ and 920′ water level. | |
| 5 Nellimokkai | | |
| 6 Othapanaikadu | Centres 3 to 10 functional in between 835′ to 890′ water level. | |
| 7 Palayavadavalli | | |
| 8 Kodapalayam | | |
| 9 Ammapalayam | | |
| 10 Water House | | |
| 11 Chinnavarambu | | |
| 12 Periavarambu | | |

## GROUP B.

*Moyar side.*

| *Fishing Centres.* | *Specifications of nets recommended for use.* | *Nature of fishery.* |
| --- | --- | --- |
| 1 Beruduraipatti | Rangoon nets 2½″ mesh all the year round and 4″ mesh Catla net between May and July for major carps and Wallagonia attu. | *Macrones aor* and *Barbus dubius* dominant. |
| 2 Benchi Pallam | Do. | Major carps *Labeo calbasu* and *Wallagonia attu.* |
| 3 Boodikuppam | Do. | .... |
| 4 Karai Mokkai | Do. | .... |
| Uppu Pallam | Centres 1 to 3 functional in between 890′ to 920′ level. | |
| (Peerkadavu | Centres 4 to 7 functional below 890′ level. | |
| 7 Pattaramangalam | | |

FISHING CENTRES IN BHAVANISAGAR RESERVOIR FOR THE YEAR 1964.




GROUP A—BHAVANI SIDE.

1 Emmanpattichalai
2 Thattapallam
3 Kothikombu
4 Dinanayakankottai
5 Neelimokkai
6 Othapanaikadu
7 Old Vadavalli
8 Kodapalayam
9 Ammapalayam
10 Water House
11 Chinnavarambu
12 Periavarambu

GROUP B—MOYAR SIDE.

1 Beruduraipatti
2 Benchipallam
3 Boodikuppam
4 Karaimokkai
5 Uppupallam
6 Peerkadauv
7 Pattaramangalam Pudoor.

TABLE I.

*Monthwise landings of fish with Rangoon nets in Bhavanisagar in relation to unit effort.*

| Months. (1) | Unit effort. | Fish landings. Number. | Fish landings. Weight. (IN KGS). |
|---|---|---|---|
| 1964— | | | |
| January | 93 | 3,651 | 5,309·75 |
| February | 87 | 4,659 | 7,163·25 |
| March | 93 | 8,447 | 11,999·00 |
| April | 120 | 7,096 | 15,075·00 |
| May | 216 | 5,354 | 10,967·75 |
| June | 360 | 4,670 | 11,524·00 |
| July | 186 | 2,400 | 8,038·50 |
| August | 186 | 1,981 | 4,473·25 |
| September | 150 | 1,636 | 2,301·50 |
| October | 155 | 744 | 1,165·25 |
| November | 150 | 1,900 | 2,594·75 |
| December | 124 | 5,962 | 8,389·50 |
| Total | 1,920 | 48,500 | 89,001·50 |

NOTE.—Average catch by one unit=46·354 kgs.

TABLE 2 (*a*)

BHAVANISAGAR FISHING—SPECIFICATIONS OF NETS USED AND STANDARDISED (DEPARTMENTAL).

*Garware—Garnyle.*

| Nets. | Length of nets (in metres.) | Weight of yarn per net (in kilograms). | Mesh size. | Number of meshes in length. | Number of meshes in row. | Code number. | Breaking strength (in kgs.) |
|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| 1 Rangoon net | 50 | 0·587 | 2″ | 1,000 | 45 | 2 (210×1×3) | 4·5 |
| 2 Rangoon net | 40 | 0·766 | 2½″ | 750 | 35 | 2 | 4·5 |
| 3 Catla net | 100 | 0·520 | 4″ | 500 | 25 | 3 (210×4) | 6·0 |

TABLE 2 (*b*).

BHAVANISAGAR FISHING—SPECIFICATIONS OF NETS USED BY METTUR FISHERMEN AND BY SPECIAL UNITS ON SHARE BASIS.

*Garware—Garnyle.*

| Nets. | Length of nets (in metres). | Weight of yarn per net (in kilograms. | Mesh size. | Number of meshes in length. | Number of meshes in row. | Code number | Breaking strength (in kgs). |
|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| 1 Catla net | 50 | 1·0 | 5″ | 400 | 17 | 3 or 4 (250×3×3) or (250×4×3) | 13·6 to 17·6 |
| 2 Catla net | 65 | 1·0 | 4·5″ | 594 | 18 | Do. | Do. |
| 3 Catla net | 65 | 1·0 | 7″ | 317 | 17 | Do. | Do. |
| 4 Catla net | 60 | 1·0 | 4″ | 575 | 25 | Do. | Do. |
| 5 Rangoon net | 30 | 0·5 | 4″ | 580 | 35 | 1 (250×3 or 210×2×2 or 210×4. | 6 |
| 6 Rangoon net | 35 | 0·5 | 5″ | 570 | 33 | Do. | Do |

TABLE 3.

*Monthwar data of total fish landings in Bhavanisagar Reservoir for 1964.*

| Serial number and name of the fish. | January. | | February. | | March. | | April. | |
|---|---|---|---|---|---|---|---|---|
| | * 893·29 | * 876·10 | 875·74 * | 859·00 | 859·06 * | 848·22 | 849·70 * | 844·96 |
| | *Number.* | *Weight.* | *Number.* | *Weight.* | *Number.* | *Weight.* | *Number.* | *Weight.* |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| 1 Barbus dubius .. .. .. .. | 2,584 | 3,327·00 | 2,752 | 3,753·25 | 4,514 | 6,145·00 | 1,997 | 2,641·60 |
| 2 Barbus carnaticus .. .. .. .. | 51 | 64·00 | 38 | 42·50 | 44 | 43·00 | 295 | 218·00 |
| 3 Barbus hexagonalepis .. .. .. | 37 | 90·75 | 12 | 27·00 | 11 | 20·75 | 116 | 181·00 |
| 4 Barbus tor .. .. .. .. .. | 11 | 23·25 | 18 | 52·25 | 12 | 15·00 | 18 | 44·75 |
| 5 Barbus sarana and others .. .. .. | 1 | 0·25 | 1 | 0·50 | 10 | 6·50 | 1 | 0·50 |
| 6 Labeo kontius .. .. .. .. | 56 | 52·75 | 146 | 134·75 | 437 | 396·75 | 561 | 582·00 |
| 7 Labeo fimbriatus .. .. .. | 31 | 94·75 | 23 | 66·00 | 3 | 6·00 | 286 | 1,053·00 |
| 8 Labeo calbasu .. .. .. .. | 89 | 316·25 | 154 | 590·75 | 71 | 251·00 | 626 | 2,380·00 |
| 9 Labeo bata .. .. .. .. .. | 10 | 9·00 | 37 | 37·75 | 502 | 487·00 | 985 | 879·75 |
| 10 Labeo paral and others .. .. .. | 13 | 15·15 | .. | .. | .. | .. | 17 | 24·50 |
| 11 Wallago attu .. .. .. .. | 66 | 181·00 | 131 | 263·75 | 291 | 549·25 | 291 | 1,010·00 |
| 12 Mystus aor .. .. .. .. | 679 | 1,024·50 | 1,330 | 2,073·25 | 2,488 | 3,872·50 | 1,585 | 2,666·00 |
| 13 Catla catla .. .. .. .. .. | 3 | 31·50 | 3 | 58·50 | 9 | 159·25 | 138 | 2,383·00 |
| 14 Labeo rohita .. .. .. .. | .. | .. | 2 | 17·00 | 4 | 26·00 | 45 | 510·50 |
| 15 Cirrhina cirrhosa .. .. .. .. | 4 | 10·25 | 4 | 15·75 | 2 | 7·00 | 30 | 89·00 |
| 16 Cirrhina mrigala .. .. .. .. | 8 | 47·75 | 4 | 29·25 | .. | .. | 56 | 383·50 |
| 17 Eel .. .. .. .. .. .. | 5 | 12·25 | .. | .. | .. | .. | .. | .. |
| 18 Murrel .. .. .. .. .. | 2 | 6·75 | .. | .. | .. | .. | 1 | 2·50 |
| 19 Mirror carp .. .. .. .. .. | .. | .. | .. | .. | .. | .. | 1 | 12·00 |
| 20 Etroplus and others .. .. .. | 1 | 0·25 | 4 | 1·00 | 49 | 14·00 | 47 | 13·50 |
| Total .. | 3,651 | 5,309·75 | 4,659 | 7,163·25 | 8,447 | 11,999·00 | 1,796 | 15,075·00 |

*Water level in the reservoir.

| (1)—*cont.* | *May.* | | *June.* | | *July.* | | *August.* | |
|---|---|---|---|---|---|---|---|---|
| | * 846·32—849·36 | | 846·72—839·63 | | 871·72—842·98 | | 918·06—871·33 | |
| | *Number.* | *Weight.* | *Number.* | *Weigh..* | *Number.* | *Weight.* | *Number.* | *Weight.* |
| | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) |
| 1 Barbus dubius .. .. .. .. | 1,247 | 1,663·50 | 1,164 | 1,616·00 | 542 | 651·25 | 647 | 717·75 |
| 2 Barbus carnaticus .. .. .. .. | 52 | 52·75 | 17 | 34·00 | 21 | 13·50 | 52 | 58·00 |
| 3 Barbus hexagonalepis .. .. .. | 80 | 174·50 | 81 | 176·00 | 77 | 212·50 | 101 | 225·00 |
| 4 Barbus tor .. .. .. .. .. | 10 | 46·00 | 27 | 114·00 | 6 | 25·75 | 11 | 36·50 |
| 5 Barbus sarana and others .. .. .. | 1 | 0·50 | .. | .. | .. | .. | .. | .. |
| 6 Labeo kontius .. .. .. .. | 711 | 838·00 | 407 | 431·00 | 134 | 200·50 | 131 | 85·00 |
| 7 Labeo fimbriatus .. .. .. .. | 139 | 491·00 | 140 | 572·25 | 66 | 190·25 | 41 | 150·25 |
| 8 Labeo calbasu .. .. .. .. | 447 | 1,640·75 | 557 | 2,163·25 | 433 | 1,644·75 | 268 | 862·50 |
| 9 Labeo bata .. .. .. .. .. | 1,057 | 1,109·00 | 908 | 937·50 | 92 | 136·50 | 263 | 214·50 |
| 10 Labeo paral and others .. .. .. | 7 | 8·50 | .. | .. | .. | .. | .. | .. |
| 11 Wallago attu .. .. .. .. | 365 | 1,526·00 | 336 | 1,917·25 | 231 | 1,146·50 | 155 | 635·75 |
| 12 Mystus aor .. .. .. .. | 1,041 | 1,947·00 | 849 | 2,087·50 | 540 | 1,605·50 | 221 | 613·00 |
| 13 Catla catla .. .. .. .. .. | 29 | 535·50 | 49 | 879·75 | 81 | 1,347·75 | 39 | 529·75 |
| 14 Labeo rohita .. .. .. .. | 26 | 219·50 | 19 | 165·50 | 103 | 352·00 | 12 | 108·75 |
| 15 Cirrhina cirrhosa .. .. .. .. | 47 | 164·00 | 16 | 67·00 | 11 | 32·00 | 7 | 25·25 |
| 16 Cirrhina mrigala .. .. .. .. | 90 | 549·00 | 49 | 325·00 | 62 | 476·75 | 33 | 211·25 |
| 17 Eel .. .. .. .. .. .. | .. | .. | .. | .. | .. | .. | .. | .. |
| 18 Murrel .. .. .. .. .. .. | .. | .. | .. | .. | 1 | 3·00 | .. | .. |
| 19 Mirror carp .. .. .. .. .. | .. | .. | 1 | 8·00 | .. | .. | .. | .. |
| 20 Etroplus and others .. .. .. | 5 | 2·25 | .. | .. | .. | .. | .. | .. |
| Total .. | 5,354 | 10,976·75 | 4,670 | 11,524·00 | 2,400 | 8,038·50 | 1,981 | 4,473·25 |

* Water level in the reservoir.

(1) - *cont.*

| | September. | | October. | | November. | | December. | | Annual. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | * 915·75—914·37 | | 914·23—912·13 | | 914·30—913·75 | | 917·94—914·83 | | | |
| | *Number.* | *Weight.* | *Number.* | *Weight.* | *Number.* | *Weight.* | *Number.* | *Weight.* | *Number.* | *Weight.* |
| | (18) | (19) | (20) | (21) | (22) | (23) | (24) | (25) | (26) | (27) |
| 1 Barbus dubius | 800 | 699·50 | 262 | 336·75 | 797 | 660·00 | 2,267 | 1,961·75 | 19,673 | 24,173·25 |
| 2 Barbus carnaticus | 43 | 36·00 | 16 | 21·00 | 29 | 28·75 | 26 | 21·50 | 684 | 633·00 |
| 3 Barbus hexagonalepis | 11 | 15·75 | 5 | 14·50 | 16 | 45·00 | 23 | 52·00 | 570 | 1,234·75 |
| 4 Barbus tor | 5 | 14·50 | 4 | 10·00 | 9 | 4·50 | 8 | 20·75 | 139 | 407·25 |
| 5 Barbus sarana and others | .. | .. | .. | .. | .. | .. | .. | .. | 14 | 8·25 |
| 6 Labeo kontius | 88 | 69·25 | 27 | 19·75 | 102 | 68·25 | 263 | 212·00 | 3,063 | 3,090·00 |
| 7 Labeo fimbriatus | 67 | 228·00 | 8 | 27·25 | 8 | 31·00 | 47 | 205·25 | 859 | 3,115·00 |
| 8 Labeo calbasu | 199 | 480·50 | 50 | 99·50 | 112 | 280·75 | 207 | 562·50 | 3,213 | 11,274·50 |
| 9 Labeo bata | 146 | 105·25 | 70 | 56·50 | 343 | 243·25 | 1,363 | 1,042·75 | 5,776 | 5,258·75 |
| 10 Labeo paral and others | .. | .. | .. | .. | .. | .. | .. | .. | 37 | 48·50 |
| 11 Wallego attu | 48 | 212·75 | 58 | 237·50 | 75 | 251·75 | 222 | 1,109·50 | 2,319 | 9,071·00 |
| 12 Mystus aor | 155 | 32·50 | 135 | 250·05 | 349 | 565·75 | 1,323 | 2,221·00 | 10,695 | 18,959·00 |
| 13 Catla catla | 12 | 217·25 | 4 | 79·50 | 47 | 315·00 | 183 | 837·75 | 587 | 7,374·50 |
| 14 Labeo rohita | 6 | 53·25 | .. | .. | 2 | 28·50 | 11 | 65·25 | 230 | 1,546·25 |
| 15 Cirrhina cirrhosa | 2 | 8·25 | .. | .. | 5 | 8·50 | 11 | 21·25 | 139 | 448·25 |
| 16 Cirrhina mrigala | 18 | 120·25 | 2 | 12·00 | 6 | 63·75 | 8 | 56·25 | 336 | 2,274·75 |
| 17 Eel | .. | .. | 3 | 00·50 | .. | .. | .. | .. | 44 | 21·25 |
| 18 Murrel | .. | .. | .. | .. | .. | .. | .. | .. | 4 | 12·25 |
| 19 Mirror carp | .. | .. | .. | .. | .. | .. | .. | .. | 2 | 20·00 |
| 20 Etroplus and others | .. | .. | .. | .. | .. | .. | .. | .. | 106 | 31·00 |
| Total | 1,636 | 2,301·50 | 744 | 1,165·25 | 1,900 | 2,594·75 | 5,962 | 8,389·50 | 48,500 | 89,001·50 |

* Water level in the reservoir.

TABLE 4 (*a*).

*Bhavanisagar fishing—Comparative results in th number and weight of fish landed in five nets with and without floats[e] in May 1964.*

| Date. | Nets without floats and sinkers. | | Nets with floats and sinkers. | |
|---|---|---|---|---|
| | *Number of fish.* | *Weight (in kgs.).* | *Number of fish.* | *Weight (in kgs.)* |
| (1) | (2) | (3) | (4) | (5) |
| 1st May 1964 .. .. .. .. .. .. | 27 | 59·50 | 137 | 248·25 |
| 2nd May 1964 .. .. .. .. .. .. | 54 | 104·00 | 220 | 374·00 |
| 3rd May 1964 .. .. .. .. .. .. | *No data.* | *No data.* | *No data.* | *No data.* |
| 4th May 1964 .. .. .. .. .. .. | 33 | 103·00 | 196 | 442·00 |
| 5th May 1964 .. .. .. .. .. .. | 56 | 103·50 | 222 | 404·00 |
| 6th May 1964 .. .. .. .. .. .. | 40 | 86·00 | 206 | 353·00 |
| 7th May 1964 .. .. .. .. .. .. | 20 | 55·00 | 274 | 252·00 |
| 8th May 1964 .. .. .. .. .. .. | 25 | 95·00 | 91 | 237·00 |
| 9th May 1964 .. .. .. .. .. .. | 41 | 104·00 | 133 | 296·00 |
| 10th May 1964 .. .. .. .. .. .. | 26 | 60·00 | 104 | 231·00 |
| 11th May 1964 .. .. .. .. .. .. | 45 | 93·00 | 179 | 311·00 |
| 12th May 1964 .. .. .. .. .. .. | 81 | 100·00 | 287 | 422·00 |
| 13th May 1964 .. .. .. .. .. .. | 48 | 94·00 | 367 | 338·00 |
| 14th May 1964 .. .. .. .. .. .. | 28 | 80·00 | .. | 369·00 |
| 15th May 1964 .. .. .. .. .. .. | 62 | 169·50 | 215 | 433·00 |
| 16th May 1964 .. .. .. .. .. .. | 58 | 108·00 | 198 | 408·00 |
| 17th May 1964 .. .. .. .. .. .. | 41 | 116·50 | 199 | 640·00 |
| 18th May 1964 .. .. .. .. .. .. | 43 | 162·00 | 204 | 584·00 |
| 19th May 1964 .. .. .. .. .. .. | 46 | 111·50 | 236 | 584·00 |
| 20th May 1964 .. .. .. .. .. .. | 41 | 92·00 | 198 | 378·00 |
| 21st May 1964 .. .. .. .. .. .. | 35 | 78·00 | 155 | 306·00 |
| 22nd May 1964 .. .. .. .. .. .. | 30 | 70·50 | 164 | 306·00 |
| 23rd May 1964 .. .. .. .. .. .. | 42 | 83·50 | 216 | 426·00 |
| 24th May 1964 .. .. .. .. .. .. | 55 | 99·25 | 265 | 505·00 |
| 25th May 1964 .. .. .. .. .. .. | 37 | 82·00 | 183 | 416·00 |
| 26th May 1964 .. .. .. .. .. .. | 43 | 68·60 | 125 | 217·00 |
| 27th May 1964 .. .. .. .. .. .. | 33 | 79·50 | 129 | 283·00 |
| 28th May 1964 .. .. .. .. .. .. | 30 | 60·00 | 122 | 233·00 |
| 29th May 1964 .. .. .. .. .. .. | *No data.* | *No data.* | *No data.* | *No data.* |
| 30th May 1964 .. .. .. .. .. .. | *No data.* | *No data.* | *No data.* | *No data.* |
| 31st May 1964 .. .. .. .. .. .. | 23 | 69·00 | 234 | 410·00 |
| Total .. | 1,143 | 2,586·25 | 5,259 | 10,301·25 |

TABLE 4 (*b*).

*Bhavanisagar fishing—Comparative results in the number and weight of fish landed in five nets with and without floats in May* **1964.**

| Date. | Without floats and frame. | | With floats and frame. | |
|---|---|---|---|---|
| | *Number of fish.* | *Weight (in kgs.).* | *Number of fish.* | *Weight (in kgs.).* |
| (1) | (2) | (3) | (4) | (5) |
| 1st June 1964 .. .. | 70 | 180·00 | 268 | 579·00 |
| 2nd June 1964 .. .. | 53 | 131·00 | 222 | 550·00 |
| 3rd June 1964 .. .. | 62 | 181·00 | 172 | 457·00 |
| 4th June 1964 .. .. | 81 | 129·00 | 227 | 447·00 |
| 5th June 1964 .. .. | 47 | 129·00 | 205 | 437·00 |
| 6th June 1964 .. .. | | *No data.* | 129 | 238·00 |
| 7th June 1964 .. .. | | *No data.* | 74 | 150·00 |
| 8th June 1964 .. .. | | *No data.* | | |
| 9th June 1964 .. .. | | *No data.* | | |
| 10th June 1964 .. .. | 65 | 110·00 | 134 | 249·00 |
| 11th June 1964 .. .. | 61 | 294·00 | 187 | 666·00 |
| 12th June 1964 .. .. | 39 | 116·00 | 156 | 368·00 |
| 13th June 1964 .. .. | 34 | 126·00 | 112 | 335·00 |
| 14th June 1964 .. .. | 23 | 64·00 | 77 | 227·00 |
| 15th June 1964 .. .. | 22 | 88·00 | 100 | 309·00 |
| 16th June 1964 .. .. | 20 | 81·00 | 67 | 249·00 |
| 17th June 1964 .. .. | 42 | 122·00 | 183 | 453·00 |
| 18th June 1964 .. .. | 28 | 118·00 | 90 | 297·00 |
| 19th June 1964 .. .. | 42 | 122·00 | 190 | 470·00 |
| 20th June 1964 .. .. | 39 | 90·00 | 184 | 393·00 |
| 21st June 1964 .. .. | 47 | 111·00 | 193 | 505·00 |
| 22nd June 1964 .. .. | 45 | 93·00 | 161 | 380·00 |
| 23rd June 1964 .. .. | 38 | 89·00 | 200 | 368·00 |
| 24th June 1964 to 30th June 1964 | | *No data.* | | |
| **Total** ... | 858 | 2,374·00 | 3,271 | 8,127·00 |

TABLE 5.

*Fishing in Bhavanisagar—Catch efficiency in relation to number of fish caught and mesh of the nets.*

| Date. | *Macrones aor.* (mesh sizes.) | | | *Wallago attu.* (mesh sizes.) | | | *Catla catla.* (mesh sizes.) | | | *Labeo calbasu and L. fimbriatus.* (mesh sizes.) | | | *Labeo bata.* (mesh sizes.) | | | *Cirrhina mrigala Labeo rohita.* (mesh sizes.) | | | *Labeo kontiu and B. dubius.* (mesh sizes.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2" | 2½" | 4" | 2" | 2½" | 4" | 2" | 2½" | 4" | 2" | 2½" | 4" | 2" | 2½" | 4" | 2" | 2½" | 4" | 2" | 2½" | 4" |
| (1) | (2) | | | (3) | | | (4) | | | (5) | | | (6) | | | (7) | | | (8) | | |
| 15th May 1964 .. .. | .. | 28 | 4 | .. | 7 | 15 | .. | .. | 1 | .. | 3 | 18 | 48 | 7 | 8 | .. | 1 | 2 | 12 | 45 | .. |
| 16th May 1964 .. .. | .. | 16 | .. | .. | 3 | 4 | .. | .. | 1 | .. | 9 | 30 | 30 | 2 | .. | .. | .. | 6 | 15 | 81 | .. |
| 17th May 1964 .. .. | .. | 25 | 13 | .. | 3 | 11 | .. | .. | 5 | .. | 11 | 32 | 32 | 5 | .. | .. | 2 | 8 | 5 | 48 | .. |
| 18th May 1964 .. .. | .. | 31 | 2 | .. | 3 | 9 | .. | .. | 3 | .. | 6 | 21 | 25 | .. | .. | .. | .. | 3 | 15 | 52 | 14 |
| 19th May 1964 .. .. | .. | 32 | 8 | .. | 3 | 18 | .. | .. | 3 | .. | 5 | 28 | 41 | 2 | .. | .. | .. | 4 | 20 | 60 | 12 |
| 20th May 1964 .. .. | .. | 28 | 3 | .. | 3 | 6 | .. | .. | 1 | .. | 2 | 16 | 34 | .. | .. | .. | 2 | 5 | 5 | 81 | 11 |
| 21st May 1964 .. .. | 3 | 28 | 5 | .. | 2 | 6 | .. | .. | 1 | .. | 4 | 8 | .. | .. | .. | .. | 1 | 7 | 12 | 65 | 7 |

TABLE 6.

*Bhavanisagar Fishing—Species and number of fish landed in low level condition (+844·96).*

Total Number of days fished.—6.

Total Units employed.—6.

Number of nets of each unit.—Catla (*a*) =10 × 50 metres.

(*b*) =5 × 65 metres.

Rangoon nets = 5 × 35 metres.

| *Date.* | | | *Barbus dubius.* | | *Catla catla.* | | *Labeo rohita.* | | *Cirrhina mrigala.* | | *Wallagonia attu.* | | *Mystus aor and Mystus Seenghala.* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* |
| (1) | | | (2) | | (3) | | (4) | | (5) | | (6) | | (7) | |
| 25th April 1964 | .. | .. | 22 | 31·50 | 18 | 292·00 | 3 | 35·00 | 13 | 92·00 | 10 | 59·00 | 37 | 92·00 |
| 26th April 1964 | .. | .. | 16 | 37·00 | 14 | 281·00 | 4 | 40·00 | 7 | 56·00 | 16 | 125·00 | 35 | 77·00 |
| 27th April 1964 | .. | .. | 31 | 35·00 | 6 | 101·00 | 5 | 60·00 | 6 | 43·00 | 12 | 33·00 | 60 | 92·50 |
| 28th April 1964 | .. | .. | 46 | 61·00 | 4 | 69·00 | 1 | 12·00 | 8 | 57·00 | 12 | 31·00 | 62 | 12·00 |
| 29th April 1964 | .. | .. | 61 | 59·00 | .. | .. | .. | .. | 1 | 4·00 | 12 | 32·50 | 64 | 109·50 |
| 30th April 1964 | .. | .. | 80 | 100·00 | 6 | 97·00 | 4 | 49·00 | 2 | 18·50 | 17 | 52·00 | 49 | 98·00 |

| (1)—*Cont.* | *Labeo ariza.* | | *Other Barbus species.* | | *Miscellaneous.* | | *Labeo kontius.* | | *Labeo calbasu.* | | *Labeo fimbriatus.* | | *Total.* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* |
| | (8) | | (9) | | (10) | | (11) | | (12) | | (13) | | (14) | |
| 25th April 1964 | 70 | 95·00 | 4 | 10·50 | 1 | 2·50 | 22 | 33·50 | 56 | 229·00 | 15 | 64·00 | 270 | 1,036·00 |
| 26th April 1964 | 56 | 64·00 | 2 | 5·00 | .. | .. | 10 | 17·00 | 65 | 239·00 | 8 | 31·00 | 233 | 972·00 |
| 27th April 1964 | 80 | 60·50 | 74 | 49·00 | 9 | 17·00 | 7 | 6·50 | 41 | 156·00 | 17 | 68·00 | 348 | 721·50 |
| 28th April 1964 | 122 | 91·00 | 29 | 55·00 | 5 | 13·00 | 14 | 13·00 | 42 | 160·50 | 20 | 78·50 | 365 | 753·00 |
| 29th April 1964 | 71 | 54·50 | 96 | 56·00 | .. | .. | .. | .. | 7 | 28·00 | 4 | 14·00 | 316 | 357·50 |
| 30th April 1964 | 46 | 32·00 | 42 | 32·00 | .. | .. | 20 | 14·50 | 23 | 84·00 | 2 | 5·50 | 291 | 582·50 |
| | | | | | | | | | | | | | 1,823 | 4,422·50 |

TABLE 7.

*Bhavani sagar Fishing—Species and number of fish landed in F. R. L.* (915+60) *in the same place as Table 6—Area drained by Bhavanisagar.*

Rangoon nets=15×35 metres.

4" Catla nets=5×60 meters.

| Date. | *Catla catla.* | | *Wallago attu.* | | *Labeo calbasu.* | | *Labeo ariza.* | | *Labeo rohita.* | | *Mystus aor and Mystus senghala.* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* |
| (1) | (2) | | (3) | | (4) | | (5) | | (6) | | (7) | |
| 15th December 1964 .. | 1 | 12·50 | 12 | 82·50 | 2 | 7·50 | 87 | 57·50 | .. | .. | 56 | 92·50 |
| 16th December 1964 .. | 5 | 46·00 | 8 | 63·50 | 19 | 54·50 | 46 | 52·50 | .. | .. | 48 | 85·00 |
| 17th December 1964 .. | 1 | 21·00 | 9 | 60·00 | 16 | 37·00 | 98 | 70·50 | .. | .. | 60 | 103·00 |
| 18th December 1964 .. | 5 | 78·50 | 2 | 24·00 | 9 | 26·00 | 38 | 33·50 | .. | .. | 35 | 60·00 |
| 19th December 1964 .. | 1 | 23·50 | 3 | 7·50 | 8 | 26·00 | 62 | 38·50 | .. | .. | 46 | 64·50 |
| 20th December 1964 .. | 3 | 53·00 | 4 | 17·50 | 7 | 20·00 | 58 | 33·50 | 1 | 8·00 | 53 | 94·00 |
| 21st December 1964 .. | 6 | 108·25 | 6 | 39·00 | 13 | 28·75 | 58 | 34·75 | .. | .. | 37 | 65·50 |

| (1)—*Cont.* | *Barbus dubius.* | | *Other barbus species.* | | *Cirina mrigala.* | | *Labeo kontius.* | | *Labeo Fimbriatus.* | | *Total.* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* |
| | (8) | | (9) | | (10) | | (11) | | (12) | | (13) | |
| 15th December 1964 .. | 43 | 45·00 | 1 | 0·50 | 8 | 16·00 | 7 | 5·00 | 2 | 6·00 | 219 | 325·00 |
| 16th December 1964 .. | 147 | 113·25 | .. | .. | .. | .. | 12 | 10·25 | 6 | 11·00 | 291 | 435·50 |
| 17th December 1964 .. | 89 | 74·00 | .. | .. | 1 | 8·00 | 13 | 11·00 | 3 | 10·50 | 290 | 395·00 |
| 18th December 1964 .. | 60 | 47·00 | .. | .. | .. | .. | 10 | 9·25 | .. | .. | 159 | 278·25 |
| 19th December 1964 .. | 67 | 54·00 | .. | .. | .. | .. | 24 | 17·75 | .. | .. | 211 | 231·75 |
| 20th December 1964 .. | 138 | 130·50 | 2 | 2·75 | .. | .. | 13 | 12·75 | .. | .. | 279 | 345·00 |
| 21st December 1964 .. | 135 | 126·50 | 14 | 10·75 | 1 | 6·50 | 13 | 9·50 | .. | .. | 283 | 429·00 |
| | | | | | | | | | | Total .. | 1,732 | 2,439·50 |

TABLE 8.

*Bhavanisagar fishing—Species and number of fish landed under 916 level—Area drained by Moyar.*

| Date. | *Barbus dubius.* | | *Mystus aor.* | | *Wallago attu.* | | *Labeo calbasu.* | | *Labeo ariza.* | | *Labeo fimbriatus.* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* |
| (1) | (2) | | (3) | | (4) | | (5) | | (6) | | (7) | |
| 1st January 1965 .. .. | 38 | 31·25 | 42 | 56·75 | 9 | 17·50 | 26 | 51·50 | 16 | 10·00 | 2 | 6·00 |
| 2nd January 1965 .. .. | 26 | 27·75 | 31 | 45·00 | 1 | 5·00 | 15 | 35·00 | 8 | 6·00 | .. | .. |
| 3rd January 1965 .. .. | 52 | 53·00 | 35 | .. | 2 | 10·00 | 6 | 13·00 | 2 | 5·50 | .. | .. |
| 4th January 1965 .. .. | 73 | 73·00 | 30 | 45·25 | 4 | 8·00 | 6 | 14·00 | 21 | 16·00 | .. | .. |
| 5th January 1695 .. .. | 59 | 73·50 | 14 | 39·25 | 2 | 6·25 | 10 | 34·00 | 42 | 32·00 | .. | .. |
| 6th January 1965 .. .. | 50 | 53·00 | 35 | 73·75 | 8 | 10·50 | 3 | 9·00 | 31 | 23·50 | .. | .. |

| (1)—*Cont.* | *Cirrhina mrigala.* | | *Labeo rohita.* | | *Catla catla.* | | *Labeo kontius.* | | *Other barbus species.* | | *Miscellaneous.* | | *Total.* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* |
| | (8) | | (9) | | (10) | | (11) | | (12) | | (13) | | (14) | |
| 1st January 1965 | .. | .. | .. | .. | 8 | 6·25 | 1 | 1·00 | 1 | 2·15 | 123 | 163·00 | 266 | 343·50 |
| 2nd January 1965 | .. | .. | .. | .. | 6 | 4·00 | 1 | 0·50 | .. | .. | 89 | 124·50 | 176 | 247·75 |
| 3rd January 1965 | 1 | 1·75 | .. | .. | 6 | 600 | 2 | 1·75 | 2 | 4·00 | 108 | 155·25 | 215 | 250.25 |
| 4th January 1965 | .. | .. | .. | .. | 4 | 3·50 | 2 | 1·50 | .. | .. | 140 | 161·25 | 280 | 322·50 |
| 5th January 1965 | 1 | 5·75 | .. | .. | 1 | 1·25 | 2 | 2·50 | 1 | 4·50 | 132 | 199·00 | 264 | 398·00 |
| 6th January 1965 | .. | .. | .. | .. | 5 | 9·00 | .. | .. | .. | .. | 132 | 183·75 | 264 | 371·00 |
| | | | | | | | | | | | | Total .. | 1,465 | 1,933·00 |

# A STUDY OF THE QUALITY OF DRIED WHITE BAITS IN THE TRADE

BY

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## Introduction

About 30,000 to 40,000 tonnes of white baits (Anchoviella sp.) are landed annualy in India, forming about 2·5 to 4 per cent of the total fish landings in the country. They occur in shoals from June to January every year (Devanesan and Chidambaram, 1953) and is mostly concentrated on the coasts of Kerala, Madras and Andhra States. White baits are highly valued in Ceylon, Burma and other South East Asian countries and most of the landings in our country are simply dried on the beach and exported to these countries. Approximately about 7,000 to 10,000 tonnes of dried spratts (white baits) are being exported annually from the Tuticorin port and this variety alone accounts for nearly 60 per cent of the total exports of dried fish from this port. However the quality of the dried white baits in the trade is in general found to be far from satisfactory, chiefly due to heavy admixture of sand and improper drying. It is very essential to prescribe and maintin certain standards of quality for the dried spratts (white baits), to retain the existing export markets and also to capture new markets. The Indian Standards Institution has taken up the work of drafting specifications for this dried fish product and has entrusted the work to the Fisheries Technological Station, Tuticorin. In the course of this work, a study of the quality of the dried spratts (white baits) in the trade was done by the present authors and the results of this study are embodied in this paper.

## Materials and methods

The trade samples of dried spratts (white baits) were collected from the various dried fish godowns at Tuticorin and from the Fish Curing Yards in Kanyakumari district and the history of each sample, i.e., the place and date of catch and the methods of processing were ascertained from the fishermen and fish merchants. The samples were immediately examined for their size (length and breadth) and count per 100 gm. and organoleptic characteristics like moisture, sodium chloride and acid insoluble ash were also estimated in each sample according to A.O.A.C. methods of analysis (1945). The T.V.N. was also determined by Conway's Method (1947).

With a view to find out the scope for improving the quality of the product, dried white baits were also prepared by the authors from fresh white baits after thorough washing in clean sea water and drying the fish on palmyrah mats in the sun. The drying was also tried on the beach sand as practised by the fishermen to know the effect of washing only. The products so obtained were also tested as detailed above for their organoleptic and chemical characteristics and compared with the trade samples.

*Results*

The results of analysis of 80 samples of dried white baits from the trade are shown in Table I. A study of the table would reveal the following:—

*Size.*—The length of the dried white baits ranged from 4·3 to 7·3 cms. and breadth from 0·57 to 1·3 cms. 76 per cent of the trade samples were of 6·0 to 7·0 cms. group, 14 per cent were of 5 to 6 cms. group, 8 per cent were above 7 cms. in length and 2 per cent were below 5 cms.

*Count.*—For grading purpose, the trade samples were also examined by counting the number of dried white baits in 100 gms. of each sample. The counts ranged from 74 to 396/100 gm. 95 per cent of the samples had counts below 200 and may be classified as large size. Five per cent had counts about 200 and may be graded as small.

*Organoleptic characteristics.*—About 70 per cent of the trade samples had good or normal light grey appearance. Only about 8 per cent of the samples were soft in texture, the rest being hard or medium hard. Flavour was poor in 16 percent of the samples and in 34 per cent of the samples, the odour was ammoniacal or pungent. Surface moisture was also noticed in 34 per cent of the samples. Only about 7·5 per cent of the trade samples had fungal attack.

*Chemical characteristics.*—The maximum and minimum ranges and the percentage of trade samples found in each range group of the various chemical characteristics like moisture, NaCl, acid insolubles and T.V.N. are summarised below :—

MOISTURE.

*Minimum*—11·3 per cent. *Maximum*—31·01 per cent.

| *Range groups.* | | *Per cent of trade samples.* |
|---|---|---|
| Below 10 per cent | .. | Nil. |
| 10·1 to 15·0 per cent | .. | 21·96 |
| 15·1 to 20·0 per cent | .. | 47·56 |
| 20·1 to 25·0 per cent | .. | 18·29 |
| Above 25 per cent | .. | 12·19 |

SODIUM CHLORIDE.

*Minimum*—0·34 per cent. *Maximum*—3·66 per cent.

| *Range groups.* | | *Per cent of trade samples.* |
|---|---|---|
| Below 1 per cent .. | .. | 14·63 |
| 1·1 to 2 per cent | .. | 57·32 |
| More than 2 per cent | .. | 28·05 |

ACID INSOLUBLES.

*Minimum*—4·3 per cent. *Maximum*—29·58 per cent.

| *Range groups.* | *Per cent of trade samples.* |
|---|---|
| Below 7 per cent .. .. .. .. | 12·20 |
| 7·1 to 10·0 per cent .. .. .. | 18·29 |
| 10·1 to 12·0 per cent .. .. .. | 17·07 |
| 12·1 to 15·0 per cent .. .. .. | 26·83 |
| 15·1 to 20·0 per cent .. .. .. | 14·63 |
| Above 20 per cent .. .. .. | 10·98 |

T.V.N. MG/100GM.

*Minimum*—64. *Maximum*—840.

| *Range groups.* | PER CENT. |
|---|---|
| Less than 20 .. .. .. .. | 45·5 |
| Between 200 and 300 .. .. .. | 31·03 |
| Above 300 .. .. .. .. | 23·47 |

The results of analysis of the samples prepared by the authors are shown in Table II. By washing the fish in clean sea water and drying on beach sand as practised in the trade, the acid insolubles were found to be 5·73 per cent and this could be brought down to 2·54 per cent by drying the fish on mats. The moisture ranged from 13·53 to 14·45 per cent and the T.V.N. from 32·0 to 54·0 mg./100 gm. The products were very attractive in appearance and had fresh flavour and good odour.

**Discussions**

George (1958) has described seven species of anchoviella (white baits) recorded from Indian waters. Out of these 3 species, namely, Anchoviella indica, A. Commersoni and A. tri. are known to be of commercial importance. The white baits are extensively sun-dried as this kind of curing seems to have a better effect on the taste of this fish. Only rarely in the rainy weather in Kerala State, they are salted. The present method of preparation of dried white baits in the trade consists of simply drying the fish catches in the sun on the beach sand without any washing or addition of salt for a day or two and then packing the dried fish in palmyrah mats in bundles of one Cwt. capacity. As the transactions are by weight the tendency in the trade is to pack the products without sufficient drying. It is also held by the trade that much dried products result in breakage of the whole fish and the product losses its market value. As much as 78·04 per cent of the trade samples had moisture above 15 per cent and 30·48 per cent of the samples had moisture above 20 per cent. This high percentage of moisture in the unsalted dried white baits accounts for its present low storage life. It may be possible to improve the shelf life of the product considerably if the product is dried to 15 per cent moisture level. In such perfect dried products, a good portion of the adhering sand particles may also fall off, yielding a product of better quality. It has however to be studied how far this dryage will increase the breakage and the optimum moisture level has to be worked out with reference to least breakage and maximum shelf life possible. Further studies are in progress in this direction.

The chief defect in the product is heavy admixture of sand during the drying process. The Acid insolubles ranged from 4·3 to 29·58 per cent in the trade samples. Only 12·2 per cent the trade samples contained acid insolubles less than 7 per cent and 69·51 per cent of the samples had more than 10 per cent of acid insolubles. As stated by Krishna Pillai et. al. (1956) this condition is due to the present unsatisfactory method of drying on open beach wherein a good amount of sand is blown into the product by wind. By properly washing the fish in clean sea water and by drying the fish over mats, the authors showed that the acid insolubles could be brought down to as low as 2·54 per cent. The trade would do well and produce better quality products by drying the fish over palmyrah mats on raised platforms instead of on beach sand.

No salt is added at present in the preparation of the product and the salt content varied from 0·34 per cent to 3·66 per cent in the trade samples. The absence of salt coupled with high moisture content account for low storage life of the product which becomes dark in colour and crumbles to pieceswith in a month. Venkataraman and Vasavan (1959) have shown that samples of salted white bait remained in good condition for two months without any attack of "red" or moulds. In fact salting of white baits is resorted to in Kerala State in wet weather and Venkataraman and Vasavan (1956) suggested a proportion of one part of salt for six parts of fish for salt curing medium sized white baits for best quality products.

In sun-dried fish products, the T. V. N. was found to vary from 50 to 300 mg./100 gm. of the product by Pillai. et. al. (1956). In our study, the T.V.N. of dried white baits in the trade ranged from 64 to 560 mg./100 gm. According to Venkataraman and Vasavan (1959), samples of salted fish in the initial stages of spoilage had a T.V.Ns. value of 200 mg./100 gm. From this standard only 45·5 per cent of the trade samples of dried white baits can be said to have not spoiled.

*Summary.*

A study of the quality of the dried white baits in the trade was done in view of the commercial importance of the product in the export as well as internal markets. The product is prepared by merely drying the whole fish on the beach, without any addition of salt. A good portion of the trade samples ranged in length from 6 cms. to 7 cms. had 'Counts' of below 200/100 gm. and can be classified as "Large size." The rest of the samples which had 'Counts' above 200/100 gm. may be graded as "small". About 70 per cent of the trade samples were normal in appearance, 8 per cent of the samples soft in texture, 34 per cent of the samples ammociacal or pungent in odour and 7·5 per cent of the samples had fungal attack. Moisture ranged from 11 · 3 per cent to 31·01 per cent and 78·04 per cent of the trade samples had moisture above 15 per cent, this high percentage of moisture probably

accounting for the low storage life of this unsalted product. Another chief defect in the product was found to be heavy admixture of sand, the acid insolubles ranging from 4·3 to 29·58 per cent in the trade samples, 77·80 per cent of which had acid insolubles more than 7 per cent. Experiments by the authors showed that the acid insolubles could be brought down to 2·54 per cent by properly cleaning the fish in clean sea water and by drying the fish over palmyrah mats.

*Acknowledgments.*

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TABLE I.

*Showing the analytical data of dried white baits in the Trade.*

| Serial number and place of catch. | Method of drying. | Average size. Length in cm. | Average size. Breadth in cm. | Count per 100 gm. | Appearance. | Texture. | Flavour. | Odour. | Surface Moisture. | Fungal attack. | H2 per cent. | Moisture free basis. Nacl. per cent. | Moisture free basis. Acid Insol. per cent. | T.V.N mg./100 gm. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) |
| 1 Thanjavur district .. | Dried without salt in open beach. | 6·8 | 1·1 | 134 | Normal. | Hard. | Fresh. | Fresh cured. | Dry. | Nil. | 14·63 | 1·63 | 11·69 | 64 |
| 2 Pondicherry .. .. | Do. | 6·1 | 0·7 | 148 | Do. | Do. | Good | Pungent | Do. | Do. | 12·8 | 0·97 | 12·28 | 208 |
| 3 Thanjavur district .. | Do. | 4·3 | 0·57 | 396 | Do. | Do. | Fair | Fresh. | Do. | Do. | 13·46 | 1·68 | 12·81 | 64 |
| 4 Do. .. .. | Do. | 5·4 | 0·8 | 228 | Do. | Do. | Good. | Do. | Do. | Do. | 13·8 | 1·84 | 14·86 | 80 |
| 5 Do. .. .. | Do. | 6·1 | 1·0 | 154 | Do. | Med. Hard | Do. | Do. | Sl. moist | Do. | 18·32 | 1·22 | 22·45 | 120 |
| 6 Kanyakumari district. | Do. | 6·4 | 1·1 | 140 | Do. | Hard. | Do. | Pungent | Dry | Do. | 13·6 | 1·2 | 13·4 | 220 |
| 7 Do. .. .. | Do. | 5·5 | 0·9 | 138 | Do. | Do. | Do. | Fresh. | Do. | Do. | 14·28 | 0·96 | 12·44 | 72 |
| 8 Do. .. .. | Do. | 6·4 | 1·0 | 136 | Do. | Do. | Do. | Do. | Do. | Do. | 15·4 | 0·7 | 8·59 | 64 |
| 9 Thanjavur district .. | Do. | 6·0 | 1·0 | 164 | Do. | Do. | Do. | Do. | Do. | Do. | 13·47 | 0·34 | 14·96 | 96 |
| 10 Do. .. .. | Do. | 5·8 | 1·0 | 170 | Do. | Do. | Do. | Do. | Do. | Do. | 13·49 | 0·95 | 11·04 | 120 |
| 11 Do. .. .. | Do. | 6·4 | 1·1 | 144 | Do. | Do. | Do. | Do. | Do. | Do. | 14·46 | 0·93 | 16·4 | 112 |
| 12 Pondicherry .. .. | Do. | 5·3 | 0·9 | 238 | Do. | Do. | Do. | Do. | Do. | Do. | 11·36 | 2·19 | 7·73 | 144 |
| 13 Thanjavur district .. | Do. | 6·4 | 1·0 | 164 | Do. | Do. | Do. | Do. | Do. | Do. | 11·94 | 1·12 | 7·4 | 156 |
| 14 Kanyakumari district | Do. | 6·7 | 1·0 | 94 | Do. | Med.Hard | Do. | Fair | Do. | Do. | 14·91 | 1·24 | 11·11 | 200 |
| 15 Do. .. .. | Do. | 6·8 | 1·1 | 106 | Do. | Do. | Do. | Do. | Do. | Do. | 14·62 | 1·10 | 12·4 | 176 |
| 16 Do. .. .. | Do. | 6·1 | 0·9 | 152 | Do. | Do. | Do. | Fresh | Do. | Do. | 14·65 | 0·9 | 10·8 | 144 |
| 17 Thanjavur district.. | Do. | 5·9 | 1·1 | 160 | Do. | Do. | Do. | Sl. moist. | Sl.moist. | Do. | 18·36 | 1·78 | 11·87 | 256 |
| 18 Do. .. .. | Do. | 6·2 | 1·0 | 138 | Do. | Do. | Do. | Fresh | Do. | Do. | 19·25 | 1·55 | 4·56 | 324 |
| 19 Do. .. .. | Do. | 6·4 | 1·0 | 135 | Do. | Do. | Do. | Good | Do. | Do. | 17·53 | 1·6 | 7·7 | 238 |
| 20 Do. .. .. | Do. | 6·5 | 1·1 | 136 | Dark | Sl. soft. | Fair | Fair | Do. | Do. | 11·73 | 0·66 | 24·51 | 186 |
| 21 Do. .. .. | Do. | 7·2 | 1·2 | 108 | Normal | Med.Hard. | Fresh | Good | Dry | Do. | 11·34 | 0·68 | 7·28 | 256 |
| 22 Kanyakumari district. | Do. | 6·6 | 1·1 | 132 | Do. | Hard | Do. | Do. | Do. | Do. | 15·87 | 1·00 | 8·77 | 372 |
| 23 Do. .. .. | Do. | 7·2 | 1·2 | 74 | Do. | Do. | Do. | Do. | Do. | Do. | 15·78 | 1·25 | 7·88 | 164 |
| 24 Do. .. .. | Do. | 6·8 | 1·3 | 100 | Grey | Do. | Good | Do. | Do. | Do. | 15·16 | 1·1 | 12·82 | 230 |
| 25 Do. .. .. | Do. | 6·0 | 1·2 | 100 | Normal | Sl.soft | Do. | Do. | Sl.soft. | Do. | 23·81 | 1·13 | 10·9 | 164 |
| 26 Do. .. .. | Do. | 5·4 | 1·1 | 160 | Do. | Med. hard. | Fresh | Do. | Do. | Do. | 18·33 | 1·43 | 14·71 | 240 |
| 27 Do. .. .. | Do. | 7·1 | 1·1 | 110 | Do. | Do. | Do. | Do. | Do. | Do. | 18·96 | 1·28 | 9·09 | 320 |
| 28 Do. .. .. | Do. | 6·6 | 0·9 | 130 | Normal | Med. Hard. | Good | Good | Dry | Do. | 16·05 | 1·42 | 10·0 | .. |
| 29 Do. .. .. | Do. | 6·8 | 1·1 | 115 | Do. | Hard | Fresh | Do. | Do. | Do. | 15·98 | 0·79 | 7·19 | .. |
| 30 Do. .. .. | Do. | 6·6 | 1·2 | 128 | Grey | Do. | Do. | Do. | Do. | Do. | 15·74 | 1·34 | 11·77 | .. |
| 31 Do. .. .. | Do. | 6·2 | 1·1 | 138 | Ash | Med. hard. | Do. | Do. | Sl. moist. | Do. | 17·25 | 1·22 | 16·56 | .. |
| 32 Do. .. .. | Do. | 6·3 | 1·1 | 128 | Normal | Hard | Do. | Do. | Dry | Do. | 12·35 | 1·29 | 15·85 | .. |
| 33 Do. .. .. | Do. | 6·6 | 1·1 | 128 | Do. | Med. hard. | Do. | Fair | Sl. moist. | Do. | 19·38 | 1·26 | 5·45 | .. |
| 34 Do. .. .. | Do. | 6·5 | 1·0 | 140 | Grey | Hard | Do. | Good | Dry | Do. | 16·62 | 1·39 | 8·87 | .. |
| 35 Do. .. .. | Do. | 6·5 | 1·1 | 128 | Normal | Med. hard. | Do. | Fair | Sl. moist. | Do. | 22·74 | 1·35 | 4·93 | .. |
| 36 Do. .. .. | Do. | 6·5 | 1·1 | 126 | Do. | Do. | Fair | Do. | Do. | Do. | 22·55 | 1·48 | 14·5 | .. |
| 37 Do. .. .. | Do. | 6·4 | 1·1 | 130 | Do. | Do. | Fresh | Good | Moist | Do. | 20·76 | 1·09 | 12·28 | .. |
| 38 Do. .. .. | Do. | 6·2 | 1·1 | 140 | Do. | Hard | Do. | Do. | Dry | Do. | 15·98 | 1·38 | 7·35 | .. |
| 39 Do. .. .. | Do. | 6·6 | 0·9 | 130 | Grey | Med. hard. | Do. | Do. | Sl. moist. | Do. | 17·49 | 1·84 | 10·15 | .. |
| 40 Do. .. .. | Do. | 6·2 | 1·1 | 138 | Normal | Hard | Do. | Do. | Do. | Do. | 16·46 | 1·43 | 13·46 | .. |
| 41 Do. .. .. | Do. | 6·5 | 1·0 | 140 | Ash grey | Med. hard. | Good | Good | Do. | Do. | 18·25 | 0·72 | 6·9 | .. |
| 42 Do. .. .. | Do. | 6·5 | 1·1 | 136 | Normal | Do. | Fresh | Do. | Do. | Do. | 19·08 | 1·09 | 13·93 | .. |
| 43 Do. .. .. | Do. | 6·0 | 1·2 | 140 | Gray | Do. | Do. | Do. | Do. | Do. | 16·52 | 1·47 | 20·15 | .. |
| 44 Do. .. .. | Do. | 6·8 | 1·3 | 100 | Ash grey | Do. | Do. | Do. | Moist | Do. | 21·37 | 1·65 | 11·61 | .. |
| 45 Do. .. .. | Do. | 6·5 | 1·1 | 136 | Grey | Do. | Do. | Do. | Do. | Do. | 19·17 | 0·82 | 4·76 | .. |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 46 | Do. | Do. | 6·4 | 1·1 | 145 | Normal | Do. | Good | Good | Sl. moist. | Do. | 18·9 | 1·8 | 7·78 | .. |
| 47 | Do. | Do. | 6·7 | 1·1 | 94 | Grey | Do. | Fresh | Do. | Do. | Do. | 19·15 | 2·08 | 10·15 | .. |
| 48 | Do. | Do. | 6·1 | 0·9 | 148 | Normal | Do. | Do. | Do. | Do. | Do. | 19·15 | 0·95 | 15·43 | .. |
| 49 | Do. | Do. | .. | .. | 136 | Poor | Hard | Poor | Ammoniacal. | Do. | Do. | 24·52 | 2·91 | 17·12 | 315 |
| 50 | Do. | Do. | .. | .. | 128 | Fair | Do. | Fair | Fresh | Dried. | Do. | 13·13 | 2·91 | 18·78 | 210 |
| 51 | Do. | Do. | .. | .. | 100 | Poor | Do. | Good | Ammoniacal. | Do. | Do. | 30·99 | 3·66 | 10·44 | 266 |
| 52 | Do. | Do. | .. | .. | 96 | Good | Do. | Do. | Fresh | Do. | Do. | 30·73 | 2·81 | 20·45 | 133 |
| 53 | Do. | Do. | .. | .. | 122 | Poor | Med. hard | Poor | Ammoniacal. | Do. | Do. | 25·77 | 3·16 | 15·26 | 245 |
| 54 | Do. | Do. | .. | .. | 98 | Good | Do. | Fair | Sl. Ammoniacal. | Do. | Do. | 27·44 | 2·89 | 29·58 | 189 |
| 55 | Do. | Do. | .. | .. | 85 | Fair | Do. | Do. | Do. | Do. | Do. | 24·76 | 1·47 | 10·49 | 105 |
| 56 | Do. | Do. | .. | .. | 105 | Good. | Do. | Do. | Do. | Do. | Do. | 29·60 | 2·17 | 6·58 | 70 |
| 57 | Do. | Do. | .. | .. | 130 | Poor | Soft | Poor | Putrid | Do. | Do. | 31·01 | 1·8 | 11·83 | 224 |
| 58 | Do. | Do. | .. | .. | 100 | Fair | Med. hard. | Fair | Strongly ammoniacal. | Do. | Do. | 17·41 | 1·85 | 22.38 | 840 |
| 59 | Do. | Do. | .. | .. | 142 | Poor | Hard | Poor | Putrid | Do. | Do. | 15·29 | 1·99 | 12·69 | 210 |
| 60 | Do. | Do. | .. | .. | 130 | Good | Med. hard. | Good | Fresh dried. | Do. | Do. | 15·44 | 2·21 | 12·21 | 140 |
| 61 | Do. | Do. | .. | .. | 175 | Poor | Hard. | Poor. | Ammoniacal. | Nil. | Nil. | 16·60 | 2·32 | 12·31 | 560 |
| 62 | Do. | Do. | .. | .. | 74 | Do. | Med. hard | Fair. | Putrid. | Do. | Do. | 16·70 | 1·87 | 10·70 | 420 |
| 63 | Do. | Do. | .. | .. | 150 | Do. | Soft | Poor. | Stinking. | Present. | Do. | 15·32 | 2·37 | 9·72 | 490 |
| 64 | Do. | Do. | .. | .. | 108 | V. Poor | Med. hard. | Do. | Do. | Do. | Do. | 21·54 | 2·10 | 16·09 | 700 |
| 65 | Do. | Do. | .. | .. | 146 | Fair. | Hard. | Do. | Ammoniacal. | Nil. | Do. | 18·18 | 2·05 | 14·81 | 350 |
| 66 | Do. | Do. | .. | .. | 142 | Do. | Do. | Fair. | Stinking. | Do. | Do. | 16·89 | 2·08 | 14·55 | 175 |
| 67 | Do. | Do. | .. | .. | 124 | V. Poor. | Soft. | Poor. | Ammoniacal. | Do. | Do. | 20·96 | 1·94 | 18·91 | 420 |
| 68 | Do. | Do. | .. | .. | 147 | Poor. | Med. hard. | Do. | Do. | Slight. | Sl. | 24·19 | 2·11 | 23·16 | 280 |
| 69 | Do. | Do. | .. | .. | 128 | Do. | Soft. | Do. | Strongly ammoniacal. | Present. | Nil. | 34·08 | 1·97 | 20·69 | 210 |
| 70 | Do. | Do. | .. | .. | 152 | Fair. | Hard. | Do. | Ammoniacal. | Nil. | Do. | 17·79 | 2·36 | 13·92 | 315 |
| 71 | Do. | Do. | .. | .. | 340 | Poor. | Do. | Do. | Do. | Do. | Do. | 21·35 | 2·29 | 19·53 | 175 |
| 72 | Mangalore | Do. | .. | .. | 142 | Fair. | Do. | Fair. | Sl. ammoniacal. | Do. | Do. | 25·02 | 2·02 | 22·03 | 140 |
| 73 | Trivandrum | Do. | .. | .. | 132 | Do. | Do. | Do. | Do. | Do. | Do. | 17·61 | 2·63 | 7·62 | 280 |
| 74 | Kanyakumari district. | Do. | .. | .. | 133 | Good. | Do. | Do. | Do. | Do. | Sl. | 18·42 | 1·87 | 5·73 | 210 |
| 75 | Alleppey | Do. | .. | .. | 115 | Do. | Do. | Good. | Fresh dried. | Do. | Nil. | 21·98 | 2·52 | 12·32 | 140 |
| 76 | Trivandrum | Do. | .. | .. | 135 | Do. | Do. | Fair. | Sl. ammoniacal. | Do. | Sl. | 22·90 | 2·52 | 17·30 | 105 |
| 77 | Do. | Do. | .. | .. | 132 | Do. | Do. | Good. | Do. | Do. | Do. | 24·06 | 2·60 | 14·96 | 350 |
| 78 | Kanyakumari district. | Do. | .. | .. | 160 | Do. | Med. Hard. | Fair | Ammoniacal. | Do | Nil. | 19·04 | 1·63 | 6·88 | 210 |
| 79 | Do. | Do. | .. | .. | 150 | Fair. | Hard. | Fair. | Do. | Do. | Present. | 18·46 | 1·83 | 12·82 | 315 |
| 80 | Do. | Do. | .. | .. | 155 | Do. | Med. hard. | Fair. | Sl. ammoniacal. | Do. | Do. | 26·74 | 1·89 | 27·70 | 175 |

TABLE II.

*Showing the analytical data of dried white baits prepared.*

| *Experiment number.* | *Place of catch.* | *Particulars.* | *Average in size.* | | *Count. per 100 gm.* | *Appearance.* | *Texture.* | *Flavour.* | *Odour.* | *Surface moisture.* | *Fungal attack.* | *Moisture.* | *H2° free basis.* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | *Length. in cm.* | *Breadth. in cm.* | | | | | | | | | *Nacl.* | *Acid. insol.* | *TV.B. (N) mg./ 100 gm.* |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) |
| 1 | Kanyakumari district. | Dried on the mat without salt. | 5·7 | 1·0 | 174 | Fresh grey. | Hard | Fresh | Good | Dry | Nil. | 14·45 | 1·95 | 2·54 | 32·0 |
| 2 | Do. | Dried on the sand without salt. | 6·4 | 1·0 | 152 | Ash grey. | Do. | Do. | Do. | Do. | Do. | 13·53 | 1·18 | 5·73 | 54·0 |

# THE EFFECT OF EPIPHYTIC ALGAE ON THE CARBON ASSIMILATION BY NAJAS GRAMINEA DEL

BY

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It was frequently noticed that aquatic plants, especially *Najas graminea Del.*, that were growing in cisterns had some slimy substances, on the surface of the leaf, stem, etc. These slimy substances occurred in a dense clump completely covering the leaf surface. A slow and regular death rate was observed many times in the experimental cisterns kept in this Research Station. The colour of those slimy material changed gradually from white to Brown. The slimy materials were examined under Miscroscope and indentified as forms belonging to *Chlorophyceae*, *Cynophyceae* and *Bacillariophyceae*.

It was believed that the epiphytic algae that occur on *Najas graminea Del*[1] have a retrading effect on the carbon assimilation of that plant and thereby ultimately leading to the death of the plant slowly. The following forms were found to occur on the leaves and stem of *Najas graminea Del*:—

*Cyanophyceae*—

1 *Oscillatoria Limosa* Ag. ex. Gamont.
2 *O. subbrevis schmidte.*
3 *Nostoc carneum* Ag. (Geitler).
4 *Crucigenia aniculata* (Lemn.) schm.
5 *Microcystis ramosa*—Bhardw.
6 *Merismopedia tenuissima* Lonm.
7 *Anabena orientalis* Dixit.
8 *Nostoc punctiformae* (Kutz) var popularum (Geitler).
9 *Phormidium ambiguum* Gomont.
10 *Schizothrix friesii* (Ag.) com.
11 *Rhaphidiopsis curvata* Fritsch and Rich.

*Chlorophycese*—

12 *Chloroccoccum humicola* Rab.
13 *Closterium lunnula* (Mull) Nitzsch.
14 *Cosmarium subhumidum* Nordst.
15 *Oedogonium humidulum* Kutz.

*Becillariophyceae*—

16 *Cymbelia hustedtti* Krasske.
17 *Navicula simplex* Krasske.
18 *Comphonema apiculatum* Ehr.
19 *Pinnularia viridis* (Nitz.) Ehr.

Carbon assimilations experiments[2] were conducted in the field, so as to find out whether the epiphytic algae have any effect on that vital process. The experiments were all begun at 9·30 a.m. and stopped at 4·0 p.m. Both the Experimental and control funnel-tubes were placed in the same cistern only 3 to 4 cms. apart. The specimens were carefully selected, regarding their age, etc. All variables such as mineral content of the water, pH and light were same for both the experimental and control. The experimental plants had epiphytic algae on their leaf, stem, etc. The volume of plants taken for all experiments was 5 c.c.

The results of the experiments are given in Table I to show the effect of epiphytic algae in carbon assimilation.

TABLE I.

*Evolution of oxygen in carbon assimilation.*

| *Number and date.* | *Control c.c.* | *Experimental c.c.* | *Difference D.* | $D^2$. | *Differences in percentage.* |
|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) |
| 1 30th October 1964 .. .. | 1·9 | 0·9 | 1·00 | 100 | 111·11 |
| 2 31st October 1964 .. .. | 1·3 | 1·0 | 0·3 | 9 | 30·00 |
| 3 Do. .. .. | 1·3 | 0·5 | 0·8 | 64 | 160.00 |
| 4 6th November 1964 .. .. | 0·9 | 0·3 | 0·6 | 36 | 200·00 |
| 5 12th November 1964 .. .. | 2·5 | 1·8 | 0·7 | 49 | 38.88 |
| 6 16th November 1964 .. .. | 2·0 | 1·4 | 0·6 | 36 | 42·85 |
| 7 17th November 1964 .. .. | 1·0 | 0·5 | 0·5 | 25 | 100·00 |
| 8 Do. .. .. | 1·0 | 0·4 | 0·6 | 36 | 150·00 |
| 9 18te November 1964 .. .. | 2·0 | 1·0 | 1·0 | 100 | 100·00 |
| 10 Do. .. .. | 2·0 | 0·9 | 1·1 | 100 | 122·22 |
| | 159 | 87 | 72 | 555 | |
| Average/Mean .. | 15·9 | 8·7 | 7·2 | 55·5 | |

[a]Average increase in control 105·50 per cent.

[1]Standard deviation :

| | | |
|---|---|---|
| Observed mean difference | | 7·2 |
| d at 0·05 level | .. 2·262 x ·092 .. | ·208 |
| d at 0·01 level | .. 3·250 x ·092 .. | ·299 |

As the value of the two critical differences at both 0·05 and 0·01 are much lower than the observed mean difference (7·2), the result is significant, namely, the plants with epiphytic algae on them produce less of oxygen than those without them. In other words, the epiphytic algae have a retarding effect on the carbon assimilation of *Najas garminea Del.*

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# CHANOS CULTURE AT THE BRACKISHWATER FISH FARM, ADYAR

BY

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## Introduction

Studies on Chanos chanos Forskal in India have been made under various aspects. Chacko (1955) has given us information on the spawning of Chanos and in 1942 has recorded his studies on the rearing of the larvae. Panikkar, Tampi and Viswanathan (1952) have made studies on the fry. The food and feeding habits have been dealt with by Chacko (1945), (1949) and Tampi (1958). Studies on growth have been made by Chidambaram and Unny (1946) and Chacko (1948). Raj (1931), Devanesan and Chacko (1944) and Chacko and Mahadevan (1955) have been interested in the culture of Chanos, while details of acclimatisation, transport and culture in inland waters have been worked out by Job and Chacko (1947), Ranganathan and Ganapathi (1949), Ganapati, Chacko, Srinivasan and Krishnamurthi (1950), Ganapati and Alikunhi (1952) and Menon, Srinivasan and Krishnamurti (1959). Malupillai and Chacko (1956)and Tampi (1960) have touched on the aspects of Chanos farming in marine fish farms and saline swamps.

Stray references have been made on the growth of Chanos in brackishwater ponds by Chacko and Mahadevan (1955) and Menon, Srinivasan and Krishnamurti (1959) but details of farming in brackishwater in India are not known. This work on the farming of Chanos chanos has been done in the specially constructed brackishwater fish farm at Adyar, which is the first of its kind in the Madras State and was constructed under the II Five-Year Plan.

## Description of farm

The farm (*see* Sketch) is 55·4 acres in extent. A reservoir 36 acres in area has been formed by the construction of a regulator across the narrowest portion of the Adyar Creek, a furlong above its confluence with the Adyar river. The creek joins the Adyar river at its Northern flank, just as it enters the Bay of Bengal. The regulator consists of three pairs of screw gearing shutters, one of each pair being perforated to be used only when water is required and escape of impounded fish is to be prevented. The judicious operation of these shutters during tidal ingress and egress facilitates the entrapping of shoals of marine fish, mostly in the juvenile stages, which enter with the tides in search of pasture.

A series of nurseries, rearing ponds, stock ponds and marketing ponds covering an area of 19·4 acres are situated on the southern bank of the reservoir. They get their supply of water either directly or indirectly from the reservoir. The nurseries are four in number, 50 ft. by 25 ft. in dimension and maintain a foot and a half of water in summer and three feet of water during the monsoons. There are three rearing ponds each 10 cents in extent which maintain the same depth of water as the nurseries. Lying parallel to the reservoir, quite close to the regulator are three pairs of stock ponds, S1, S2, S3, S4, S5, and S6 respectively, each 120 feet by 100 feet in dimensions maintaining three to six feet of water. Three of them S1, S3 and S5 are directly in connection with the reservoir, each of them being provided with a small shutter that can be lifted up to allow entry of fish and water. As the shutter is perforated it can be kept closed to prevent escape of fish, without in any way preventing entry of water. Of the three pairs, S1 is connected with S2 by a shutter, while S4 and S6 get their supply from the Marketing pond S8 which in turn gets its supply from the reservoir, S8 is 8 acres in extent and leads on to Marketing pond S7 which has no other connection. S7 is 5 acres in extent. 3 to 6 feet of water is maintained it the Marketing ponds also, depending on the season of the year.

All connections with the reservoir are cut off during the summer months when the bar is closed and drought conditions prevail due to intense evaporation. The water level is then at its lowest.

High water level is maintained during the monsoons when freshwater floods from the river not only pervade the sea but also enter the reservoir. High levels are also maintained during the high tides of the post monsoon period.

## Observations

1. *Availability of fry*—Four and a half years records show that there have always been two peak periods of availability of Chanos fry at Adyar. There is a major peak period in summer and a minor peak period during the monsoons. Fry of sizes ranging from 14 mms. to 40. mms. can be collected during these periods.

In summer the bar is usually closed. Fry have invariably been collected in the months of May and July although there have been instances where they have been available as early as April, sometimes in June and even as late as August in spite of the bar being closed.

This year fry of size 14 mms. to 21 mms. were first collected on 25th April 1963. It was interesting to note that the bar which was closed for summer, temporarily opened up on 22nd April 1963 the night of new moon and remained so for a few days. The opening up was caused by the action of the high breakers usually common during new moon. There were showers on the 21st, 23rd and 24th April 1963.

The monsoon period collection always begins in October and fry have been recorded as late as December. The bar is usually open during this period. Fry of Chanos are detected just after showers when flood waters recede, exposing innumerable shallow puddles of water along the Adyar estuary and creek. These puddles are found teeming with millions of Chanos fry which can be collected with little effort using coarse rectangular pieces of cloth or nets of velon screen also rectangular in shape. There is practically no mortality during these operations except when the fry have been kept over long in the tin carriers without change of water or when they have been overcrowded in the containers. Death occurs as a result of rise in temperature and depletion of oxygen.

Following collection the fry are best transferred to happas or very small enclosures made in the nursery ponds where they must be protected from birds (usually King fishers and herons,) snakes (usually *Cerebrus rhyncops* and predatory fish (especially *Therapon jarbua*). The depth of water to be maintained is from 15 cms. to 23 cms. There must be a good supply of natural food such as plankton and algal encrustations if growth is to be rapid. Artificial food may be resorted to in the absence of natural food. A week or two after, depending on the successful growth of the fry they may be given entrance into the deeper waters of the nursery varying in depth from 30 cms.to 46 cms. Here they will be exposed to a wider area, greater pressure of water and greater possibilities of attacks by enemies and they wil have to be stronger and more active to withstand these dangers. Experiment showed that while barely 3 per cent of fry survived when introduced directly into a nursery of dimensions 50 feet by 25 feet by 2 feet, 71 per cent survived when the above precautions were taken.

2. *Food of Chanos.*—The food of Chanos at various sizes in the farm was found to be as follows :—

(*a*) 25 *mms. to* 100 *mms.*—This group could be further divided into two size ranges on the strength of their feeding habits, i.e.,

(1) 25 *mms.* to 40 *mms.*—

*Zoo organisms*—

| | | |
|---|---|---|
| Brachionus | .. | P |
| Copepods | .. | P |
| Notholca | .. | F |

*Phyto organisms*—

| | | |
|---|---|---|
| Oscillatoria | .. | P |
| Navicula | .. | F |
| Gyrosigma | .. | F |
| Debris .. | .. | P |
| Sand grains | | F |

(2) 41 *mms. to* 100 *mms.*—

Stomach contents had a fine orange, yellow or orangish yellow colour—

Zoo organisms—

| | | |
|---|---|---|
| Brachionus | .. | P |
| Copepods | .. | P |
| Copepod eggs | .. | P |
| Nauplii .. | .. | P |
| Peridinium | .. | P |
| Nematodes | .. | F |
| Gastropod post larvae | | F |

Phyto organisms—

| | | |
|---|---|---|
| Oscillatoria | .. | P |
| Microcystis | .. | P |
| Spirulina | .. | C |
| Enteromorpha | .. | C |
| Chaetomorpha | .. | C |
| Gyrosigma | .. | S |
| Navicula | .. | C |
| Fragillaria | .. | C |
| Thalassiosira | .. | C |
| Guinardia flaccida. | | C |
| **Debris** .. | .. | F |
| **Sand grains** | .. | F |

(*b*) 101 *mms. to* 200 *mms.*—

Zoo organisms—

| | | |
|---|---|---|
| Brachionus | .. | C |
| Copepods .. | .. | C |
| Copepod eggs | .. | P |
| Nauplii .. | .. | C |
| Peridinium | .. | S |
| Gastropod post larvae. | | F |
| Foraminifera | .. | F |

Phyto organisms—

| | | |
|---|---|---|
| Oscillatoria | .. | P |
| Microcystis | .. | C |
| Enteromorpha | .. | C |
| Chaetomorpha | .. | C |
| Navicula .. | .. | P |
| Thalassiosira | .. | P |
| Rhizosolenium | .. | F |
| Suriella .. | .. | F |
| Diploneis .. | .. | F |
| Amphora .. | .. | F |
| Debris .. | .. | F |
| Sand grains .. | .. | P |

(*c*) 201 *mms. to* 300 *mms.*—

Zoo organisms—

| | | |
|---|---|---|
| Nauplii .. | .. | C |
| Peridinium | .. | C |

Phyto organisms—

| | | |
|---|---|---|
| Gyrosigma .. | .. | C |
| Navicula .. | .. | C |
| Thalassiosira | .. | P |
| Nitzschia closterium. | | C |
| Nitzschia closterium var levidensis. | | P |
| Debris .. | .. | C |
| Sand grains | .. | C |

(*d*) 301 *mms. to* 400 *mms.*—

Zoo organism—Nil.

Phyto organisms—

| | | |
|---|---|---|
| Anabaena .. | .. | C |
| Merismopedia | .. | C |
| Navicula .. | .. | C |
| Coscinodiscus | .. | F |
| Tabellaria .. | .. | F |

(*e*) 401 *mms. to* 500 *mms.*—

Gut contents slimy and whitish. **Empty in most** cases.

Zoo organisms—

| | | |
|---|---|---|
| Peridinium .. | .. | C |
| Nematodes | .. | F |

Phyto organisms—

| | | |
|---|---|---|
| Anabaena .. | .. | C |
| Navicula .. | .. | C |
| Gyrosigma | .. | C |

The fry of Chanos feed voraciously and this voracity continues up to the 300 mm. stage when it dwindles. In the 401 mm. to 500 mm. size group many were found with empty stomachs.

"F" indicates—Few.
"C" indicates—Common.
"P" Indicates—Abundant.
"S" indicates—Swarms.

3. *Growth.*—(*a*) *Fry and fingerlings.*—Growth of fry under natural conditions was compared with the growth of those in the nurseries of the farm. Fry and fingerlings of size range 24 mm. to 74 mm. stocked in a nursery grew to a size range of 70 mm. to 82 mm. in one month and eighteen days. Fry of 21 mms. to 38 mms. size range in the estuary were found to have grown to a size range of 65 mms. to 90 mms. in one month and four days, which was decidedly better than that under artificial conditions.

(*b*) *Juveniles.*—Growth of young Chanos, just passed the fingerling stage, which is the best stock size, was studied in the stock ponds of the fish farm. Water spread of these ponds was nearly a sixth of an acre. Tables appended show the observations made.

Tables 1 and 2 show the growth of Chanos in stock ponds one and two. Stock pond one (S1) lies adjacent to the reservoir and receives its supply of water directly from the reservoir. Stock pond two (S2) which lies parallel to S1 and further away from the reservoir gets its supply from S1.

Two hundred and fifty Chanos of sizes ranging from 40 mms. to 125 mms. were stocked in S1 and S2 on 15th December 1959. Owing to the disparity in the size of the fish stocked, the same disparity was noticed throughout the period of investigation. The trend in the growth was similar in both ponds but growth was all along better in S2 which gets only an indirect supply of water from the reservoir through S1.

Planktological and hydrographical investigations were made in S1 and S2 during the same period to observe how growth was correlated with these factors. Tables 3 to 9 give an idea of the phyto and zoo-planktonic organisms, occuring in the various months in 1960 and 1961 and their relative abundance. A greater variety of zoo-plankton is observed in S2 although Copepods and Nauplii are more abundant in S1. Phytoplankton is definitely more varied and more abundant in S2.

Slight but definite differences exist in the hydrographical conditions of the two ponds. Tables 10 and 11 show the meteorological conditions in the various months and tables 12 to 15 show the hydrographical conditions in S1 and S2 in 1930 and 1961. Salinity is higher in S2 from July to December 1960 whereas it is higher, or equal in S1 from January 1960 to June 1960. Salinity range in 10·15% to 36·2% in S1 and 16·2% to 37·93% in S2, Surface temperature is always equal or higher in S2, rarely less. Oxygen values are always 4.06 cc/L and over, even as high as 5·76 cc/L in S1 in April. In S2 they have been found to be as low as 3·10, 3·57 and 3·08 cc/L in the months of April, June and September but it has been as high as 5·57 cc/L in May 1960.

Silicate contents have been higher in S2 from January to July 1960 except in April 1960 when it was equal to that of S1. From August onwards the value has been alternatively higher in each pond starting with S1.

The months when the water has been very clear are September, October, November and December and S2 has all along shown the greater clarity during these months. The months of high turbidity are from March to July and in these months up to June the waters of S2 are more turbid.

Ph is as high as 8·7 in both ponds from January to March. It goes down to 8·4 in both ponds in April and remains so till July in S1 but fluctuates between 8·0 and 8·2 in S 2. In August there is a big drop to 7·4 in S1 but this drop occurs in the next month in S2 to the value of 7·2. S2 remains at 7·6 after this till December whereas it fluctuates between 7·6 and 7·8 in S1.

The disparity is size of the Chanos stocked ranged over a difference of 85 mm. both in S1 and S2 at the time of stocking. This difference was found to increase to 130 mm. in S1 and 75 mm. in S2 in one year.

Graphs 1 and 3 and Tables 1 and 2 show that growth in length steadily increases in both S1 and S2 from December 1959 to May 1960 in S1 and December 1959 to June 1960 in S2. After this growth is poor and continues to remain so till January 1961 in S1 and December 1960 in S2. The maximum length attained in five months time in S1 is 33·3 cm. or 1'1" nearly and the maximum length attained in S2 in the same period is 34·7 cm. or 1' 1·7"nearly, which increases to 40·2 cm. or 1' 3·9" nearly in the space of a month.

Graphs 2 and 3A also show the increase in weight in S1 and S2. In S1 there is a gradual increase in weight till May 1960 parallelling the increase in length. June and July show a stagnation in growth both in weight and length after which there is a shooting up in August. After August there seems to be no increase in weight or length till January 1961. There is a similar direct relationship in the increase in weight and length in S2. Till April the increase is gradual after which there is a steep rise till June both in weight and length. After June the increase in weight is not as rapid although it is steadily on the increase whereas the increase in length is very slight till August and then is imperceptible till December. The weight attained in five months in S1, is 225 grams or ½lb. nearly, while in S2 it is 360 grams or ¾ lb. nearly. A weight of 515 grams or a little over 1 lb. is reached in S2 in six months.

It was observed that longer fish very often weighed less than shorter ones. For a period of 6 months the fish in S1 were smaller than those in S2 by a maximum length of 6·9 cm. or 2·7" and a weight of half a pound. June to December is seen to be the common period of poor growth in both ponds.

The maximum length reached in S1 for one year is 39·5 cm. or 1' 3·6" nearly and that in S2, 43 cm. or 1'5" nearly. The maximum weight reached in S1, is 470 grams or a little more than 1 lb. and that in S2, 650 grams or 1¼ lbs.

Growth is resumed in December, 1960 but it is not as quick as the first six months of life in the stock ponds. The second year of life is more a growth in weight than in length. The maximum length reached in 1 year 9 months in S1 was 47·9 cm. or 1' 6·9" and in S2, 50·0 cm. or 1' 11·2". The maximum weight reached in S1, for the same period is 800 grams or 1¾ lbs. nearly and for S2, 1300 grams or 2¾ lbs. nearly. Again, in the second year the major growth is noticed up to June. The maxumim length reached in 3 years is not much more but the weight increases to 2 Kilo grams.

After a year and two months nearly a peculiar phenomenon was noticed in both ponds. The fish which were 380 cm. or 1¼ feet in size and more, and which weighed 454 grams or 1 pound and more were found to jump wildly in the water dashing their heads against the sides of the ponds and injurying themselves so that they died. The dead specimens when examined revealed wounds on the snout and head. The adipose eyelids and the membrane covering the snout was opaque, swollen and spongy. The stomach and guts were practically empty with whitish slimy matter in which no food material could be identified except stray Navicula occuring singly.

A good portion of the Chanos were disposed at this stage leaving a small number for further study. About 40 per cent of the numbers of the Chanos put in were lost due to natural causes. The remaining 60 per cent were harvested resulting in an output of approximately 450 Kilogrammes or 900 lb. of Chanos per acre per *annum* at a stocking rate of 1,500 seed per acre.

Several other stocking experiments were conducted and the observations recorded. (*a*) On 17th June 1960 Chanos fry of size range 10 mm. to 45 mm. size range were stocked at the rate 400 and 500 respectively in S1 and S2. 100 per cent mortality was recorded. (*b*) On 29th October 1960, 500 Chanos and Megalops fry of size range 15 mm to 85 mm were stocked in S1. 100 per cent mortality was recorded. (*c*) On 17th February 1961, Chanos fingerlings of 82 mm. to 135 mm. and 62 mm. to 125 mm. size range were stocked in S1 and S2. respectively at the rate of 200 and 100 numbers. The larger sizes were put into S1 which exhibited poorer growth in the first experiment. Half the number only were put into S2 to see whether this difference would create an outstanding increase in the growth rate.

Results as seen in Table 16 show that larger fish naturally grow bigger first and so by stocking bigger fish in a pond with a poor growth rate, sizes obtained at harvest time can be expected to be similar to that in the pond with a better growth rate. Further, dimunition in numbers stocked has a limit 200 and 100 numbers stocked have not given better results than 250 stocked. There has been a wastage of area and food which would have been profitably utilised if more had been put in.

Tables 3—15 on Plankotology and Hydrography, of S1 and S2 in 1960, 1961 show that environmental conditions vary from year to year and hence the corresponding variations in growth from year to year. However growth in both ponds in 9 months is about a foot in length and over ¾ pound in weight.

(*d*) 2,850 Chanos fry of size range 30 mm. to 45 mm. were stocked in S3 and 4,350 Chanos fingerlings of size 60 mm. to 85 mm. were stocked in S5 on 1st June 1960.

Both ponds are similar in having direct connection with the reservoir and taking their water supply from it as they lie side by side, adjacent to the reservoir. The planktological and hydrographical conditions of these two ponds as seen from tables vary.

100 per cent mortality was recorded in S3 into which fry were stocked and 90 per cent mortality was recorded in S5 which though stocked with fingerlings was over stocked. The rate of growth of the remaining 10 per cent, i.e., 435 fish in S5 was very poor in spite of half of them being removed in the seventh and eighth months. Table 5 shows their growth. Maximum length reached in one year is 29·7 cm. or 11·5″ and maximum weight reached 150 grams or about ⅓ lb. 100 of those removed on 23rd February 1961 were stocked in S3 but no improvement in the growth rate was found. Table 6 gives the growth recorded.

4. *Combination Cultures.*—Etroplus suratensis of size range 50 mm. to 165 mm. was cultured with Chanos in the ratio of 1 : 3 in S2, the pond which showed better growth. Growth of chanos was equally good in both the ponds S1 and S2 in the first quarter. This may be due to the introduction of Etroplus suratensis which is a bottom feeder as are the young stages of Chanos, but for which growth may have been better in S2 even at the very beginning.

Etroplus was found to breed in the ninth month and had migrated to S1 in the eleventh month from which 1,500 fry were collected for supply to inland waters. This indicated that the combination was a profitable concern.

Stocks of prawn larvae were found to naturally ascend the two ponds S1 and S2 and formed an attractive fishery. Penaeus indicus which formed the major prawn fishery was found to attain a maximum size of 18·1 cm. or 7 inches in March, three months after stocking of Chanos. 25 prawns of this size weighed a pound. Such sizes were available continuously after every second or third month during the growth of Chanos in the course of the year making it profitable especially as the growth of Chanos was in no way affected by its presence or its bottom feeding habit. Penaeus carinatus were also found in small numbers. They attained a size of 24·7 cm. or 9·5 inches in 3 to 4 months with a weight of a pound for 5 prawns put together.

## Discussion

Ganapathi and Chacko (1950) state that fish productivity of a pond depends on its size and nourishing power. Several other factors also play an important part in the yield of fish. Collection of seeds in the larval stages is more economical in that more seeds can be transported in a lesser number of containers and with a far lesser mortality rate than the collection of fingerlings. Experiments show that care has to be taken in the rearing of the larvae and fry so that here again, the survival rate may be high and growth may be as good as it would be in the natural environments.

The most suitable size for transference from the nurseries to the stock ponds is the fingerling stage, i.e., 80 mm. and over. Fry are lost in the wide and deep waters of the stock ponds. Fish stock of more or less the same size may preferably be stocked together as disparity in sizes during stocking continues to the time of harvesting, inconveniencing the harvesting of full grown as the undersized have to be retained for sale at a later date when they have sufficiently grown. The Chinese sieving method may be resorted to to segregate the Chanos fry just after the collection of the Chanos larvae and fry so that the different sizes may be reared in separate nurseries and then stocked separately, thereby eliminating this difficulty.

The collection of Chanos fry for stocking is inevitable as Chanos, unlike other marine species such as Mugil spp. Elops indicus, Chaetoessus nasus, Engraulis purava, Leiognathus sp. Therapon jarbua, Penaeus-indicus and such others, was not found to ascend the brackish water ponds in appreciable numbers naturally, even though the larvae were always collected four to eight furlongs up the river and creek and never near the sea mouth, from where they are supposed to enter the estuary from the sea. One has therefore to concentrate on the periods of availability of the larvae to ensure an adequate supply of seeds for the year without which the Chanos crop would be a failure. The availability of larvae in summer even after the bar is closed gives ample food for thought. The possibilities are that the larvae enter the estuary via the Buckingham canal but this is ruled out by the fact that even when the canal was closed on the Madras side, due to repairs and when the bar at the Vellar estuary and the Cooum estuary were closed larvae were available. Granting that the canal was open it would not be possible for the delicate larvae to negotiate such deep waters. The temporary opening of the bar observed this year in April during New Moon time when Chanos larvae were also collected suggest two other possibilities. Either the breakers are so high during New moon, which is the usual spawning period, that eggs and larvae are washed over by the waves and carried by the force of the high tides as far up the river as possible or else temporary connections between the sea and estuary are formed when the larvae enter with the tides for a short spell, the connections closing up as quickly and unnoticed as they opened. Observation shows that the appearance of Chanos larvae varies slightly from year to year depending on the preceding rainfall. Malu Pillai and Chacko (1956) have also recorded this. There are however two distinct periods at Adyar which is very advantageous in that two collection periods will facilitate two stocking programmes during the year and enable a dual harvest per annum. Growth studies show that there is good growth in length and weight during the first five or six months after the fingerlings stage after which progress is slow. By the eight or ninth month a marketable size of approximately 1′3″ or 37·5 cm. in length and ¾ th pound or 375 grams in weight is reached when they can be disposed and a new stock of fingerlings introduced. Disposal will be possible even in the sixth month after stocking provided there is a good feeding programme as the results obtained in the growth studies made, are from unaided natural conditions when a foot has been attained in six months with a weight of half a pound, at which stage itself they are marketable.

Menon, Srinivasan and Krishnamurti (1952) and Chacko and Mahadevan (1954) also report that growth of Chanos in the first six months is rapid, slowing down in the next six. Studies at Adyar show that this is so independent of whether they are the October collection stocked in December or the April collection stocked in June. The fingerling stage of 80 mm. and over is reached in the space of two months and this is the best time for stocking if the mortality rate is to be low. Experiments show the large scale mortality incurred by stocking in the fry stage.

Overstocking also is found to result in a very high mortality rate. 250 fingerlings stocked in an area of a sixth of an acre has given the best results. The number could be increased to 500 and not over with satisfactory results depending on food supply and congenial hydrographical factors.

The food organisms taken in by the fish at various size is similar to that recorded by Chacko (1949), Esquerra (1951) and Tampi (1958) who attribute to it a browsing mode of feeding. It is however not selective and feeds on whatever is available either at the bottom or in the plankton and hence its fairly good growth with very little attention. The feeding phase is between the 41 mm. and 300 mm. stage and hence the good growth during the first six months after stocking. Tampi (1958) reports fish over 300 mm. with only a white mass of mucoid substance in the guts. This was noticed in fish of length 400 mm. to 500 mm. at Adyar. Their gonads were undifferentiated. They exhibited a strange phenomenon of madly jumping about probably in an urge to find a means of return to the sea for breeding. Tampi 1958 has also recorded specimens of 500 mm. from the sea with the sex differentiated which shows that they are large enough at this stage to attain sexual maturity. Immature specimens of the same size with empty stomachs have also been recorded from the sea.

Extraneous fish were found to enter into the Chanos ponds in the larval stages but it was not found advisable to grow them with the Chanos except for the prawns Penaeus indicus and Penaeus carinatus which formed a valuable source of food and income without detriment to the culture of Chanos. Food concurrents such as Mugil species and predators such as *Therapon jarbua* and *Elops indicus* had, as suggested by Schuster 1952, to be eradicated if sufficient food and space was to be maintained for the optimum growth of Chanos.

*Etroplus suratensis* when introduced in the proportion of 1 : 3 did not appreciably reduce the growth of Chanos and was welcome as a source of ready seed for supply to inland waters.

The general conclusions that may be drawn from the studies made, point to the fact that variations occur in hydrographical conditions from pond to pond of the same farm thereby altering the productivity also. This indicates that variations from farm to farm can normally be expected and suitable adjustments must be made to suit the particular piece of water to be farmed so that the maximum yield can be ensured. The growth of Chanos though it may not be as good as it is in fresh water is better than that recorded in a saline environment by Tampi (1960). There is ample scope for the culture of Chanos in Brackish water farms which can serve as storehouses for Chanos seed to be supplied to inland waters and form reservoirs of tasty and cheap fish food supply to the public at intervals of six months. A pre-planned programme of collection, nursing, rearing, stocking and harvesting together with favourable environmental conditions is necessary to achieve the goal.

## *Acknowledgment.*

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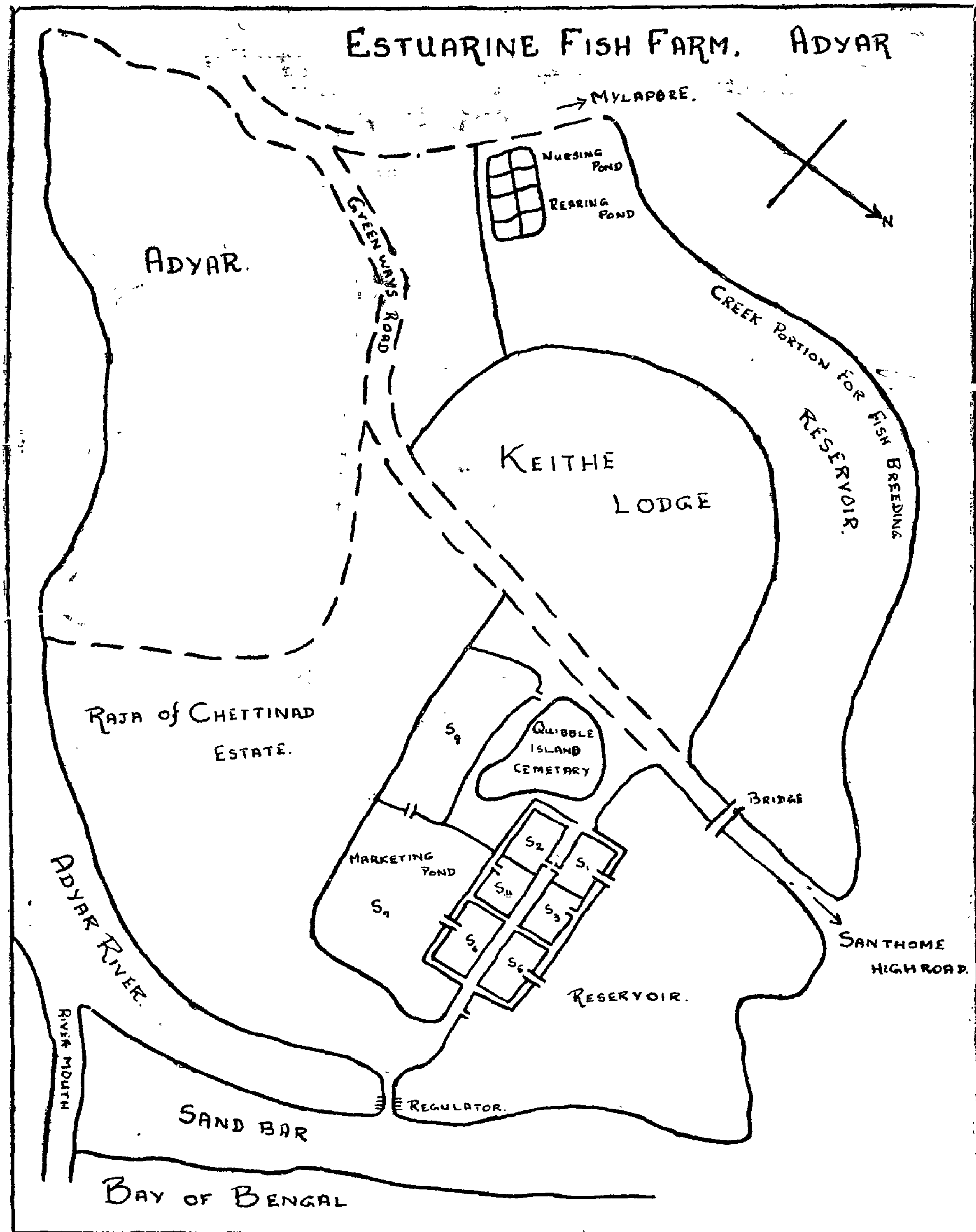


ESTUARINE FISH FARM, ADYAR
MYLAPORE.
N
NURSING POND
REARING POND
ADYAR.
GREEN WAYS ROAD
CREEK PORTION FOR FISH BREEDING
RESERVOIR.
KEITHE LODGE
RAJA of CHETTINAD ESTATE.
S8
QUIBBLE ISLAND CEMETARY
BRIDGE
MARKETING POND
S7
S2
S1
S4
S3
S6
S5
SANTHOME HIGHROAD.
ADYAR RIVER.
RESERVOIR.
RIVER MOUTH
REGULATOR.
SAND BAR
BAY OF BENGAL

TABLE 1.

*Growth Studies of Chanos chanos.*

Numbers stocked—250. In S.1. Date of stocking—15th December 1959.

| *Date of Trial netting.* (1) | *Size Range in m.m.* *Minimum.* (2) | *Maximum.* (3) | *Weight Range in Grams.* *Minimum.* (4) | *Maximum.* (5) |
|---|---|---|---|---|
| 15th December 1959 .. .. .. | 40 | 125 | 1·2 | 2·4 |
| 24th February 1960 .. .. .. | 155 | 192 | 32 | 63 |
| 16th March 1960 .. .. .. | 175 | 203 | 44 | 65 |
| 21st April 1960 .. .. .. | 200 | 271 | 75 | 190 |
| 25th May 1960 .. .. .. .. | 240 | 333 | 115 | 225 |
| 28th June 1960 .. .. .. .. | 269 | 320 | 100 | 225 |
| 23rd July 1960 .. .. .. | 222 | 318 | 155 | 225 |
| 11th August 1960 .. .. .. | 210 | 375 | 150 | 375 |
| 22nd September 1960 .. .. .. | 268 | 356 | 175 | 240 |
| 29th November 1960 .. .. .. | High water—not available. | | | |
| 17th December 1960 .. .. .. | 340 | 395 | 280 | 470 |
| 30th January 1961 .. .. .. | 265 | 385 | 350 | 455 |
| 4th February 1961 .. .. .. | 337 | 466 | 325 | 600 |
| 5th February 1961 .. .. .. | Chanos dying. Disposed by sale. | | | |
| 24th March 1961 .. .. .. | Ten left for observation. | | | |
| 25th March 1961 .. .. .. | 372 | .. | 395 | .. |
| 22nd April 1961 .. .. .. | Not available. | | | |
| 29th May 1961 .. .. .. | 431 | 477 | 610 | 800 |
| 27th June 1961 .. .. .. | 433 | 479 | 660 | 750 |
| 15th July 1961 .. .. .. | 470 | .. | 750 | .. |
| 19th August 1961 .. .. .. | 436 | .. | 620 | .. |
| 16th September 1961 .. .. .. | 440 | .. | 640 | .. |

TABLE 2.

*Growth Studies of Chanos chanos.*

Numbers stocked—250. In S. 2. Date of stocking—15th December 1959.

| *Date of Trial netting.* (1) | *Size Range in m.m.* *Minimum.* (2) | *Maximum.* (3) | *Weight Range in Grams.* *Minimum.* (4) | *Maximum.* (5) |
|---|---|---|---|---|
| 15th December 1959 .. .. .. | 40 | 125 | 1·2 | 2·4 |
| 24th February 1960 .. .. .. | 110 | 191 | 24 | 72 |
| 16th March 1960 .. .. | 188 | 233 | 69 | 105 |
| 21st April 1960 .. .. .. | 245 | 270 | 115 | 170 |
| 25th May 1960 .. .. .. | 278 | 347 | 150 | 360 |
| 28th June 1960 .. .. .. | 275 | 402 | 185 | 515 |
| 23rd July 1960 .. .. .. | 305 | 415 | 280 | 560 |
| 11th August 1960 .. .. .. | 287 | 425 | 250 | 575 |
| 22nd September 1960 .. .. .. | 343 | .. | .. | 345 |
| 31st October 1960 .. .. .. | 395 | 428 | .. | 600 |
| 29th November 1960 .. .. .. | 335 | 352 | 275 | 345 |
| 17th December 1960 .. .. .. | 426 | 430 | 535 | 650 |
| 30th January 1961 .. .. .. | 372 | 455 | 375 | 700 |
| 4th February 1961 .. .. .. | 382 | 502 | 450 | 700 |
| | Chanos dying—Partly disposed. | | | |
| 25th March 1961 .. .. .. | 355 | 590 | 350 | 490 |
| 22nd April 1961 .. .. .. | 392 | 480 | 410 | 705 |
| 29th May 1961 .. .. .. | 426 | 492 | 600 | 840 |
| 27th June 1961 .. .. .. | 450 | 492 | 650 | 800 |
| 15th July 1961 .. .. .. | 440 | 460 | 620 | 730 |
| 19th August 1961 .. .. .. | 450 | 513 | 680 | 1,300 |
| 16th September 1961 .. .. .. | 430 | 465 | 650 | 1,000 |

TABLE 3.

*Plankton* 1960 *S*1 *Numbers per cc.*

| | *April.* | *May.* | *June.* | *July.* | *August.* | *September.* | *October.* | *November.* | *December* |
|---|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| *Zoo plankton—* | | | | | | | | | |
| 1 Rotifer .. .. .. | .. | .. | .. | .. | .. | 720 | .. | .. | .. |
| 2 Insect larvæ .. .. .. | .. | .. | .. | .. | .. | .. | .. | Rare. | .. |
| 3 Nauplii .. .. .. | 60,476 | 20,210 | 4,474 | 824 | 3,805 | 6,108 | 1,680 | 180 | 1,440 |
| 4 Copepod .. .. .. .. | 194,399 | 847,163 | 3,986 | 470 | 2,435 | 2,378 | 780 | 120 | 6,710 |
| 5 Lepadid .. .. .. .. | 181 | 15 | 14 | 10 | 1 | 1 | 1 | 2 | 4 |
| 6 Medusæ .. .. .. .. | 178 | 6 | 3 | 20 | 25 | 55 | 3 | .. | 3 |
| 7 Mesopodopsis .. .. .. | 5 | Rare. | 1 | 18 | 1 | 54 | 90 | 39 | Rare |
| 8 Cypris .. .. .. .. | .. | .. | .. | .. | .. | .. | 85 | .. | .. |
| 9 Wing scale of dipteran .. | .. | .. | .. | .. | .. | .. | .. | Rare. | .. |
| 10 Lucifer .. .. .. .. | 17 | 1 | 1 | .. | .. | .. | .. | .. | .. |
| 11 Argulid .. .. .. .. | 1 | .. | 1 | 1 | 1 | .. | .. | .. | .. |
| 12 Sagitta .. .. .. .. | 153 | 325 | 6 | 10 | 5 | .. | .. | .. | .. |
| 13 Fish Larvæ .. .. .. | .. | 1 | .. | .. | 3 | .. | Rare. | Rare. | Rare |
| 14 Fish Eggs .. .. .. | 16 | 1 | 6 | 3 | 6 | 4 | 25 | .. | 4 |
| 15 Nematode .. .. .. | 1 | .. | .. | .. | .. | .. | .. | .. | .. |
| 16 Amphipod .. .. .. | .. | .. | Rare. | 3 | 2 | 4 | Rare | .. | 180 |
| 17 Zœa .. .. .. .. | .. | .. | 1 | .. | .. | .. | .. | .. | Rare |
| 18 Gastropod post larvæ .. .. | .. | .. | Rare. | .. | .. | .. | .. | .. | .. |
| 19 Isopod .. .. .. .. | .. | .. | .. | .. | Rare. | 1 | .. | .. | .. |
| 20 Prawn Larvæ .. .. .. | .. | .. | .. | .. | .. | .. | Rare. | 1 | 1 |
| *Phyto Plankton—* | | | | | | | | | |
| 1 Navicula .. .. .. | 1,100 | .. | 7 | .. | .. | 1 | .. | 900 | 5,580 |
| 2 Coscinodiscus .. .. .. | .. | .. | .. | .. | .. | .. | .. | .. | 60 |
| 3 Gyrosigma .. .. .. | .. | .. | 60 | .. | .. | .. | .. | .. | .. |
| 4 Guinardia .. .. .. | .. | .. | .. | .. | .. | .. | .. | 60 | 2,220 |
| 5 Green algæ .. .. | .. | .. | .. | .. | 1 | 3 | .. | .. | .. |
| 6 Oscillatoria .. .. .. | .. | .. | .. | .. | .. | 254 | .. | .. | .. |
| 7 Rhizosolenium alata .. .. | .. | .. | .. | .. | .. | .. | .. | Rare. | .. |
| 8 Diploneis .. .. .. | .. | .. | .. | .. | .. | .. | .. | .. | Rare |

TABLE 4.

*Zoo-plankton 1961 S1 Numbers per c.c.*

| *Zoo-plankton.* (1) | *January.* (2) | *February.* (3) | *March.* (4) | *April.* (5) | *May.* (6) | *June.* (7) | *July.* (8) | *August.* (9) | *September.* (10) | *October.* (11) | *November.* (12) | *December* (13) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Mesopodopsis .. | .. | .. | .. | 18 | 3 | 1 | 5 | Rare. | .. | .. | .. | .. |
| 2 Copepods .. | 4,140 | 720 | 3,880 | 6,300 | 5,470 | 5,070 | 1,020 | 480 | 1,520 | 720 | 1,680 | 1,080 |
| 3 Lepadid .. | .. | .. | .. | 3 | 1 | Rare. | 3 | 6 | 4 | 5 | 3 | .. |
| 4 Fish eggs. .. | .. | 25 | 28 | 24 | 1 | 13 | .. | Rare. | .. | .. | .. | .. |
| 5 Polychaete Post-larvae. | .. | 120 | 60 | 120 | .. | .. | .. | 96 | .. | .. | .. | .. |
| 6 Nauplii .. .. | 1,080 | 40 | 2,580 | 780 | 2,220 | 4,560 | 780 | 288 | 1,360 | 400 | 240 | 1,320 |
| 7 Medusae .. .. | 1 | 8 | .. | 5 | 38 | 3 | 187 | 68 | Rare. | Rare. | 12 | .. |
| 8 Fish larvae .. | 5 | Rare. | 13 | 6 | 1 | Rare. | .. | .. | .. | .. | .. | 8 |
| 9 Amphipod .. | .. | 20 | 60 | 120 | 60 | .. | 60 | 172 | .. | Rare. | 6 | .. |
| 10 Freshwater shrimp. | .. | .. | .. | 1 | .. | 10 | .. | Rare. | .. | .. | .. | .. |
| 11 Prawn larvae .. | 1 | .. | 1 | .. | 4 | 2 | .. | .. | .. | .. | .. | .. |
| 12 Obelia .. .. | .. | .. | .. | .. | Rare. | Rare. | .. | 48 | Rare. | 81 | .. | .. |
| 13 Megalopa .. .. | .. | 3 | .. | .. | 1 | .. | .. | .. | Rare. | Rare. | .. | .. |
| 14 Dipteran wing scale. | .. | .. | .. | .. | .. | .. | 60 | .. | .. | Rare. | .. | .. |
| 15 Water skater .. | .. | .. | .. | .. | .. | .. | .. | 2 | .. | .. | .. | .. |
| 16 Beetle larvae .. | .. | .. | .. | .. | .. | .. | .. | 48 | .. | .. | .. | 120 |
| 17 Polychætes .. | .. | .. | .. | .. | .. | .. | .. | 48 | .. | .. | .. | .. |
| 18 Crab gill with lepas. | .. | .. | .. | .. | .. | .. | .. | Rare. | .. | .. | .. | .. |
| 19 Amphipod moults | .. | .. | .. | .. | .. | .. | .. | .. | 2 | Rare. | 18 | 38 |
| 20 Caligus sp. .. | .. | .. | .. | .. | .. | .. | .. | .. | Rare. | Rare. | .. | .. |
| 21 Cypris .. .. | 60 | .. | 60 | .. | .. | .. | .. | .. | 160 | 240 | .. | 240 |
| 22 Bug larvae .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 60 | .. | .. |
| 23 Isopod .. .. | .. | .. | .. | .. | .. | .. | .. | .. | Rare. | .. | .. | .. |
| 24 Zoea .. .. | .. | Rare. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| 25 Gastropod post larvæ. .. | .. | 60 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| 26 Alpheids .. | .. | .. | Rare. | .. | .. | .. | .. | .. | .. | .. | .. | .. |

TABLE 5.

*Phyto plankton* 1961 *Sl Numbers per c.c.*

| (1) Phyto Plantation— | *January.* (2) | *February.* (3) | *March.* (4) | *April.* (5) | *May.* (6) | *June.* (7) | *July.* (8) | *August.* (9) | *September.* (10) | *October.* (11) | *November.* (12) | *December.* (13) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Navicula .. .. | 4,800 | 2,160 | 2,100 | 3,300 | 840 | .. | 60 | 384 | 2,45,600 | 13,200 | 2,640 | 360 |
| 2 Nitzchia closterium. | 300 | 12,960 | 3,000 | 2,520 | 120 | .. | 60 | .. | .. | 1,200 | .. | .. |
| 3 Gyrosigma .. | 120 | 12) | 860 | 1,140 | .. | 60 | .. | .. | 480 | 500 | .. | .. |
| 4 Oscillatoria .. | .. | 60 | 120 | 240 | .. | .. | .. | 48 | 80 | 400 | 480 | .. |
| 5 Chaetomorpha .. | .. | .. | .. | .. | .. | 2 | .. | 384 | .. | .. | .. | .. |
| 6 Microcystis .. | .. | .. | .. | .. | .. | .. | 600 | .. | .. | .. | .. | .. |
| 7 Bacillaria .. | .. | .. | .. | .. | .. | .. | .. | 48 | .. | .. | .. | .. |
| 8 Polysiphonia .. | .. | .. | .. | .. | .. | .. | .. | 2 | .. | .. | .. | .. |
| 9 Englena .. .. | .. | .. | .. | .. | .. | .. | .. | .. | 160 | 1,680 | .. | .. |
| 10 Cladophora .. | .. | .. | .. | .. | .. | .. | .. | .. | 80 | 160 | 240 | 360 |
| 11 Achnanthes .. | .. | .. | .. | .. | .. | .. | .. | .. | 80 | 320 | .. | .. |
| 12 Enteromorpha .. | .. | .. | .. | .. | .. | .. | .. | .. | 80 | .. | .. | .. |
| 13 Pandorina .. | .. | .. | .. | .. | .. | .. | .. | .. | 80 | .. | .. | .. |
| 14 Melosira .. .. | .. | .. | .. | .. | .. | .. | .. | .. | 80 | 80 | .. | .. |
| 15 Merismopedia .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 160 | .. | .. |
| 16 Diploneis .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 80 | .. | .. |
| 17 Guinardia .. | .. | 360 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| 18 Nitschia seriatum | .. | 540 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |

TABLE 6.

*Zoo-Plankton* 1960 $S^2$ *Numbers per c.c.*

| (1) | *April.* (2) | *May.* (3) | *June.* (4) | *July.* (5) | *August.* (6) | *September.* (7) | *October.* (8) | *November.* (9) | *December* (10) |
|---|---|---|---|---|---|---|---|---|---|
| *Zoo Plankton—* | | | | | | | | | |
| 1 Isopods .. .. | .. | .. | .. | .. | .. | .. | 3 | .. | .. |
| 2 Polychaete post larvae | .. | .. | .. | .. | .. | 4 | .. | .. | .. |
| 3 Nauplii .. .. .. | .. | 104 | 196 | 499 | 1,826 | 120 | 2,040 | 120 | 600 |
| 4 Shrimps .. .. .. | .. | .. | .. | .. | Rare. | .. | .. | .. | .. |
| 5 Peridinium .. .. | .. | 60 | .. | .. | .. | .. | .. | .. | .. |
| 6 Wing scale of Dipteran | .. | .. | .. | .. | .. | .. | .. | .. | 60 |
| 7 Caligus sp. .. .. | .. | .. | .. | 1 | Rare. | .. | .. | .. | .. |
| 8 Copepods .. .. | .. | 224 | 4,700 | 1,592 | 2,085 | 278 | 360 | 60 | .. |
| 9 Vivipara .. .. | .. | .. | .. | Rare. | .. | .. | .. | .. | .. |
| 10 [illegible] larvæ .. .. | Rare. | .. | .. | .. | .. | .. | .. | .. | Rare |
| 11 Mesopodopsis .. .. | 2,804 | 1,219 | Rare. | 75 | 9 | 2 | 194 | 78 | .. |
| 12 Fish Larvæ .. .. | .. | 6 | 60 | 1 | 1 | 1 | 5 | .. | .. |
| 13 Obelia .. .. .. | .. | .. | .. | .. | .. | .. | .. | .. | Rare. |
| 14 Lucifer .. .. .. | Rare. | .. | .. | .. | .. | .. | .. | .. | .. |
| 15 Lepadid .. .. .. | Rare. | .. | .. | 13 | 1 | .. | .. | Rare. | 2 |
| 16 Fish eggs .. .. | 1 | .. | .. | .. | .. | Rare. | .. | 10 | .. |
| 17 Medusæ .. .. .. | Rare. | .. | 4 | 3 | 3 | .. | 3 | .. | 84 |
| 18 Sagitta .. .. .. | .. | 4 | .. | .. | 18 | .. | .. | .. | .. |
| 19 Cypris .. .. .. | .. | .. | 7 | 51 | .. | .. | 180 | .. | .. |
| 20 Amphipods .. .. | .. | .. | 1 | 6 | 1 | 3 | .. | .. | .. |
| 21 Amphipod moults .. | .. | .. | .. | .. | .. | 10 | .. | .. | .. |

TABLE 7.

*Phyto-Plankton* 1960 $S_2$ *Numbers per c.c.*

| (1) | *April.* (2) | *May.* (3) | *June.* (4) | *July.* (5) | *August.* (6) | *September.* (7) | *October* (8) | *November.* (9) | *December.* (10) |
|---|---|---|---|---|---|---|---|---|---|
| *Phyto-Plankton—* | | | | | | | | | |
| 1 Spirulina .. .. .. | .. | 132 | .. | .. | .. | .. | .. | .. | .. |
| 2 Oscillatoria .. .. .. | .. | 4,020 | 106 | .. | .. | .. | .. | .. | .. |
| 3 Navicula .. .. .. | .. | 15,330 | 963 | .. | Rare. | 3,394 | 420 | 5,250 | 1,296 |
| 4 Gyrosigma .. .. .. | .. | 300 | .. | .. | .. | .. | 60 | 540 | 240 |
| 5 Suriella .. .. .. | .. | .. | .. | .. | .. | .. | .. | 180 | .. |
| 6 Guinardia .. .. .. | .. | .. | .. | .. | .. | .. | .. | 120 | .. |
| 7 Thalassiosira .. .. .. | .. | .. | .. | .. | .. | .. | .. | .. | 240 |
| 8 Chætoceras .. .. .. | .. | .. | 517 | .. | .. | .. | .. | .. | 180 |
| 9 Phæocystis .. .. .. | Rare. | .. | Rare. | .. | .. | .. | 60 | .. | Rare. |
| 10 Nostoc .. .. .. | .. | 88 | .. | .. | .. | .. | .. | .. | .. |
| 11 Phromidium .. .. .. | .. | 22 | .. | .. | .. | .. | .. | .. | .. |
| 12 Nitzchia closterium .. .. | .. | 3,180 | 60 | .. | .. | .. | .. | .. | .. |
| 13 Enteromorpha .. .. | .. | .. | .. | .. | .. | 14 | .. | .. | .. |

TABLE 8.

*Zoo-Plankton* 1961 $S_2$. *Numbers per c.c.*

| (1) | *January.* (2) | *February.* (3) | *March.* (4) | *April.* (5) | *May.* (6) | *June.* (7) | *July.* (8) | *August.* (9) | *September.* (10) | *October.* (11) | *November.* (12) | *December.* (13) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Zoo-Plankton.*— | | | | | | | | | | | | |
| 1 Fresh water shrimp. | .. | .. | .. | 1 | 3 | .. | .. | 1 | .. | .. | .. | .. |
| 2 Medusae .. | 302 | 349 | 600 | 123 | 507 | 577 | 71 | 227 | 197 | 308 | 117 | 233 |
| 3 Fish eggs .. | Rare. | 3 | 15 | 6 | .. | 15 | .. | 4 | 1 | .. | 1 | .. |
| 4 Copepods .. | 5,475 | 220 | 1,080 | 1,020 | 1,860 | 3,540 | 660 | 288 | 480 | 909 | 137 | 1,604 |
| 5 Nauplii .. .. | 840 | 961 | 1,320 | 60 | 1,320 | 2,580 | 420 | 672 | 720 | 807 | 1,107 | 895 |
| 6 Mesopodopsis .. | .. | .. | .. | 4 | .. | .. | .. | 6 | .. | 1 | 20 | 2 |
| 7 Dipteran wingscale. | .. | .. | .. | 60 | .. | .. | .. | .. | .. | .. | .. | .. |
| 8 Gastropod post-larvae. | .. | .. | .. | .. | 60 | .. | .. | .. | .. | .. | .. | .. |
| 9 Polychaete Post-larvae. | .. | .. | .. | .. | 60 | .. | .. | .. | .. | .. | .. | 1 |
| 10 Nematode .. | .. | .. | .. | .. | 60 | .. | .. | .. | 80 | .. | .. | .. |
| 11 Penaeus indicus larvae | .. | 220 | .. | .. | 3 | .. | .. | .. | .. | .. | .. | .. |
| 12 Fish larvae .. | Rare. | .. | 50 | .. | .. | 1 | .. | 20 | .. | .. | 2 | 5 |
| 13 Water beetle larvae. | .. | 1 | 60 | .. | .. | .. | 60 | 48 | .. | .. | .. | .. |
| 14 Bug larvae .. | .. | .. | .. | .. | .. | .. | .. | 1 | 1 | 22 | .. | .. |
| 15 Spionid .. .. | .. | .. | .. | .. | .. | .. | .. | 48 | .. | .. | .. | .. |
| 16 Caligus sp. .. | .. | .. | .. | .. | .. | .. | .. | .. | 1 | 1 | 1 | .. |
| 17 Euglena .. .. | 470 | .. | .. | .. | .. | .. | .. | .. | 80 | 2,116 | 173 | .. |
| 18 Amphipod moults. | 1 | .. | .. | .. | .. | .. | .. | .. | 33 | 10 | 9 | 59 |
| 19 Lepadid .. .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 1 | .. | .. |
| 20 Amphipods .. | 1 | .. | .. | .. | .. | .. | .. | .. | .. | 11 | 1 | 17 |
| 21 Megalopa .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 1 | .. | .. |
| 22 Obelia .. .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 1 | .. | .. |
| 23 Cypris .. .. | 3 | .. | .. | .. | .. | .. | .. | .. | .. | 153 | 173 | 404 |
| 24 Foraminiferan .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 22 | 13 | .. |
| 25 Gastropod egg raft. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 1 | 1 |
| 26 Water mite .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 11 |
| 27 Nothalca .. .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 11 |

TABLE 9.

*Phyto-Plankton* $S_2$ 1961 *Number per c.c.*

| (1) | *January.* (2) | *February.* (3) | *March.* (4) | *April.* (5) | *May.* (6) | *June.* (7) | *July.* (8) | *August.* (9) | *September.* (10) | *October.* (11) | *November.* (12) | *December.* (13) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Phyto-Plankton*— | | | | | | | | | | | | |
| 1 Nitzchia closterium. | 780 | 1,380 | .. | 1,800 | 60 | .. | .. | .. | .. | 196 | .. | .. |
| 2 Navicula .. .. | 4,695 | 1,680 | 120 | 1,440 | 5,460 | .. | .. | 96 | 9,760 | 5,738 | 1,880 | 65 |
| 3 Gyrosigma .. | 300 | .. | .. | 300 | .. | .. | 240 | .. | 640 | 153 | 53 | .. |
| 4 Thalassiosira .. | .. | .. | .. | 2,100 | .. | .. | .. | .. | .. | .. | .. | .. |
| 5 Phormidium .. | .. | .. | .. | 60 | .. | .. | .. | .. | 20,000 | .. | .. | .. |
| 6 Chaetomorpha .. | .. | .. | .. | .. | 60 | .. | .. | 48 | .. | .. | .. | .. |
| 7 Oscillatoria .. | .. | 2 | .. | .. | 60 | .. | .. | .. | .. | 109 | 40 | 360 |
| 8 Phaeocystis .. | .. | .. | .. | .. | .. | .. | .. | 3 | .. | .. | .. | .. |
| 9 Cladophora .. | .. | .. | .. | .. | .. | .. | .. | .. | 80 | 44 | .. | .. |
| 10 Achnanthes .. | .. | .. | .. | .. | .. | .. | .. | .. | 480 | 65 | .. | .. |
| 11 Diploneis .. | .. | .. | .. | .. | .. | .. | .. | .. | 80 | .. | .. | .. |
| 12 Bacillaria .. .. | .. | .. | 60 | .. | .. | .. | .. | .. | 80 | .. | .. | .. |
| 13 Merismopedia .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 22 | .. | .. |
| 14 Anabaena .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 22 | .. | .. |
| 15 Coscinodiscus .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 13 | .. |
| 16 Spirogyra .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 27 | 22 |
| 17 Enteromorpha .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 1 |
| 18 Nitzschia seriatum. | .. | 240 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| 19 Pleodorina .. | .. | 3 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| 20 Bacillariaceae .. | .. | 300 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |

TABLE 10.

*Meteorology of Fish Farm* 1960.

| *Months.* | *Air temperature.* | | *Wet bulb.* | *Dry bulb.* | *Relative humidity.* | *Water surface temperature.* | *Specific gravity.* |
|---|---|---|---|---|---|---|---|
| | *Maximum.* | *Minimum.* | | | | | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| | °C | °C | | | PER CENT. | °C | |
| January .. .. .. | 26·5 | 23·5 | .. | .. | .. | 26·5 | 1·001 |
| February .. .. .. | 27·5 | 24·5 | .. | .. | .. | .. | .. |
| March .. .. .. | 30·5 | 26·5 | .. | .. | .. | 29·5 | 1·010 |
| April .. .. .. | 31·0 | 28·25 | .. | .. | .. | 31·0 | 1·010 |
| May .. .. .. | 34·75 | 30·5 | .. | .. | .. | 30·5 | 1·010 |
| June .. .. .. | 34·5 | 31·0 | .. | .. | .. | 29·25 | 1·010 |
| July .. .. .. | 31·25 | 29·0 | .. | .. | .. | 30·25 | 1·010 |
| August .. .. .. | 33·25 | 29·25 | .. | .. | .. | 30·0 | 1·010 |
| September .. .. | 30·0 | 27·25 | 80·25 | 80·2 | 74·5 | 30·0 | 1·015 |
| October .. .. .. | 29·75 | 27·25 | 85 | 78 | 66·5 | 29·75 | 1·021 |
| November .. .. | 26·25 | 23·75 | 75 | 76 | 82·0 | 26·5 | 1·006 |
| December .. .. | 26·75 | 23·75 | 80 | 76 | 83·0 | 27·5 | 1·021 |

TABLE 11.

*Meteorology* 1961.

| *Months.* | *Air temperature.* | | *Wet bulb.* | *Dry bulb.* | *Relative humidity.* | *Weather.* | *Water surface temperature.* | *Specific gravity.* |
|---|---|---|---|---|---|---|---|---|
| | *Maximum.* | *Minimum.* | | | | | | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| | °C | °C | | | PER CENT. | | °C | |
| January .. .. .. | 26·5 | 24·5 | 75 | 80 | 79 | Showers. | 28·0 | 1·007 |
| February .. .. .. | 27·5 | 25·5 | 78 | 82 | 83 | Fair .. | 29·0 | 1·010 |
| March .. .. .. | 29·0 | 27·25 | 82 | 87 | 80 | Dry .. | 30·0 | 1·016 |
| April .. .. .. | 32·5 | 30·5 | 80 | 86 | 76 | Dry .. | 32·0 | 1·020 |
| May .. .. .. .. | 33·5 | 31·5 | 81 | 80 | 66 | Dry .. | 31·0 | 1·016 |
| June .. .. .. | 32·0 | 29·0 | 77 | 84 | 72 | Fair .. | 30·0 | 1·016 |
| July .. .. .. .. | 31·0 | 27·5 | 82 | 86 | 84 | Wet .. | 29·5 | 1·010 |
| August .. .. .. | 31·0 | 26·5 | 79 | 82 | 87 | Wet .. | 30·5 | 1·005 |
| September .. .. .. | 30·0 | 27·5 | 82 | 86 | 84 | Wet .. | 31·5 | 1·001 |
| October .. .. .. | 29·0 | 26·5 | 83 | 86 | 84 | Cloudy .. | 32·0 | 1·010 |
| November .. .. .. | 27·5 | 25·5 | 78 | 82 | 84 | Fair .. | 29·0 | 1·010 |
| December .. .. .. | 27·5 | 25·5 | 76 | 80 | 83 | Fair .. | 28·0 | 1·010 |

TABLE 12.

*Hydrology of Estuarine Fish Farm.*

1960 Pond S1.

| *Months.* | *Surface Temperature.* | *Specific gravity.* | *Turbidity.* | *Ph. value.* | *Salinity.* | *Oxygen.* | *Silicate.* |
|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| | °C. | | CMS. | | ‰ | c.c./L | Mgm/L |
| January .. .. .. | 24·5 | 1·001 | 52·0 | 8·7 | 27·1 | 4·75 | 24·0 |
| February .. .. .. | 25·0 | 1·010 | 54·5 | 8·7 | 29·6 | 4·40 | 39·6 |
| March .. .. .. | 26·5 | 1·012 | 29·75 | 8·7 | 31·0 | 4·50 | 53·2 |
| April .. .. .. | 27·0 | 1·012 | 45·0 | 8·4 | 35·6 | 5·75 | 52·1 |
| May .. .. .. | 27·5 | 1·020 | 41·0 | 8·4 | 35·6 | 4·34 | 50·0 |
| June .. .. .. | 26·5 | 1·020 | 41·5 | 8·4 | 36·1 | 4·27 | 50·0 |
| July .. .. .. | 27·5 | 1·020 | 48·0 | 8·4 | 36·2 | 4·34 | 63·3 |
| August .. .. .. | 28·0 | 1·020 | 54·5 | 7·4 | 36·0 | 4·50 | 62·5 |
| September .. .. | 28·5 | 1·021 | 71·0 | 8·0 | 31·06 | 4·06 | 69·5 |
| October .. .. .. | 27·5 | 1·021 | 56·5 | 7·8 | 21·25 | 4·69 | 62·0 |
| November .. .. | 25·5 | 1·010 | 76·0 | 7·6 | 10·15 | 4·41 | 31·25 |
| December .. .. | 26·0 | 1·001 | 107·0 | 7·8 | 20·6 | 4·06 | 11·25 |

TABLE 13.

*Hydrology of Estuarine Fish Farm.*

1961 Pond S. I.

| *Months.* (1) | *Surface Temp.* (2) | *Sp. Gr.* (3) | *Turbidity.* (4) CMS. | *Salinity.* (5) of%. | *Oxygen.* (6) cc/L. | *Carbon-dioxide.* (7) PPM. | *Carbonate.* (8) PPM. | *Bicar-bonate.* (9) PPM. | *Silicate.* (10) MGM/L. | *Phosphate.* (11) PPM | *Ph.* (12) | *Depth* (13) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| January .. .. | 26·5°c | 1·010 | 130·0 | 22·78 | 4·2 | 1·1 | .. | .. | 10·0 | .. | 7·6 | 5′0″ |
| February .. | 27·0°c | 1·012 | 109·0 | 25·82 | 4·06 | 1·0 | .. | .. | 22·0 | .. | 7·6 | 4′6″ |
| March .. .. | 27·5°c | 1·012 | 120·0 | 30·51 | 5·63 | Nil. | .. | .. | 32·12 | .. | 8·0 | 4′3″ |
| April .. .. | 28·5°c | 1·020 | 75·5 | 35·15 | 3·25 | Nil. | 3·5 | 32·0 | 48·0 | 1·39 | 8·4 | .. |
| May .. .. .. | 30·5°c | 1·020 | 84·0 | 31·6 | 3·16 | Nil. | 1·8 | 39·65 | 36·0 | 0·88 | 8·0 | .. |
| June .. .. | 29·5°c | 1·020 | 72·5 | 27·75 | 4·06 | Nil. | 1·5 | 20·13 | 24·25 | 0·72 | 8·1 | .. |
| July .. .. | 28·0°c | 1·012 | 85·0 | 16·75 | 4·2 | Nil. | 1·6 | 32·5 | 17·50 | .. | 8·2 | .. |
| August .. .. | 28·5°c | 1·010 | 91·5 | 20·3 | 4·36 | 2·5 | 1·5 | 28·0 | 7·50 | .. | 8·6 | .. |
| September .. .. | 31·5°c | 1·010 | 75·5 | 19·9 | 3·98 | 1·8 | 2·0 | 29·0 | 7·80 | 0·72 | 8·4 | .. |
| October .. .. | 31·5°c | 1·010 | 80·5 | 17·75 | 4·55 | 2 | 1·5 | 36·5 | 6·75 | .. | 7·8 | .. |
| November .. .. | 28·0°c | 1·010 | 80·0 | 16·66 | 4·6 | 1·5 | 1·5 | 43·01 | 8·50 | 0·68 | 7·8 | .. |
| December .. .. | 27·5°c | 1·010 | 86·5 | 17·25 | 4·13 | 1·2 | 2·5 | 41·5 | 8·0 | .. | 8·2 | .. |

TABLE 14.

*Hydrology of Estuarine Fish Farm.*

1960 Pond S. II.

| *Months.* | *Surface Temperature.* | *Specific gravity.* | *Turbidity.* | *Ph. value.* | *Salinity.* | *Oxygen.* | *Silicate.* |
|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| | °C. | | CMS. | | %. | *c.c./L.* | *Mgm.* |
| January .. .. .. | 25·5 | 1·001 | 44·5 | 8·7 | 24·58 | 4·75 | 48·3 |
| February .. .. | 26·0 | 1·010 | 48·2 | 8·7 | 28·6 | 4·00 | 53·3 |
| March .. .. .. | 26·5 | 1·010 | 50·5 | 8·7 | 31·1 | 4·62 | 55·5 |
| April .. .. .. | 26·5 | 1·020 | 52·0 | 8·4 | 34·1 | 3·1 | 52·1 |
| May .. .. .. | 27·0 | 1·020 | 44·0 | 8·0 | 35·6 | 5·57 | 56·8 |
| June .. .. .. | 27·5 | 1·020 | 44·0 | 8·0 | 35·5 | 3·57 | 83·3 |
| July .. .. .. | 27·5 | 1·020 | 49·0 | 8·2 | 36·8 | 4·19 | 65·7 |
| August .. .. .. | 28·0 | 1·020 | 52·0 | 8·1 | 36·6 | 4·06 | 83·3 |
| September .. .. | 28·5 | 1·021 | 79·0 | 7·2 | 32·13 | 3·08 | 71·4 |
| October .. .. .. | 26·0 | 1·021 | 116·0 | 7·6 | 24·85 | 3·85 | 27·7 |
| November .. .. | 25·5 | 1·001 | 120·0 | 7·6 | 16·2 | 4·62 | 12·0 |
| December .. .. | 25·5 | 1·001 | 110·0 | 7·6 | 22·0 | 4·13 | 10·12 |

TABLE 15.

*Hydrology of Estuarine fish farm.*

**1961** *Pond S. II.*

| *Months.* | *Surface Temp.* | *Sp. Gr.* | *Turbidity.* | *Salinity.* | *Oxygen.* | *Ph.* | *Silicate.* | *Carbonate.* | *Bicarbonate.* | *Carbon-dioxide.* | *Phosphate.* | *Depth.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) |
| | | | CM. | % | cc/L. | MGM. | PPM. | PPM. | PPM. | PPM. | PPM. | F. ins. |
| January .. .. .. .. | 26·5° | 1·010 | 125·0 | 23·14 | 4·41 | 7·6 | 10·0 | .. | .. | 1·1 | .. | 4′ 3″ |
| February .. .. .. .. | 27·0° | 1·011 | 110·0 | 25·02 | 3·85 | 7·6 | 30·0 | .. | .. | 1·0 | .. | 4′8½″ |
| March .. .. .. .. | 28·0° | 1·012 | 122·0 | 30·14 | 5·95 | 7·8 | 46·0 | .. | .. | 2·0 | .. | 3′10″ |
| April .. .. .. .. | 29·0° | 1·020 | 114·0 | 37·93 | 3·38 | 8·2 | 51·35 | 5·5 | 37·5 | 1·0 | 1·32 | .. |
| May .. .. .. .. | 30·5° | 1·020 | 117·0 | 30·9 | 3·00 | 8·2 | 35·3 | 1·0 | 46·6 | Nil. | 1·39 | .. |
| June .. .. .. .. | 29·5° | 1·020 | 94·5 | 30·25 | 3·97 | 7·8 | 29·60 | 1·1 | 48·8 | Nil. | 1·32 | .. |
| July .. .. .. .. | 28·0° | 1·018 | 98·0 | 26·5 | 3·75 | 7·6 | 25·25 | 1·5 | 25·25 | 0·5 | .. | .. |
| August .. .. .. .. | 28·5° | 1·012 | 97·0 | 25·05 | 3·1 | 8·2 | 26·5 | 1·8 | 26·5 | 2·2 | 0·92 | .. |
| September .. .. .. .. | 31·5° | 1·010 | 92·0 | 23·7 | 3·6 | 8·4 | 29·40 | 1·8 | 29·4 | 2·0 | .. | .. |
| October .. .. .. .. | 32·0° | 1·010 | 96·0 | 21·6 | 3·1 | 7·8 | 46·33 | 1·6 | 40·33 | 2·5 | 0·92 | .. |
| November .. .. .. .. | 31·5° | 1·010 | 85·5 | 19·33 | 3·99 | 7·6 | 41·175 | 1·5 | 41·78 | 2·5 | 0·71 | .. |
| December .. .. .. .. | 28·0° | 1·010 | 94·5 | 19·89 | 4·2 | 8·2 | 43·31 | 1·5 | 48·8 | 2·0 | 0·87 | .. |

TABLE 16-A.

*Growth studies of chanos chanos in "S. 1."*

Numbers stocked—200.

Date of stocking—17th February 1961.

| *Date.* | *Size range in mm.* | | *Weight range in grams.* | |
|---|---|---|---|---|
| | *Minimum.* | *Maximum.* | *Minimum.* | *Maximum.* |
| (1) | (2) | (3) | (4) | (5) |
| 17th February 1961 | 82 | 135 | 8 | 10 |
| 25th March 1961 | 150 | 216 | 40 | 90 |
| 22nd April 1961 | 195 | 267 | 55 | 145 |
| 29th May 1961 | 195 | 337 | 83 | 270 |
| 27th June 1961 | 255 | 380 | 230 | 380 |
| 15th July 1961 | 330 | 470 | 240 | 350 |
| 19th August 1961 | 342 | 380 | 310 | 400 |
| 16th September 1961 | 356 | 372 | 350 | 410 |

TABLE 16-B.

*Growth studies of chanos chanos in "S. 2."*

Numbers stocked—100.

Date of stocking—17th February 1961.

| *Date.* | *Size range in mm.* | | *Weight range in grams.* | |
|---|---|---|---|---|
| | *Minimum.* | *Maximum.* | *Minimum.* | *Maximum.* |
| (1) | (2) | (3) | (4) | (5) |
| 17th February 1961 | 62 | 125 | 75 | 14 |
| 25th March 1961 | 157 | 190 | 30 | 65 |
| 22nd April 1961 | 155 | 269 | 50 | 140 |
| 29th May 1961 | 195 | 298 | 62 | 180 |
| 27th June 1961 | 216 | 354 | 70 | 320 |
| 15th July 1961 | 225 | 377 | 80 | 572 |
| 19th August 1961 | 287 | 359 | 205 | 320 |
| 16th September 1961 | 313 | 384 | 250 | 400 |

TABLE 17-A.

*Growth studies of chanos chanos in " S. 5."*

Number stocked—4350. Date of stocking—1st June 1960.

| Date. | Size range in mm. | | Weight range in grams. | |
|---|---|---|---|---|
| | Minimum. | Maximum. | Minimum. | Maximum. |
| (1) | (2) | (3) | (4) | (5) |
| 1st June 1960 .. .. .. .. .. | 50 | 85 | 0·5 | 2 |
| 27th August 1960 .. .. .. .. .. | 90 | 135 | 19 | 34 |
| 27th September 1960 .. .. .. .. | 140 | 180 | 32 | 56 |
| 10th October 1960 .. .. .. .. | 120 | 195 | 40 | 95 |
| 30th November 1960 .. .. .. .. | 155 | 220 | 70 | 120 |
| 31st December 1960 .. .. .. .. | 115 | 235 | 52 | 155 |
| 23rd February 1961 .. .. .. .. | 172 | 296 | 60 | 130 |
| 11th March 1961 .. .. .. .. | 112 | 297 | 90 | 150 |
| | (Partly disposed by sale to thin out population.) | | | |
| 27th April 1961 .. .. .. .. .. | 215 | 276 | 90 | 150 |
| 2nd June 1961 .. .. .. .. .. | 243 | 264 | 110 | 150 |
| 29th July 1961 .. .. .. .. .. | 259 | 300 | 160 | 250 |
| 24th August 1961 .. .. .. .. .. | 203 | 300 | 110 | 240 |

TABLE 17-B.

*Growth studies of chanos chanos in " S. 3."*

Number stocked—100 from " S. 5." Date of transference—23rd February 1961.

| Date. | Size range in mm. | | Weight range in grams. | |
|---|---|---|---|---|
| | Minimum. | Maximum. | Minimum. | Maximum. |
| (1) | (2) | (3) | (4) | (5) |
| 23rd February 1961 .. .. .. .. | 172 | 251 | 52 | 155 |
| 18th March 1961 .. .. .. .. .. | 220 | 264 | 85 | 170 |
| 26th April 1961 .. .. .. .. .. | 212 | 260 | 80 | 120 |
| 29th May 1961 .. .. .. .. .. | 207 | 267 | 100 | 140 |
| | (Not available in June and July.) | | | |
| 24th August 1961 .. .. .. .. .. | 272 | 276 | 170 | 180 |

**TABLE 18.**

*Plankton S. 5.—1960 Numbers per c c.*

| (1) | April. (2) | May. (3) | June. (4) | July. (5) | August. (6) | September. (7) | October. (8) | November. (9) | December. (10) |
|---|---|---|---|---|---|---|---|---|---|
| *Zoo plankton*— | | | | | | | | | |
| 1 Naupli | 5,740 | 3,717 | 590 | 2,777 | 83 | 789 | 912 | .. | 540 |
| 2 Shrimp | .. | .. | .. | .. | .. | .. | .. | .. | Rare. |
| 3 Peridinium | .. | 3,781 | .. | .. | .. | .. | .. | .. | .. |
| 4 Water mite | .. | .. | .. | .. | Rare. | .. | .. | .. | .. |
| 5 Rotifer | .. | .. | .. | .. | .. | 60 | 96 | .. | .. |
| 6 Lepadid | .. | 1 | 13 | 14 | 12 | 14 | 3 | .. | 1 |
| 7 Copepods | 1,716 | 3,516 | 1,804 | 4,118 | 143 | 2,107 | 2,192 | .. | 1,140 |
| 8 Vivipara | .. | .. | .. | 24 | .. | .. | .. | .. | .. |
| 9 Sagitta | .. | .. | .. | 21 | .. | .. | .. | 1 | .. |
| 10 Wing scale of Dipteran | .. | .. | .. | .. | .. | .. | .. | .. | 360 |
| 11 Fish larvae | .. | Rare. | 33 | Rare. | 2 | .. | .. | 16 | 1 |
| 12 Mesoposdopsis | .. | .. | .. | 1 | 19 | 1 | 26 | 16 | 2 |
| 13 *Lucifer* | .. | .. | .. | Rare. | .. | .. | Rare. | .. | .. |
| 14 Cypris | .. | Rare. | .. | 13 | .. | .. | .. | .. | .. |
| 15 Amphipod | .. | 1 | 131 | 27 | 36 | .. | .. | .. | .. |
| 16 Amphipod moults | .. | .. | .. | .. | .. | 1 | 1 | .. | .. |
| 17 Prawn larvae | .. | .. | .. | .. | .. | .. | 1 | Rare. | 1 |
| 18 Medusae | .. | .. | .. | .. | .. | .. | 1 | .. | 3 |
| 19 Polychaete Post larvae | .. | .. | 121 | .. | .. | .. | .. | .. | .. |
| 20 Nemotode | .. | Rare. | .. | Rare. | .. | .. | .. | .. | Rare. |
| 21 Fish eggs | .. | .. | 37 | .. | .. | .. | Rare. | .. | .. |
| 22 Argulids | .. | .. | 3 | .. | .. | .. | .. | .. | .. |
| 23 Ceratium furca | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| 24 Zoea | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| 25 Gastropod post larvae | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| 26 Nepa | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| 27 Obelia | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| *Phyto Plankton*— | | | | | | | | | |
| 1 Phaeocystis | 20,724 | 96 | 19 | 27 | .. | .. | .. | .. | .. |
| 2 Chaetoceras | 220 | 156,800 | .. | .. | .. | .. | .. | 780 | .. |
| 3 Rhizosolenium alata | 220 | .. | .. | .. | .. | .. | .. | .. | .. |
| 4 Navicula | 264 | 8,928 | 3,202 | 70 | 618 | .. | 1,056 | 1,560 | 600 |
| 5 Nitzschia closterium | 440 | .. | .. | .. | .. | .. | .. | 780 | .. |
| 6 Microcystis | .. | .. | 4,231 | .. | .. | .. | .. | .. | .. |
| 7 Gyrosigma | .. | .. | 460 | .. | .. | .. | .. | 180 | 480 |
| 8 Thalassiosira | .. | .. | .. | .. | .. | .. | 48 | .. | .. |
| 9 Oscillatoria | .. | .. | .. | .. | .. | .. | .. | 120 | .. |
| 10 Guinardia | .. | .. | .. | .. | .. | .. | .. | 60 | .. |
| 11 Suriella | .. | .. | .. | .. | .. | .. | .. | 60 | .. |
| 12 Pleodorina | .. | .. | .. | .. | .. | .. | .. | 60 | .. |
| 13 Nostoc | .. | .. | .. | .. | .. | .. | .. | .. | Rare. |
| 14 Merismopedia | .. | .. | .. | .. | .. | .. | .. | .. | 60 |

TABLE 19.

*S. 5.—1961 Number per c c.*

| *Zoo plankton.* | *January.* | *February.* | *March.* | *April.* | *May.* | *June.* | *July.* | *August.* | *September.* | *October.* | *November.* | *December.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) |
| 1961— | | | | | | | | | | | | |
| 1 Lepadid .. .. .. .. | 4 | 15 | .. | 1 | 1 | .. | .. | .. | 4 | 3 | .. | .. |
| 2 Copepods .. .. .. .. | 1,920 | 2,340 | 9,840 | 1,680 | 2,280 | 1,140 | 300 | 1,152 | 1,120 | 1,560 | 2,040 | 480 |
| 3 Nauplii .. .. .. .. | 2,500 | 2,880 | 1,670 | 1,680 | 1,320 | 1,800 | 780 | 1,488 | 160 | 360 | 720 | 600 |
| 4 Mesopodopsis .. .. .. | .. | 5 | 10 | 6 | 30 | 273 | 10 | 30 | 2 | 6 | .. | 3 |
| 5 Medusae .. .. .. .. | .. | 60 | 2 | 6 | 8 | 7 | 2 | 17 | 1 | 38 | 28 | 75 |
| 6 Polychaetepost larvae .. .. | .. | 180 | .. | 60 | .. | .. | .. | 43 | .. | .. | .. | .. |
| 7 Prawn larvae .. .. .. | .. | .. | 1 | .. | 2 | 2 | .. | .. | .. | .. | .. | .. |
| 8 Cypris .. .. .. .. | .. | .. | .. | .. | 61 | .. | .. | 43 | 160 | 360 | 240 | 600 |
| 9 Fish larvae .. .. .. | 3 | Rare. | .. | .. | 1 | .. | .. | .. | 3 | .. | 1 | .. |
| 10 Obelia .. .. .. .. | .. | 2 | 2 | .. | 180 | 150 | .. | .. | .. | .. | .. | .. |
| 11 Brachionus .. .. .. | .. | .. | .. | .. | 0 | .. | .. | .. | .. | .. | .. | .. |
| 12 Spionid .. .. .. .. | .. | .. | .. | .. | 60 | .. | .. | .. | .. | .. | .. | .. |
| 13 Dipteran wing scale .. .. | .. | .. | .. | .. | .. | 25 | .. | .. | .. | .. | .. | .. |
| 14 Fish eggs .. .. .. .. | Rare. | 15 | 2 | .. | .. | 50 | .. | 3 | 2 | .. | .. | .. |
| 15 Amphipod .. .. .. | Rare. | .. | .. | .. | .. | 120 | .. | 6 | 163 | .. | 11 | 4 |
| 16 Peridinium .. .. .. | 120 | .. | .. | .. | .. | .. | 60 | .. | .. | .. | .. | .. |
| 17 Amphipod moults .. .. | 1 | .. | .. | .. | .. | .. | .. | 1 | 16 | .. | .. | .. |
| 18 Lamellibranch post larvae .. | .. | .. | .. | .. | .. | .. | .. | 48 | .. | .. | .. | .. |
| 19 Pandorina.. .. .. .. | .. | .. | .. | .. | .. | .. | .. | 1 | .. | .. | .. | .. |
| 20 Megalopa .. .. .. .. | .. | .. | .. | .. | .. | .. | .. | .. | 1 | .. | .. | .. |
| 21 Caligus sp. .. .. .. | .. | .. | .. | .. | .. | .. | .. | .. | 1 | 1 | 1 | .. |
| 22 Vorticella .. .. .. .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 120 | .. | .. |
| 23 Water beetle .. .. .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 120 | .. | .. |
| 24 Foraminiferan .. .. .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 120 | .. | .. |
| 25 Gastropod post larvae .. .. | 60 | .. | .. | .. | .. | .. | .. | .. | .. | .. | 120 | .. |
| 26 Ceratium furca .. .. .. | 60 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| 27 Zoea .. .. .. .. | 1 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| 28 Nepa .. .. .. .. | Rare. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |

TABLE 20.

*Phyto plankton S. 5.—1961 Numbers per c c.*

| | *January.* | *February.* | *March.* | *April.* | *May.* | *June.* | *July.* | *August.* | *September.* | *October.* | *November.* | *December.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) |
| *Phyto plankton—* | | | | | | | | | | | | |
| 1 Oscillatoria .. .. .. | .. | .. | .. | 34,500 | 360 | .. | .. | .. | 160 | 1,200 | 2,760 | 1,200 |
| 2 Navicula .. .. .. .. | 600 | .. | 6,900 | .. | 11,640 | .. | .. | .. | .. | 3,600 | 15,400 | 5,400 |
| 3 Gyrosigma .. .. .. | 480 | 120 | .. | .. | 240 | .. | .. | .. | .. | .. | .. | 240 |
| 4 Phaeocystis .. .. .. | .. | .. | .. | .. | 1 | 75 | | .. | .. | .. | .. | .. |
| 5 Nitzschia closterium .. .. | .. | .. | 2,580 | .. | 480 | .. | .. | .. | .. | .. | .. | 120 |
| 6 Microcystis .. .. .. | .. | .. | .. | .. | 1,140 | .. | .. | .. | .. | .. | .. | .. |
| 7 Phormidium .. .. .. | .. | .. | .. | .. | .. | 60 | 540 | 48 | .. | .. | .. | .. |
| 8 Guinardia .. .. .. | .. | .. | .. | .. | .. | 60 | .. | .. | .. | .. | .. | .. |
| 9 Melosira .. .. .. .. | .. | .. | .. | .. | .. | 60 | .. | .. | .. | .. | .. | .. |
| 10 Polysiphonia .. .. .. | .. | .. | .. | .. | .. | 50 | .. | .. | .. | | .. | .. |
| 11 Enteromorpha .. .. .. | .. | .. | .. | .. | .. | .. | 1 | .. | 1 | .. | .. | .. |
| 12 Merismopedia .. .. .. | .. | 60 | .. | .. | .. | .. | .. | 48 | .. | .. | .. | .. |
| 13 Achnanthes .. .. .. | .. | .. | .. | .. | .. | .. | .. | .. | 80 | 120 | 1,800 | .. |
| 14 Thalassiosira .. .. .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 120 | .. | .. |
| 15 Fragillaria .. .. .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 120 | .. |
| 16 Chaetomorpha .. .. .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| 17 Nostoc .. .. .. .. | Rare. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |

TABLE 21.

*Plankton S. 3.—1961 Number per cc.*

| | *January.* | *February.* | *March.* | *April.* | *May.* | *June.* | *July.* | *August.* | *September.* | *October.* | *November.* | *December.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) |
| *Zoo plankton—* | | | | | | | | | | | | |
| 1 Mesopodopsis .. | Rare. | 9 | .. | 83 | 4 | 20 | 54 | 7 | 58 | .. | .. | .. |
| 2 Medusae .. | 151 | 13 | 11 | 243 | 243 | 265 | 10 | 83 | 12 | 23 | 36 | 50 |
| 3 Fish eggs .. | .. | .. | 26 | 167 | 49 | 94 | 397 | 162 | 99 | .. | .. | .. |
| 4 Cypris .. | .. | .. | .. | 180 | 60 | 60 | 180 | 48 | 80 | .. | 240 | 240 |
| 5 Copepods .. | 9,560 | 1,980 | 3,660 | 3,000 | 2,640 | 1,500 | 840 | 528 | 1,520 | 1,760 | 960 | 360 |
| 6 Naupiil .. .. | 480 | 1,020 | 5,660 | 1,680 | 3,480 | 2,820 | 360 | 576 | 640 | 560 | 480 | 380 |
| 7 Fish fry .. .. | .. | .. | .. | .. | 5 | .. | .. | 2 | 5 | 2 | .. | 10 |
| 8 Nematodes .. | 6 | .. | .. | .. | 120 | .. | .. | .. | .. | .. | .. | .. |
| 9 Obelia .. .. | .. | .. | .. | .. | 3 | .. | .. | .. | .. | .. | .. | .. |
| 10 Penaeus indicus .. | .. | .. | .. | .. | .. | 5 | .. | .. | .. | Rare. | .. | .. |
| 11 Amphipod .. | .. | .. | .. | .. | .. | .. | 120 | 96 | 80 | .. | .. | .. |
| 12 Caligus sp. .. | .. | .. | .. | .. | .. | .. | 38 | .. | 12 | .. | .. | .. |
| 13 Water mite .. | .. | .. | .. | .. | .. | .. | 60 | .. | .. | .. | .. | .. |
| 14 Anuraea .. .. | .. | .. | .. | .. | .. | .. | .. | 48 | .. | .. | .. | .. |
| 15 Gastropods .. | .. | .. | .. | .. | .. | .. | .. | 4 | .. | .. | .. | .. |
| 16 Water beetle .. | 6 | .. | .. | .. | .. | .. | .. | 48 | .. | .. | .. | .. |
| 17 Zoea .. .. | .. | .. | .. | .. | .. | .. | .. | 144 | .. | .. | .. | .. |
| 18 Amphipod moults | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 25 |
| 19 Fish larvae .. | Rare. | 2 | 25 | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| *Phyto plankton—* | | | | | | | | | | | | |
| 1 Pleodorina .. | .. | 120 | .. | 60 | .. | .. | .. | .. | .. | .. | .. | .. |
| 2 Navicula .. | 13 | 60 | .. | 40,140 | 120 | .. | .. | .. | .. | .. | .. | 240 |
| 3 Chaetophora .. | .. | .. | .. | 240 | .. | .. | .. | .. | .. | .. | .. | .. |
| 4 Nitzschia closterium. | .. | .. | .. | 900 | .. | .. | .. | .. | .. | .. | .. | .. |
| 5 Chaetoceras .. | .. | .. | .. | 60 | .. | .. | .. | .. | .. | .. | .. | .. |
| 6 Nostoc .. .. | .. | .. | .. | 180 | .. | .. | .. | .. | .. | .. | .. | .. |
| 7 Phaeocystis .. | .. | .. | .. | 375 | .. | 1 | .. | .. | .. | .. | .. | .. |
| 8 Oscillatoria .. | .. | 60 | .. | .. | 120 | .. | .. | .. | .. | .. | .. | .. |
| 9 Merismopedia .. | .. | 120 | .. | .. | 60 | .. | .. | .. | .. | .. | .. | 120 |
| 10 Polysiphonia .. | .. | .. | .. | .. | .. | .. | 63 | .. | .. | .. | .. | .. |
| 11 Gyrosigma .. | 19 | .. | .. | .. | .. | .. | 60 | .. | .. | .. | .. | 240 |
| 12 Cosmarium .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 120 |

TABLE 22.

*Hydrology of Estuarine Fish Farm Ponds*—SV. 1960.

| *Months.* (1) 1960. | *Temperature.* (2) °c. | *Specific gravity.* (3) | *Turbidity.* (4) CM. | *PH. Value.* (5) | *Salinity.* (6) PER CENT. | *Oxygen.* (7) cc/L. | *Silicate.* (8) MGM. |
|---|---|---|---|---|---|---|---|
| January .. .. .. | .. | .. | .. | .. | .. | .. | .. |
| February .. .. .. | 27·5 | 1·001 | 48·0 | 8·7 | 31·59 | 3·54 | 65·8 |
| March .. .. .. | 26·0 | 1·001 | 44·4 | 8·7 | 36·1 | 4·52 | 58·2 |
| April .. .. .. | 27·5 | 1·02 | 43·0 | 8·4 | 39·4 | 4·26 | 65·8 |
| May .. .. .. | 27·0 | 1·02 | 42·0 | 8·4 | 42·72 | 4·27 | 69·4 |
| June .. .. .. | 25·0 | 1·02 | 29·5 | 8·4 | 43·4 | 4·48 | 62·5 |
| July .. .. .. | 27·5 | 1·021 | 44·0 | 8·2 | 44·0 | 4·06 | 53·2 |
| August .. .. .. | 28·0 | 1·021 | 48·0 | 8·1 | 43·5 | 5·11 | 50·0 |
| September .. .. | 27·5 | 1·021 | 69·0 | 8·2 | 34·38 | 4·41 | 45·6 |
| October .. .. .. | 27·0 | 1·01 | 71·0 | 8·0 | 21·5 | 4·41 | 24·0 |
| November .. .. | 26·0 | 1·001 | 64·25 | 8·4 | 9·95 | 4·41 | 10·75 |
| December .. .. .. | 25·56 | 1·001 | 92·0 | 8·5 | 15·0 | 4·55 | 10·5 |

TABLE 23.

*Hydrology of Estuarine Fish Farm—Pond SV. 1961.*

| *Months.* | *Temperature.* | *Specific gravity.* | *Turbidity.* | *Salinity.* | *Oxygen.* | *PH. Value.* | *Silicate.* | *Carbon-dioxide.* | *Carbonate.* | *Bi-carbonate.* | *Phosphate.* | *Depth.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) |
| 1961. | °c. | | CM. | 0/00. | cc/L. | | MGM/L | PPM. | PPM. | PPM. | PPM. | FT. INS. |
| January .. .. | 26·5 | 1·1012 | 72·0 | 23·49 | 4·41 | 8·0 | 10·0 | 1·1 | .. | .. | .. | 4·3 |
| February .. .. | 27·0 | 1·012 | 75·0 | 25·48 | 3·92 | 8·0 | 27·5 | 1·0 | .. | .. | .. | 4·0 |
| March .. .. .. | 28·0 | 1·012 | 57·5 | 32·78 | 5·18 | 8·2 | 41·6 | .. | .. | .. | .. | 3·9 |
| April .. .. .. | 28·5 | 1·02 | 36·5 | 36·9 | 3·25 | 8·4 | 43·5 | Nil. | 2·0 | 26·0 | 1·87 | .. |
| May .. .. .. | 31·0 | 1·02 | 53·5 | 31·96 | 2·6 | 7·6 | 30·25 | Nil. | 1·0 | 25·5 | 1·89 | .. |
| June .. .. .. | 28·5 | 1·016 | 58·5 | 29·675 | 4·425 | 8·3 | 24·4 | Nil. | 1·5 | 24·4 | .. | .. |
| July .. .. .. | 28·0 | 1·016 | 66·5 | 19·25 | 4·36 | 8·2 | 18·75 | Nil. | 2·0 | 30·0 | 0·68 | .. |
| August .. .. | 29·0 | 1·008 | 64·5 | 20·9 | 4·2 | 8·6 | 7·25 | 2·0 | 1·2 | 28·8 | 0·68 | .. |
| September .. .. | 29·5 | 1·01 | 63·0 | 20·95 | 4·2 | 8·2 | 6·5 | 2·0 | 2·0 | 28·25 | .. | .. |
| October .. .. | 30·5 | 1·01 | 71·5 | 15·81 | 4·26 | 7·8 | 7·0 | 2·2 | 1·5 | 33·55 | 0·78 | .. |
| November .. .. | 32·0 | 1·01 | 73·5 | 14·6 | 4·56 | 8·0 | 6·0 | 1·0 | 1·6 | 44·5 | 0·69 | .. |
| December .. .. | 28·0 | 1·01 | 62·0 | 16·06 | 4·27 | 8·0 | 6·0 | 1·0 | 1·2 | 34·5 | 0·92 | .. |

TABLE 24.

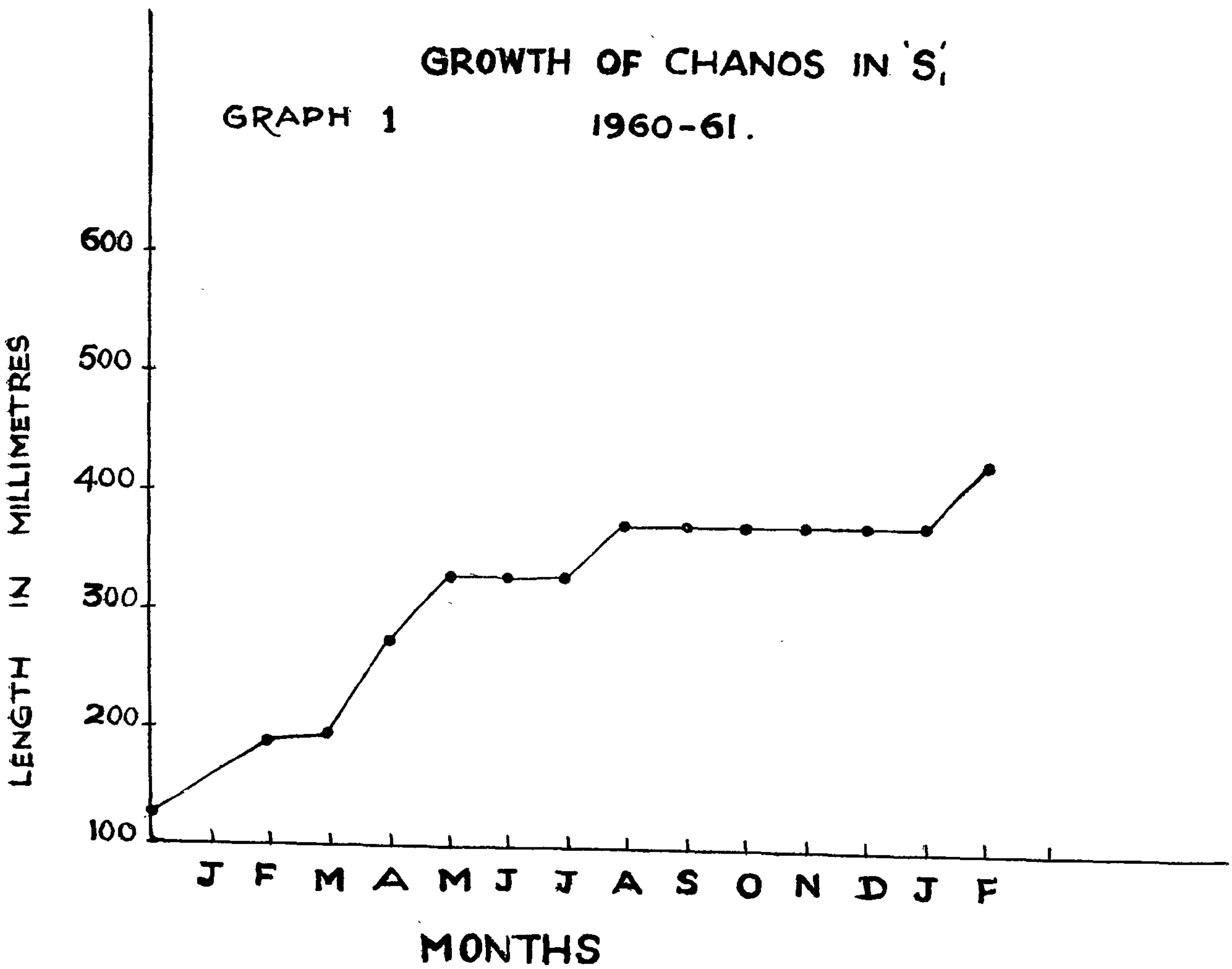
*Hydrology of Estuairne Fish Farm—Pond* S. *III*. 1960.

| *Months.* | *Temperature.* | *Specific gravity.* | *Turbidity.* | *PH. value.* | *Salinity.* | *Oxygen cc/L.* | *Silicate.* |
|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| 1960. | °C. | | CM. | | C/OC. | CC/L. | MGM/L. |
| January .. .. .. | 24·5 | 1·001 | 35·0 | 8·7 | 25·94 | 4·362 | 31·25 |
| February .. .. .. | 27·5 | 1·001 | 30·5 | 8·7 | 35·5 | 4·2 | 62·5 |
| March .. .. .. | 26·5 | 1·001 | 55·4 | 8·7 | 32·7 | 4·26 | 62·5 |
| April .. .. .. | 27·0 | 1·02 | 42·0 | 8·4 | 34·0 | 4·605 | 54·3 |
| May .. .. .. | 27·5 | 1·02 | 40·0 | 8·4 | 31·7 | 4·76 | 59·5 |
| June .. .. .. | 25·0 | 1·02 | 39·0 | 8·4 | 33·2 | 4·0 | 78·2 |
| July .. .. .. | 27·5 | 1·02 | 44·0 | 7·8 | 33·4 | 3·64 | 65·5 |
| August .. .. .. | 27·5 | 1·021 | 73·0 | 8·1 | 33·25 | 4·2 | 56·8 |
| September .. .. | 28·0 | 1·02 | 96·0 | 7·8 | 30·31 | 3·7 | 78·1 |
| October .. .. .. | 27·0 | 1·01 | 82·7 | 7·6 | 22·7 | 4·06 | 22·5 |
| November .. .. | 26·0 | 1·012 | 100·0 | 7·4 | 10·5 | 4·34 | 8·75 |
| December .. .. .. | 25·5 | 1·001 | 93·25 | 7·4 | 14·25 | 4·2 | 11·25 |

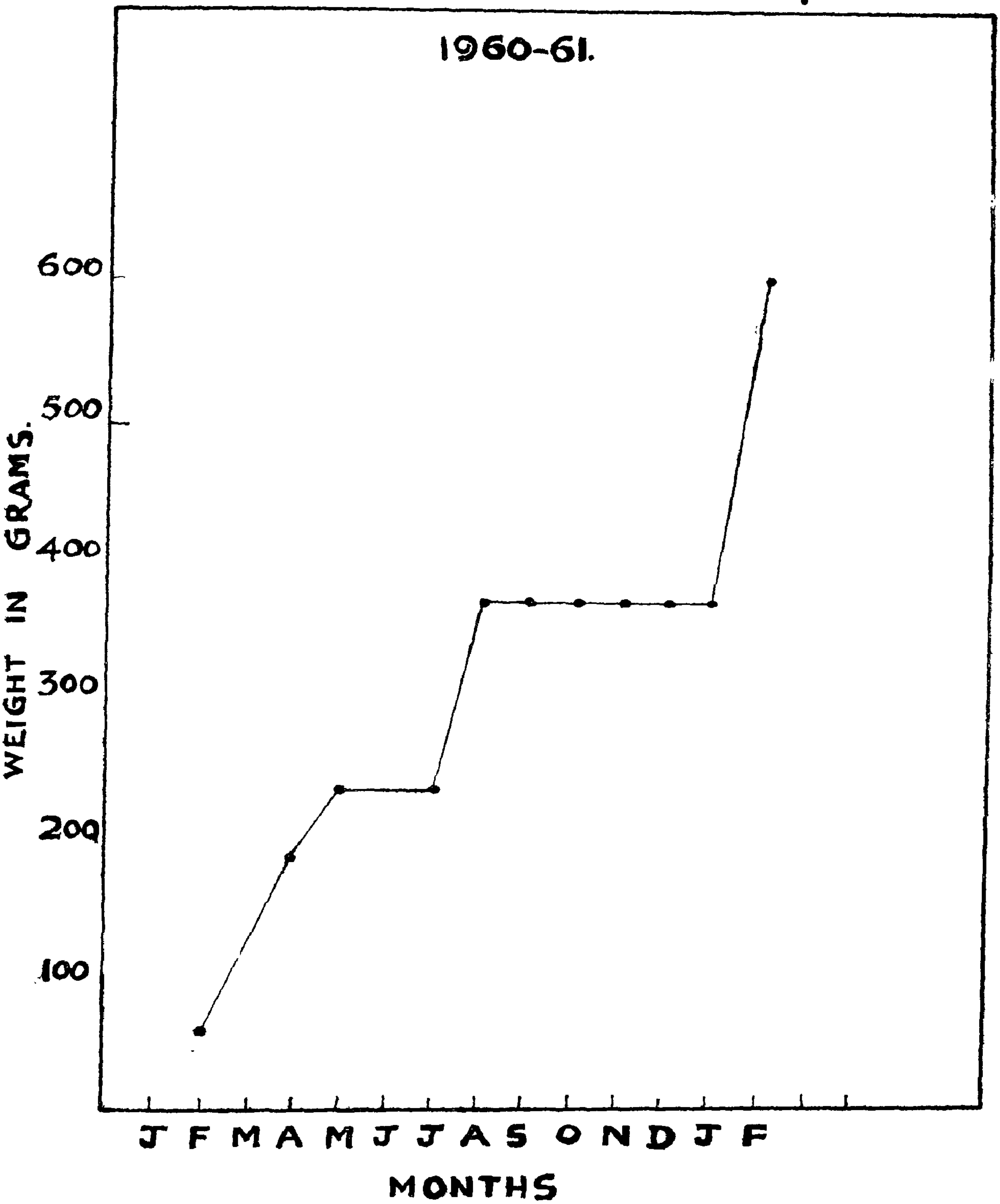
TABLE 25.

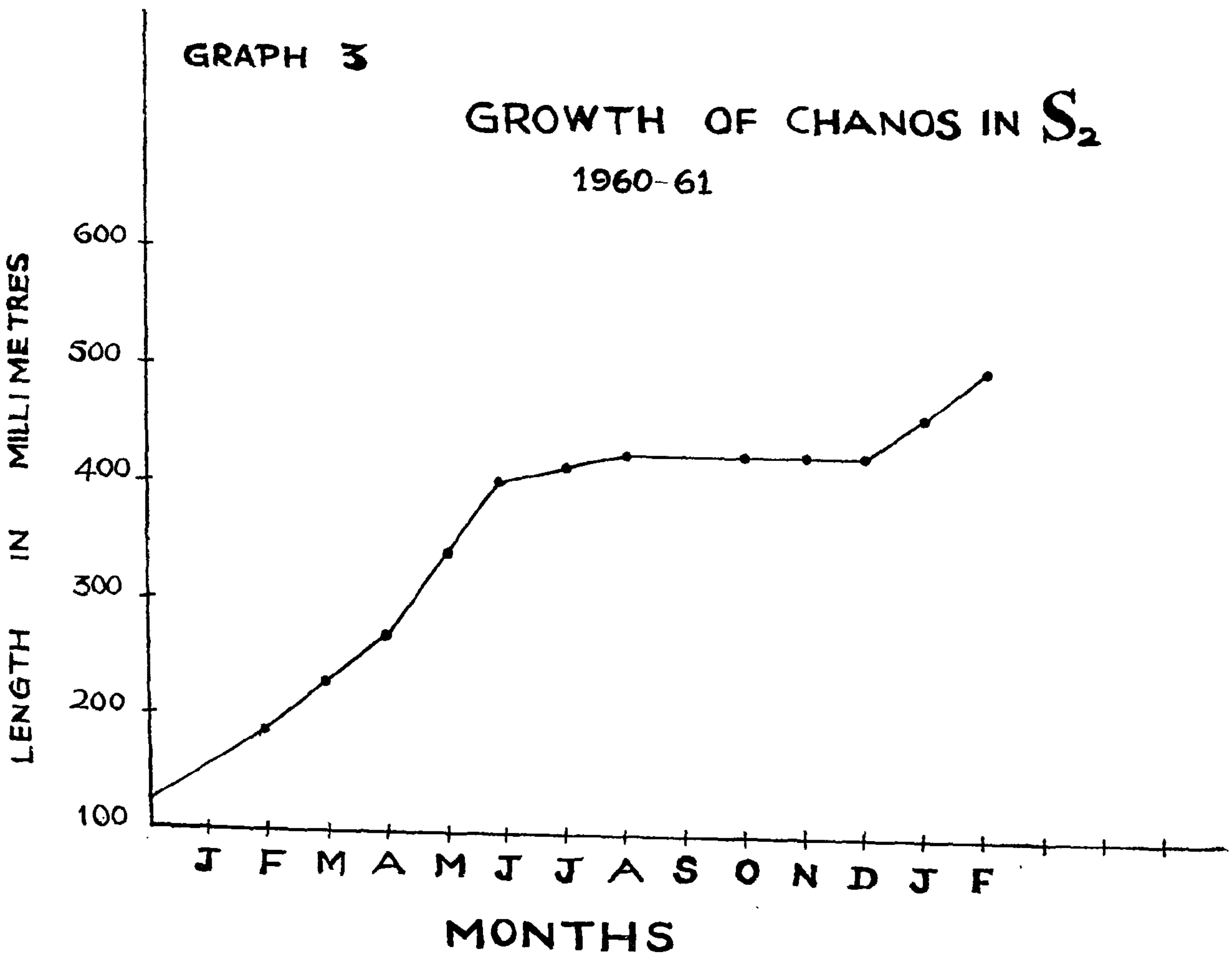
*Hydrology of Estuarine Fish Farm—Pond S III.* 1961.

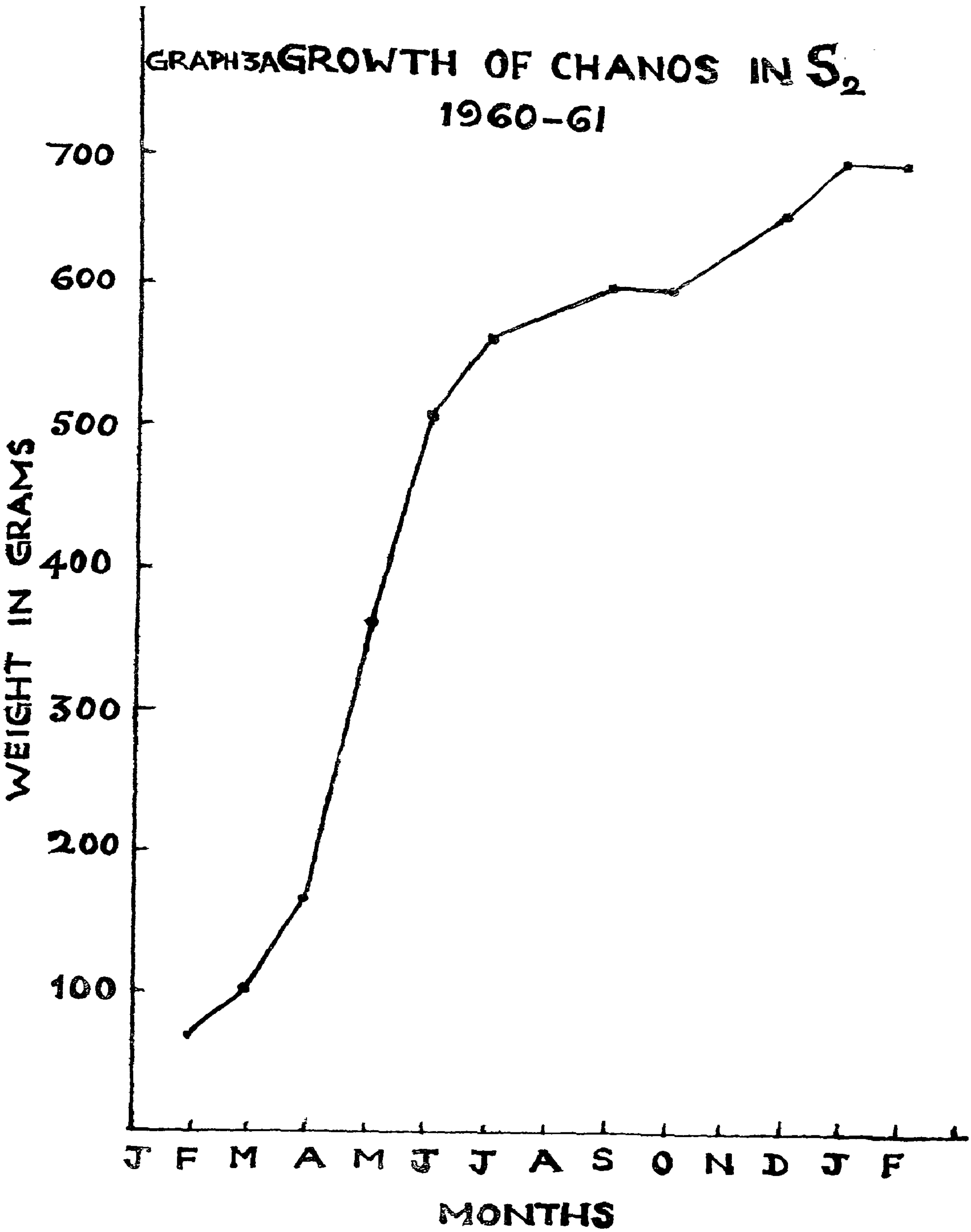
| *Months.* | *Temperature.* | *Specific gravity.* | *Turbidity.* | *Salinity.* | *Oxygen cc/L.* | *Silicate.* | *PH. value.* | *Carbon dioxide.* | *Bicarbonate.* | *Phosphate.* | *Depth.* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
| | °C. | 'C. | CM. | 0/00 | | Mgm/L. | | Ppm. | Ppm. | Ppm. | FT. |
| January .. .. | 27·0 | 1·01 | 86·0 | 17·72 | 4·41 | 10·5 | 7·6 | 1·1 | .. | .. | 4—6 |
| February .. .. | 27·0 | 1·012 | 90·5 | 18·62 | 3·85 | 30·5 | 7·6 | 1·0 | .. | .. | 4—1 |
| March .. .. .. | 28·0 | 1·012 | 78·0 | 22·26 | 5·6 | 20·13 | 8·2 | Nil. | .. | .. | 4—½ |
| April .. .. .. | 29·5 | 1·02 | 75·0 | 25·65 | 3·62 | 50·65 | 8·4 | Nil. | 26·0 | 1·2 | .. |
| May .. .. .. | 31·0 | 1·02 | 92·5 | 24·6 | 3·5 | 30·4 | 7·8 | Nil. | 38·5 | .. | .. |
| June .. .. .. | 29·5 | 1·02 | 82·5 | 21·15 | 3·92 | 33·0 | 8·0 | Nil. | 36·6 | 0·98 | .. |
| July .. .. .. | 28·0 | 1·01 | 94·0 | 17·01 | 3·877 | 11·5 | 8·2 | Nil. | 30·15 | .. | .. |
| August .. .. | 29·0 | 1·008 | 89·5 | 20·576 | 3·25 | 17·5 | 8·4 | 2·1 | 25·0 | 0·79 | .. |
| September .. .. | 30·5 | 1·01 | 74·5 | 19·55 | 3·9 | 7·5 | 7·8 | 2·5 | 27·5 | .. | .. |
| October .. .. | 31·0 | 1·01 | 79·0 | 17·11 | 3·99 | 6·5 | 7·8 | 2·0 | 31·5 | 0·79 | .. |
| November .. .. | 28·5 | 1·01 | 85·5 | 15·25 | 4·68 | 5·6 | 8·0 | 1·6 | 45·33 | 0·78 | .. |
| December .. .. | 28·0 | 1·01 | 111·0 | 16·0 | 4·2 | 8·0 | 8·02 | 1·5 | 48·0 | 0·98 | .. |

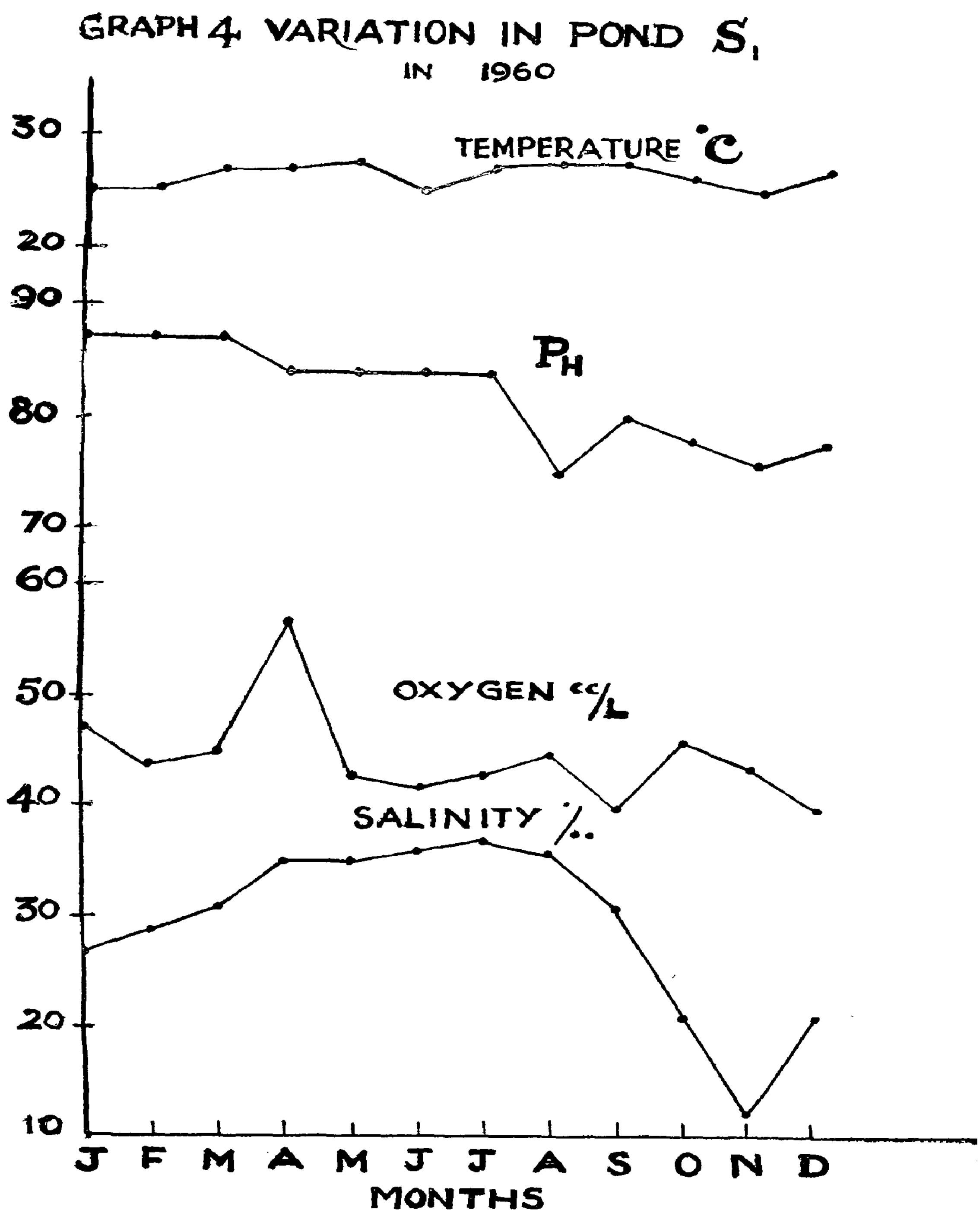

GROWTH OF CHANOS IN 'S1'
GRAPH 1
1960-61.
LENGTH IN MILLIMETRES
600
500
400
300
200
100
J F M A M J J A S O N D J F
MONTHS

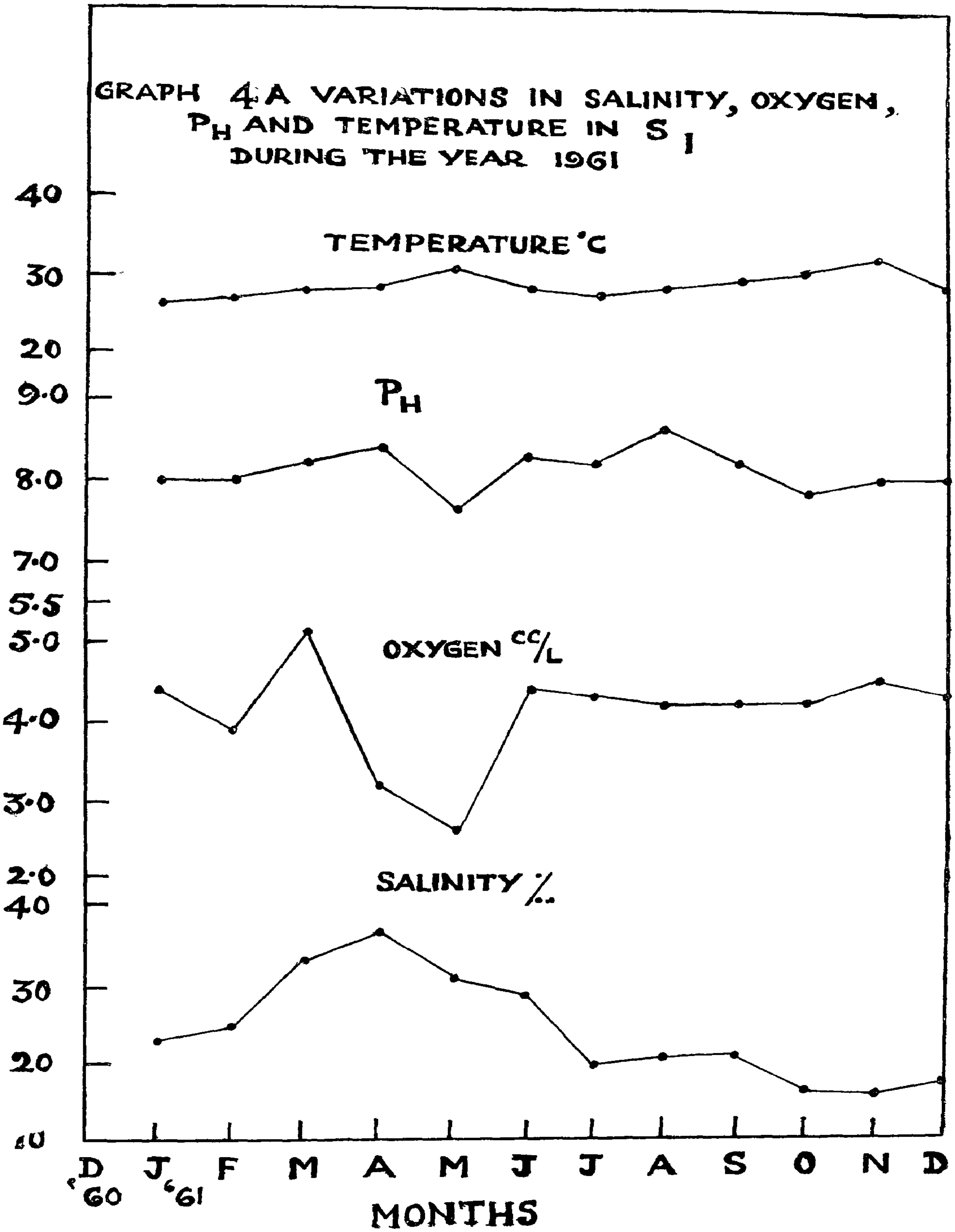
GRAPH 2 GROWTH OF CHANOS IN $S_1$



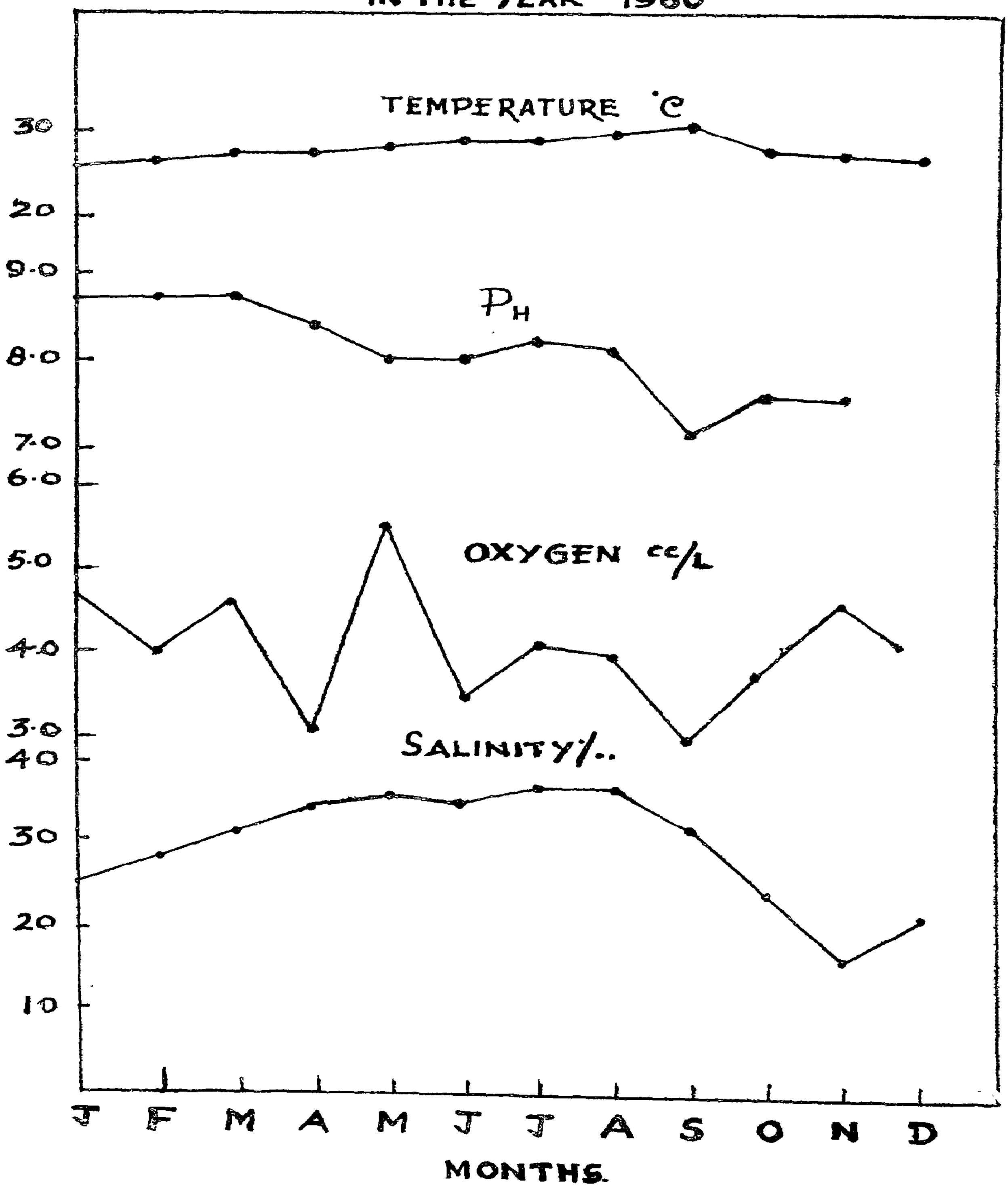

GRAPH 3
GROWTH OF CHANOS IN S2
1960-61
LENGTH IN MILLIMETRES
600
500
400
300
200
100
J F M A M J J A S O N D J F
MONTHS

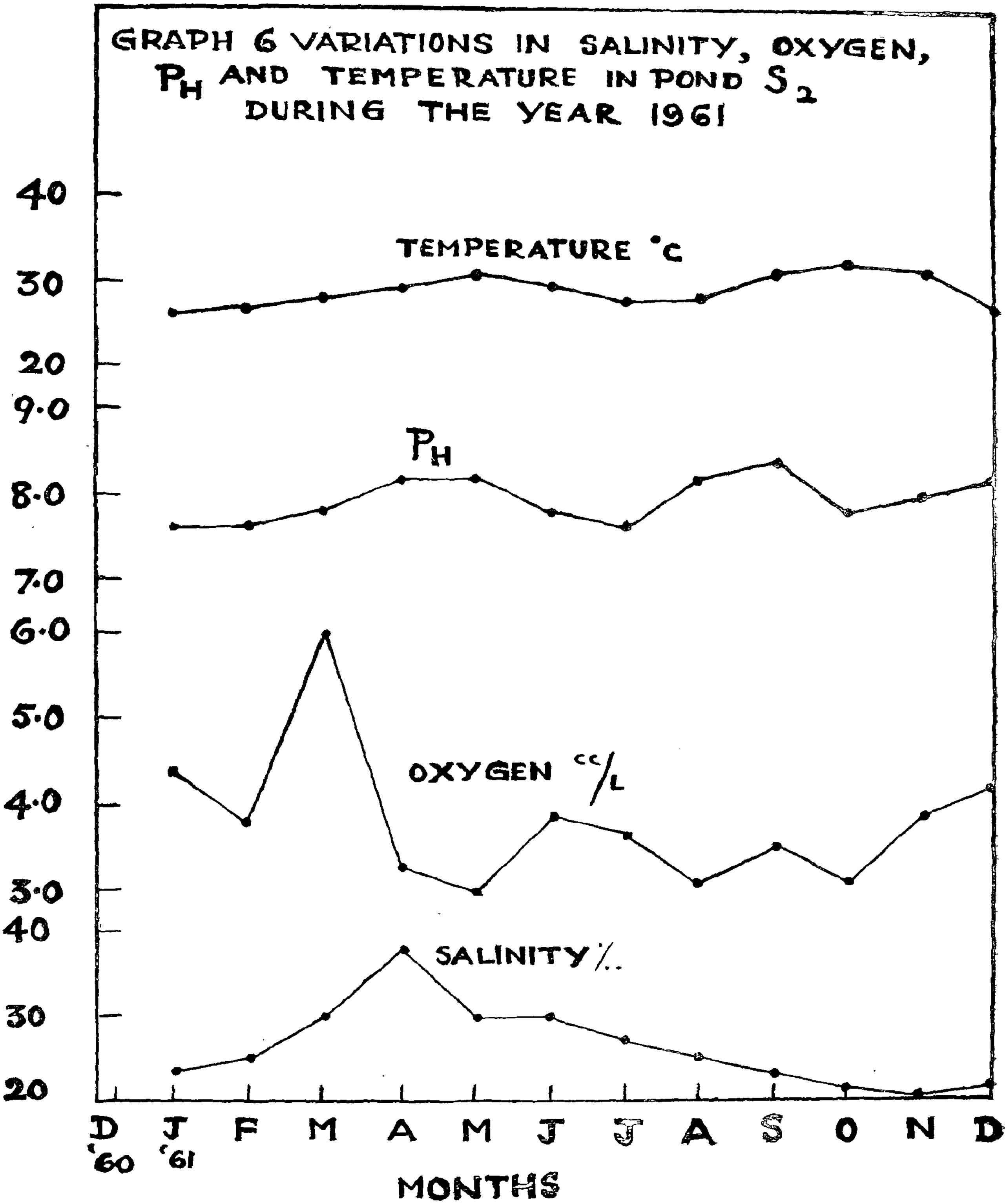

GRAPH 3A GROWTH OF CHANOS IN S2
1960-61
700
600
500
400
300
200
100
WEIGHT IN GRAMS
J F M A M J J A S O N D J F
MONTHS

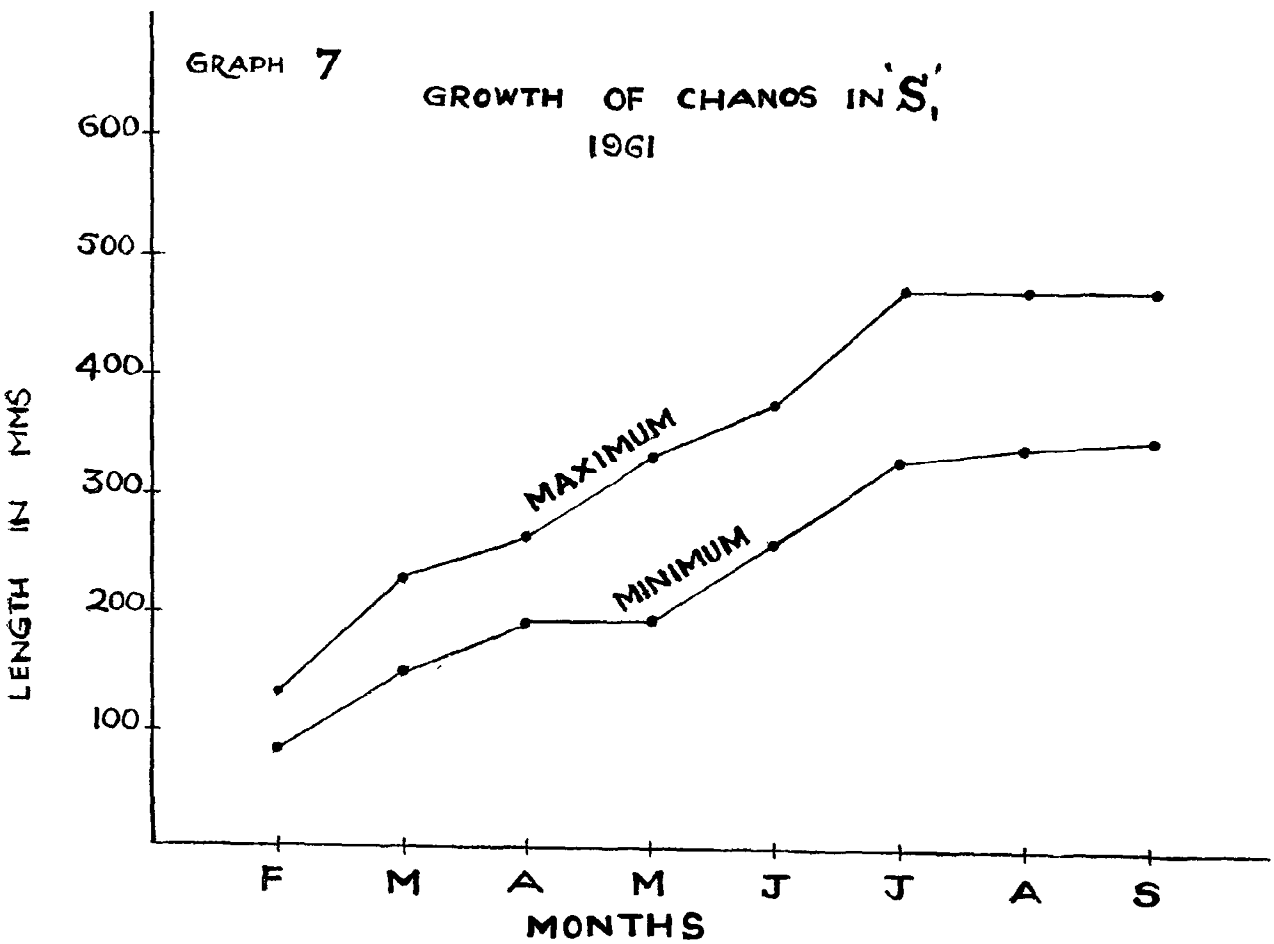

GRAPH 4. VARIATION IN POND S1
IN 1960
30
20
90
80
70
60
50
40
30
20
10
TEMPERATURE °C
PH
OXYGEN cc/L
SALINITY ‰
J F M A M J J A S O N D
MONTHS

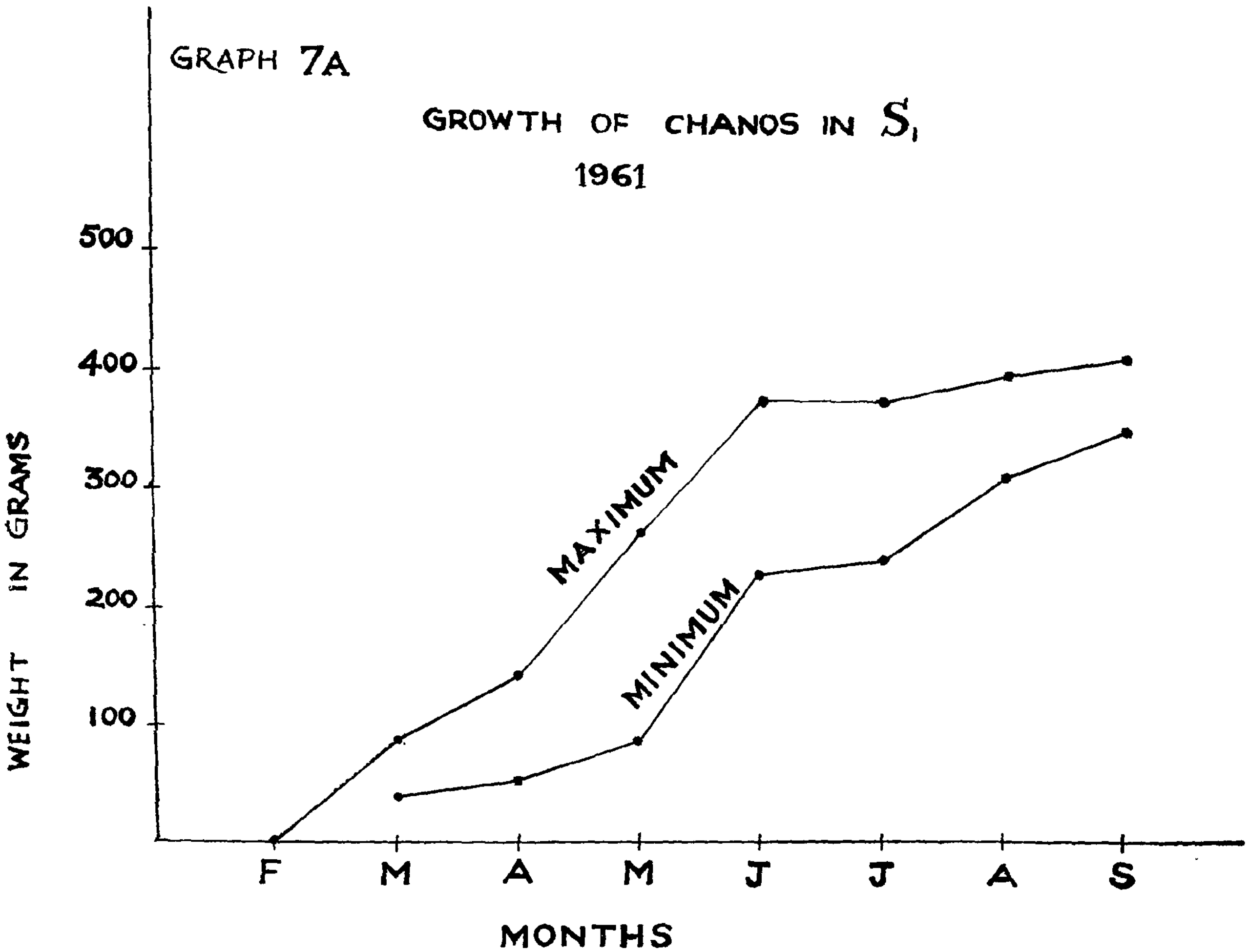

GRAPH 4 A VARIATIONS IN SALINITY, OXYGEN, PH AND TEMPERATURE IN S 1 DURING THE YEAR 1961
TEMPERATURE °C
PH
OXYGEN cc/L
SALINITY ‰
40
30
20
9.0
8.0
7.0
5.5
5.0
4.0
3.0
2.0
40
30
20
10
D '60
J '61
F
M
A
M
J
J
A
S
O
N
D
MONTHS

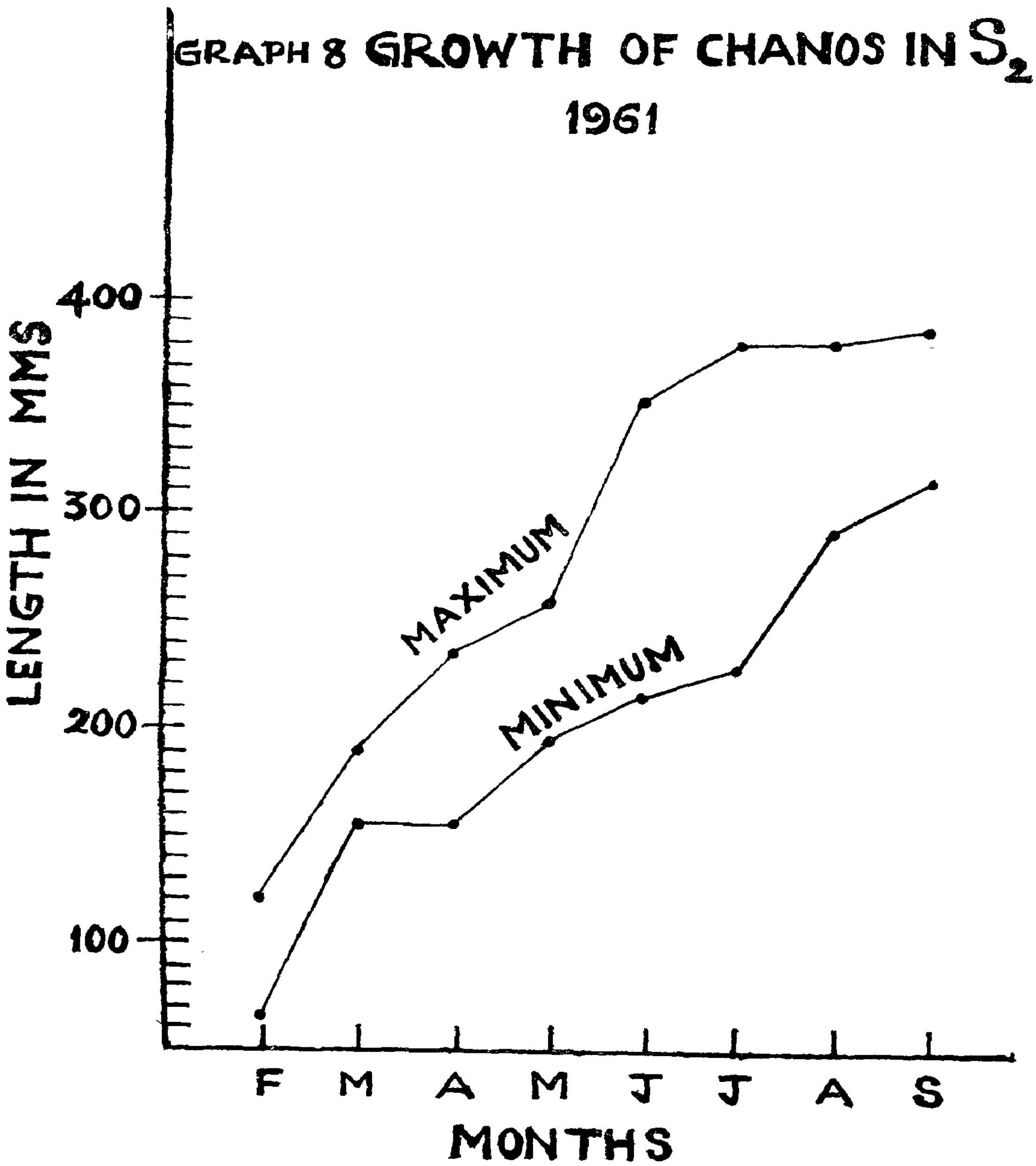
GRAPH 5 VARIATIONS IN SALINITY OXYGEN $P_H$ AND TEMPERATURE IN POND $S_2$ IN THE YEAR 1960

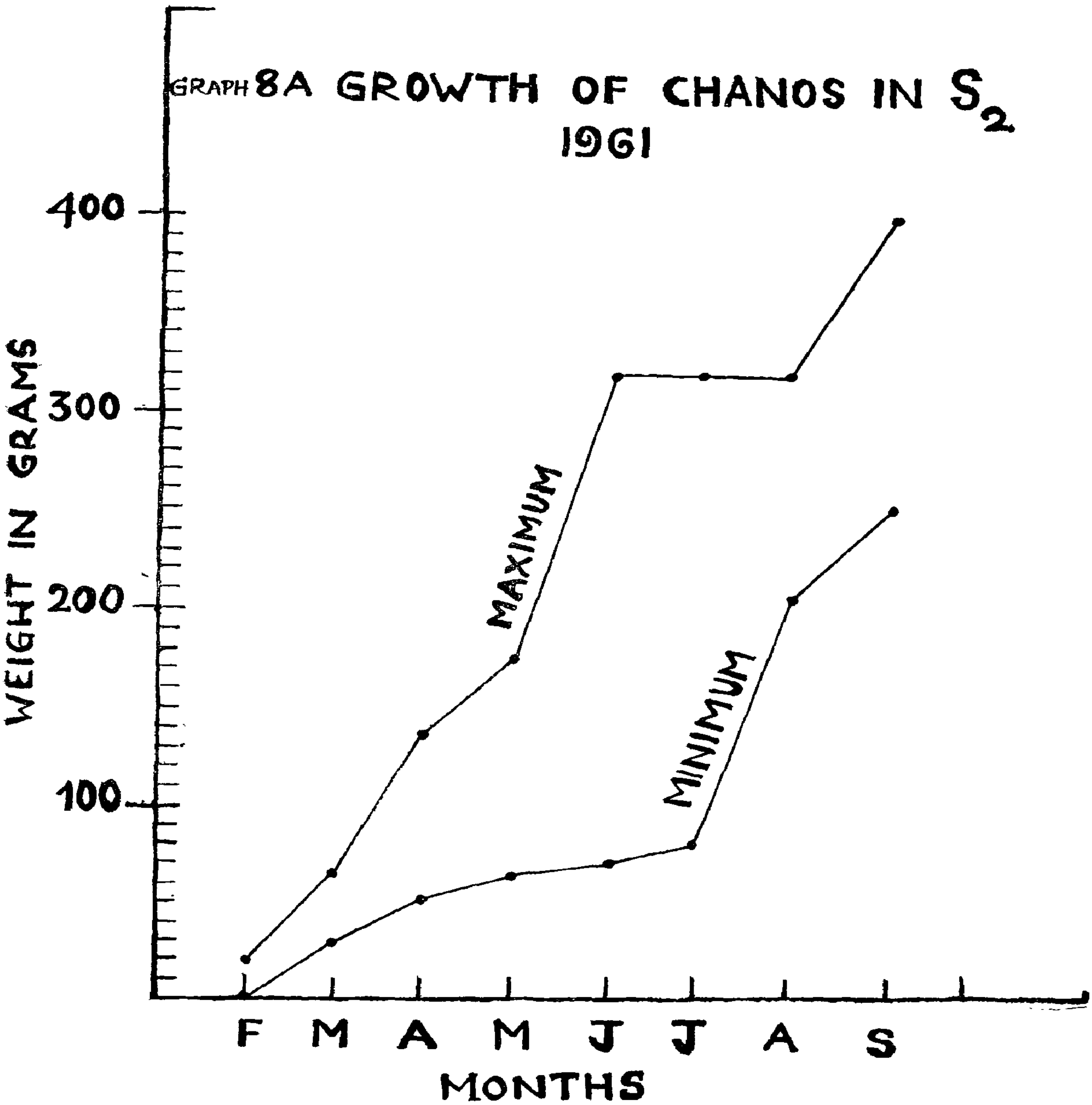


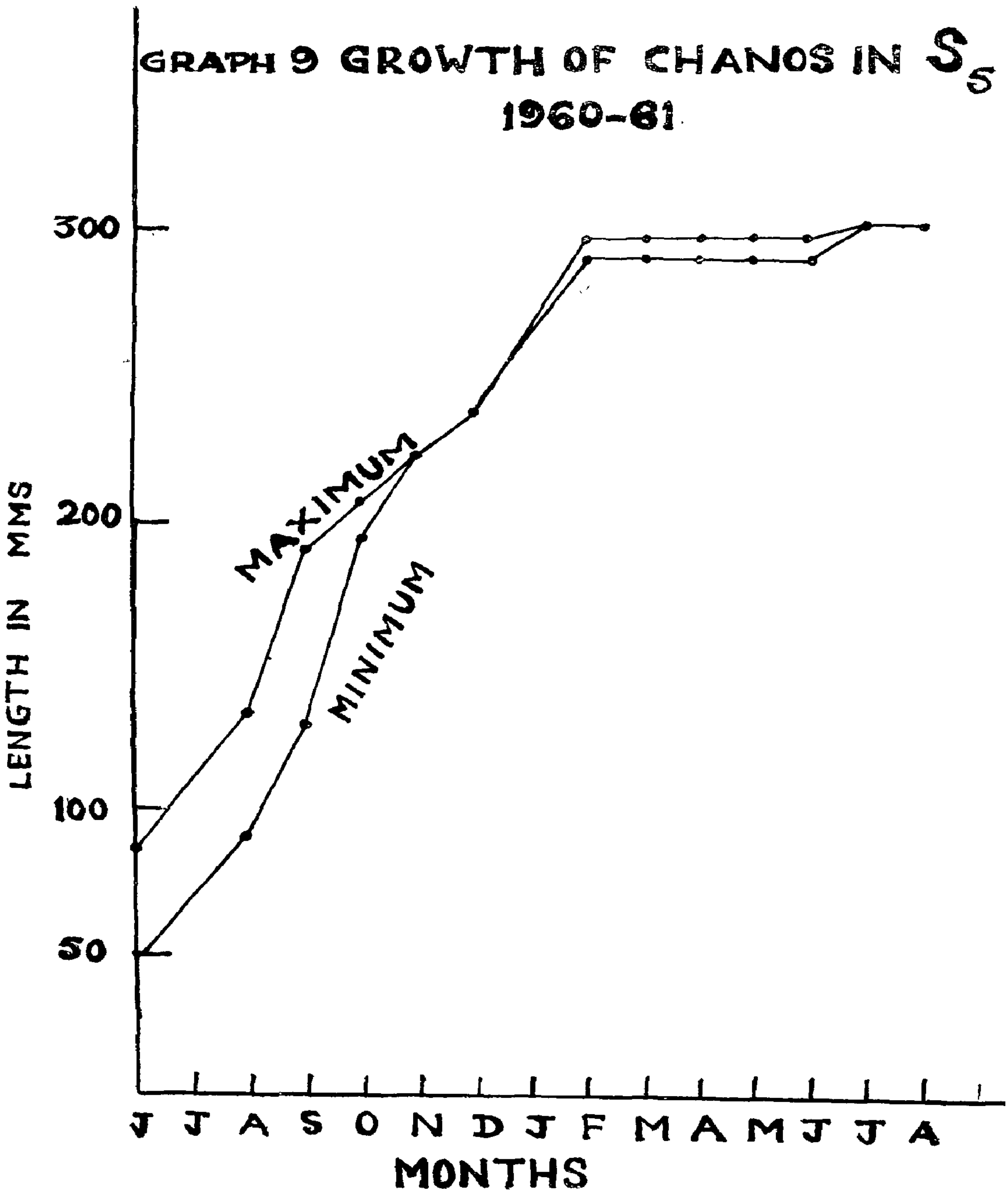

GRAPH 6 VARIATIONS IN SALINITY, OXYGEN, PH AND TEMPERATURE IN POND S2 DURING THE YEAR 1961
TEMPERATURE °C
PH
OXYGEN cc/L
SALINITY ‰
40
30
20
9.0
8.0
7.0
6.0
5.0
4.0
3.0
40
30
20
D '60
J '61
F
M
A
M
J
J
A
S
O
N
D
MONTHS

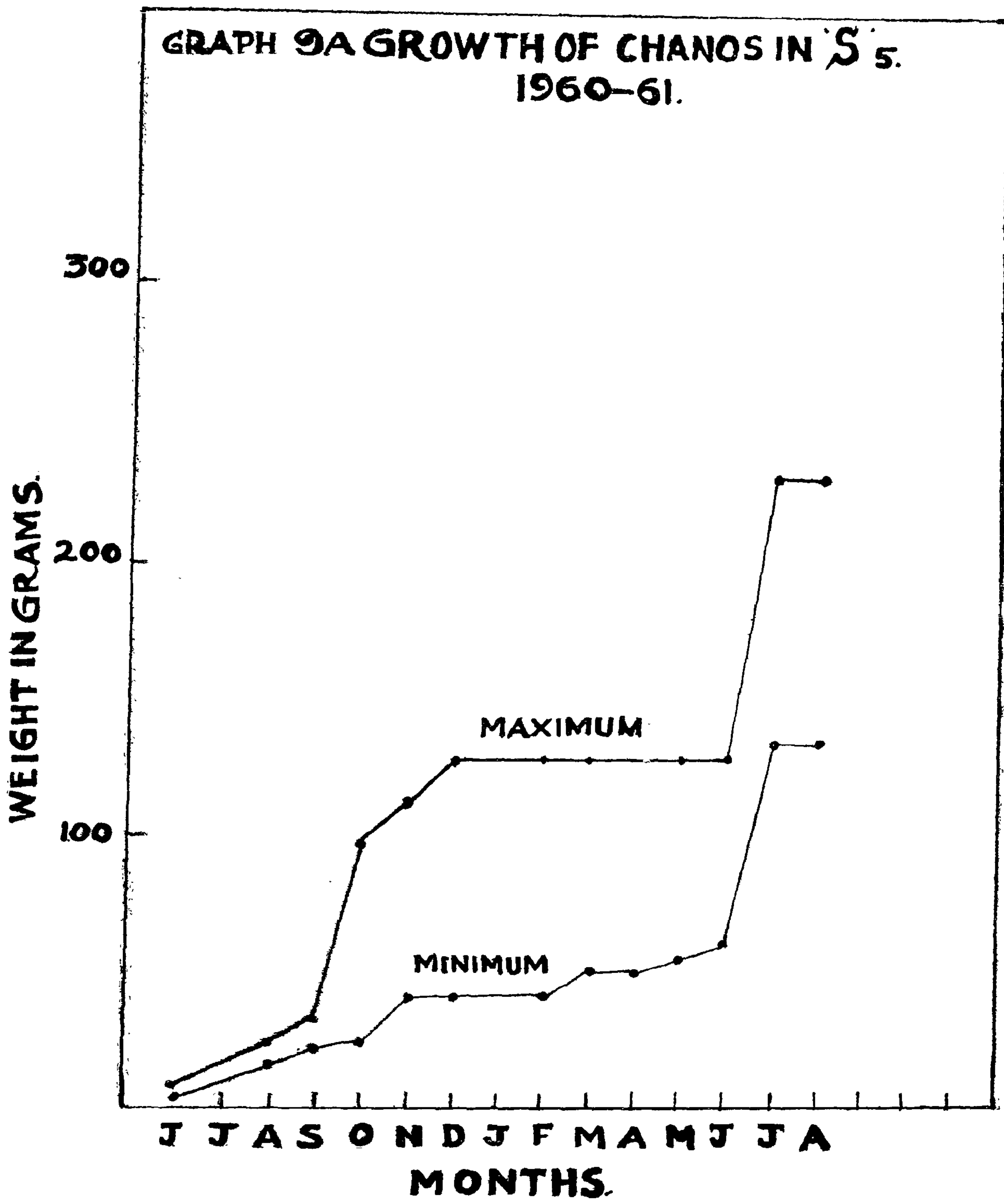

GRAPH 7
GROWTH OF CHANOS IN 'S1'
1961
600
500
400
300
200
100
LENGTH IN MMS
MAXIMUM
MINIMUM
F
M
A
M
J
J
A
S
MONTHS


GRAPH 7A
GROWTH OF CHANOS IN $S_1$
1961
500
400
300
200
100
WEIGHT IN GRAMS
MAXIMUM
MINIMUM
F
M
A
M
J
J
A
S
MONTHS

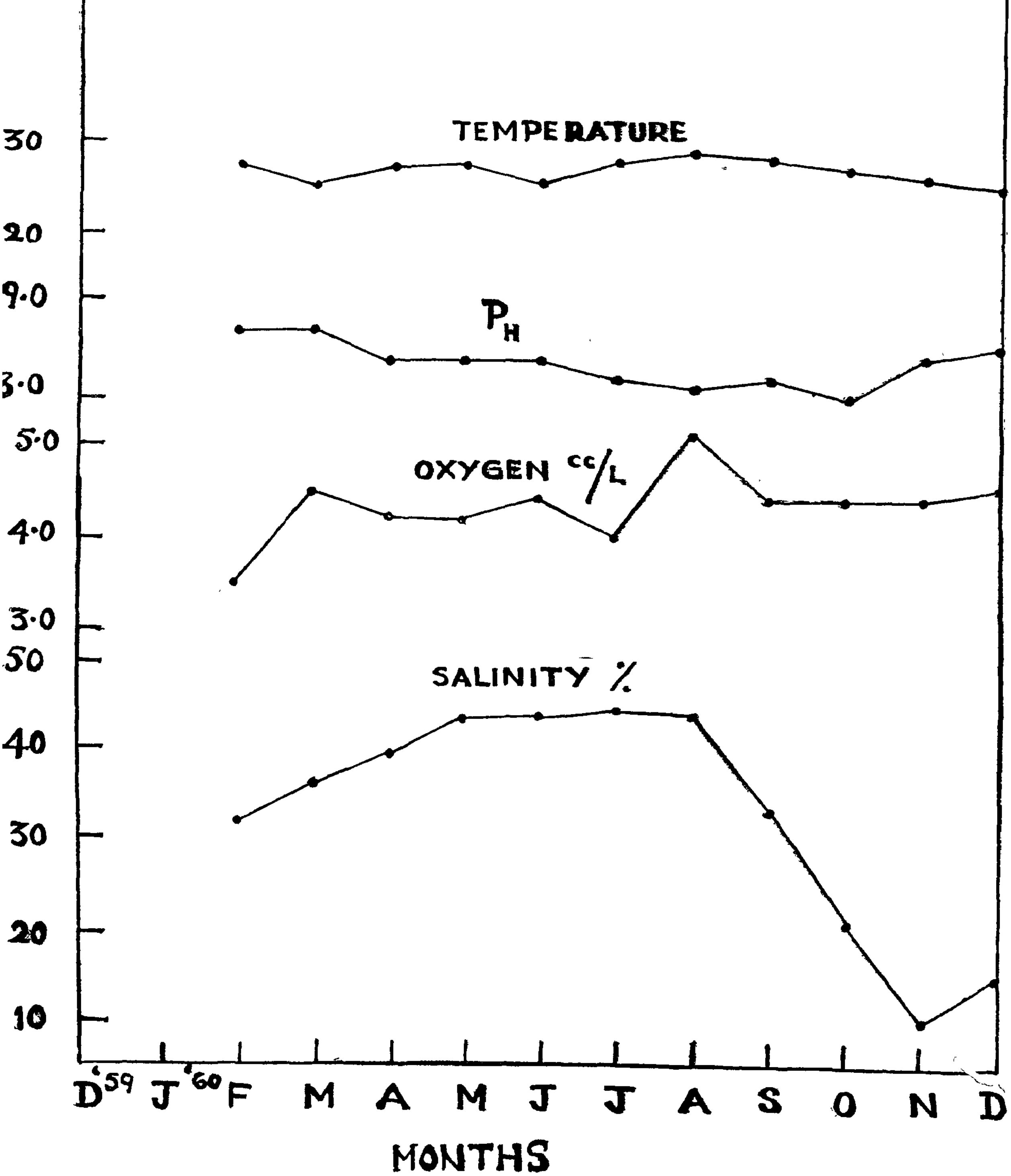

GRAPH 8 GROWTH OF CHANOS IN $S_2$
1961
LENGTH IN MMS
400
300
200
100
MAXIMUM
MINIMUM
F M A M J J A S
MONTHS


GRAPH 8A GROWTH OF CHANOS IN S2
1961
WEIGHT IN GRAMS
400
300
200
100
MAXIMUM
MINIMUM
F
M
A
M
J
J
A
S
MONTHS

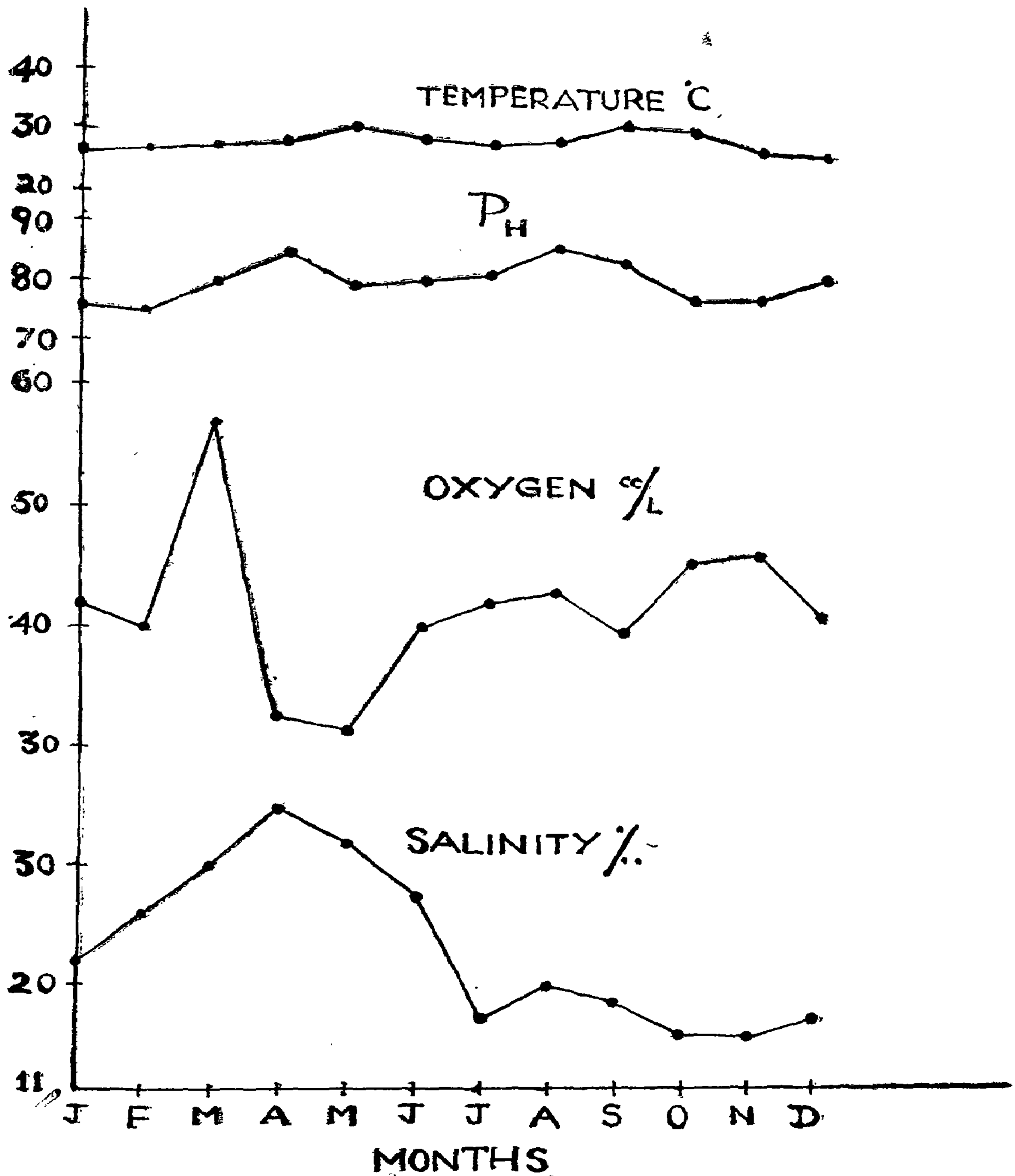

GRAPH 9 GROWTH OF CHANOS IN $S_5$
1960-61
LENGTH IN MMS
300
200
100
50
MAXIMUM
MINIMUM
J J A S O N D J F M A M J J A
MONTHS

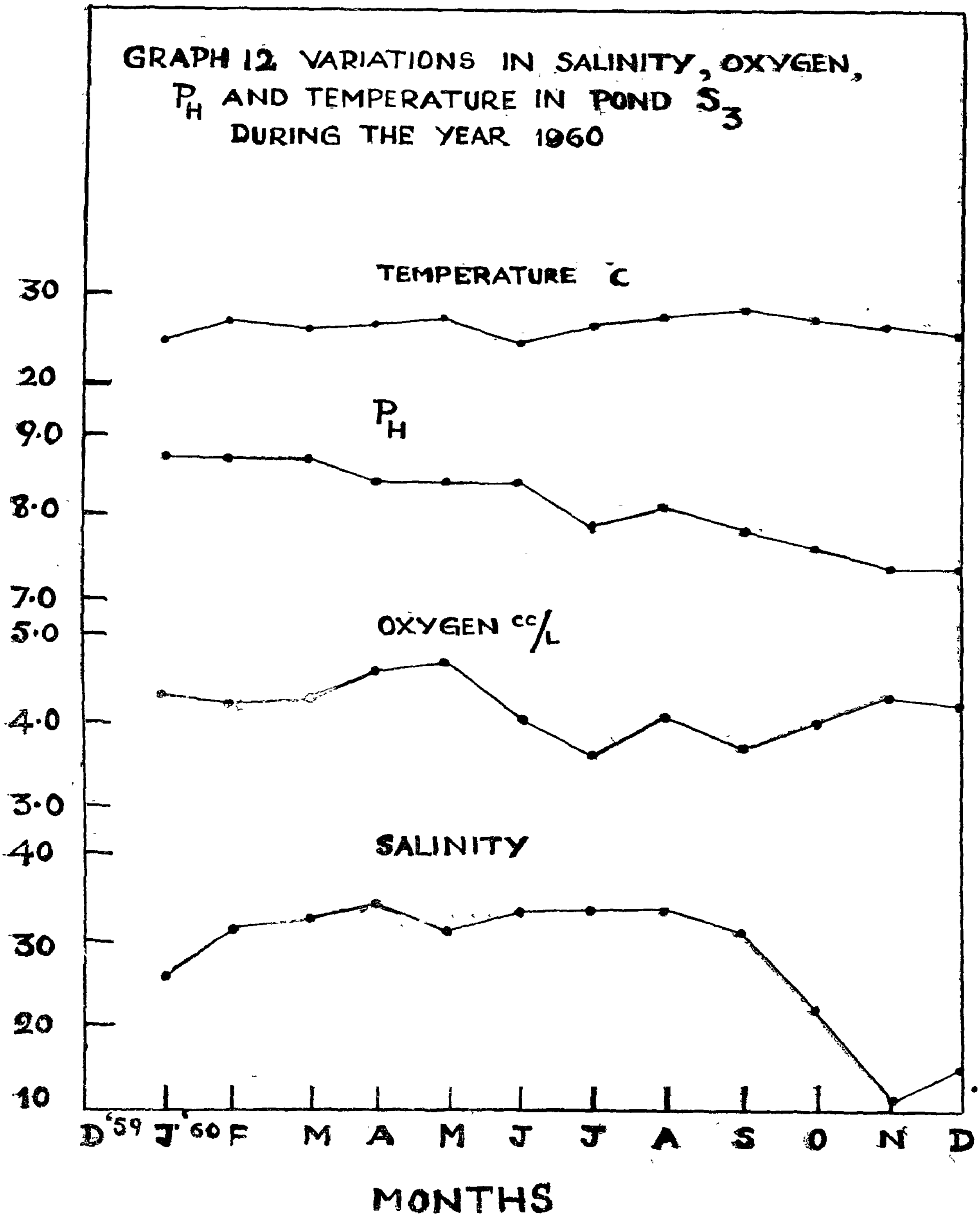

GRAPH 9A GROWTH OF CHANOS IN 'S' 5.
1960–61.
300
200
100
WEIGHT IN GRAMS.
MAXIMUM
MINIMUM
J J A S O N D J F M A M J J A
MONTHS.

GRAPH 10 VARIATIONS IN SALINITY, OXYGEN, $P_H$ AND TEMPERATURE IN POND 5 DURING THE YEAR 1960

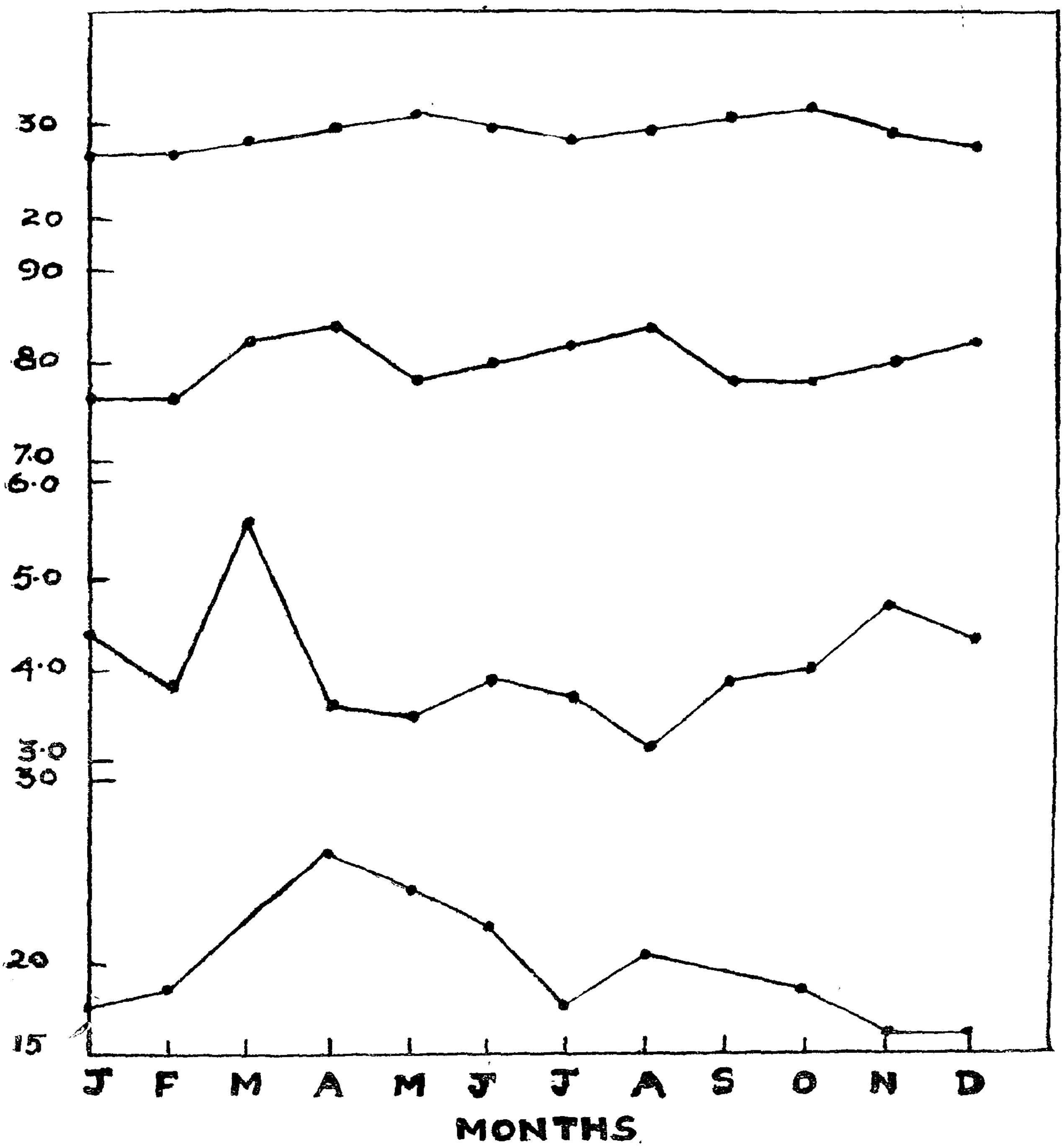


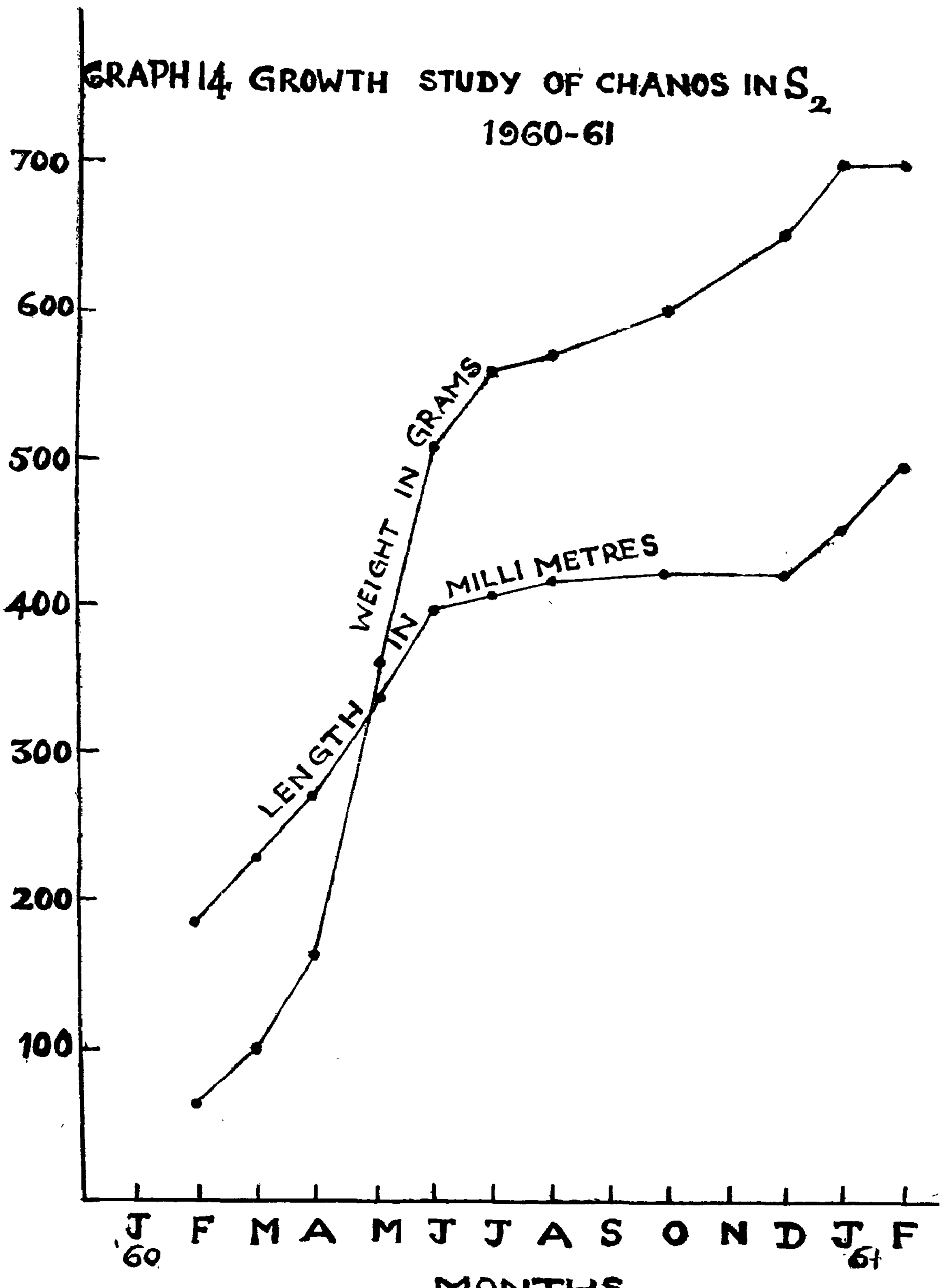
GRAPH 11 VARIATIONS IN SALINITY, OXYGEN, PH AND TEMPERATURE IN POND 5 DURING THE YEAR 1961




GRAPH 12 VARIATIONS IN SALINITY, OXYGEN, $P_H$ AND TEMPERATURE IN POND $S_3$ DURING THE YEAR 1960
TEMPERATURE °C
$P_H$
OXYGEN cc/L
SALINITY
30
20
9.0
8.0
7.0
5.0
4.0
3.0
40
30
20
10
D'59 J'60 F M A M J J A S O N D
MONTHS

GRAPH 13 VARIATIONS IN SALINITY, OXYGEN. PH. AND TEMPERATURE IN THE POND $S_3$ IN THE YEAR - 1961.




GRAPH 14. GROWTH STUDY OF CHANOS IN S2
1960-61
700
600
500
400
300
200
100
WEIGHT IN GRAMS
LENGTH IN MILLI METRES
J '60
F
M
A
M
J
J
A
S
O
N
D
J '61
F
MONTHS

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# OXYGEN CONSUMPTION BY FRESH WATER FISHES *

BY

A. SRINIVASAN, FRESH WATER BIOLOGICAL STATION, BHAVANISAGAR.

## Introduction

With the intensification of fish cultural activities throughout India, collection and transport of fish seed and fingerlings as is assuming importance. In many cases the seed collection centres and ponds to be stocked with fish seed are separated by long distances, requiring transport over long periods of time under varying temperature and physico-chemical conditions. It would be therefore of practical importance to have some knowledge of the oxygen consumption by different species of fish. In Madras State mostly early and advanced fingerlings are transported for stocking and hence most of the experiments were performed with these. The results are also of ecological application in indicating the survival of fish under varying conditions of oxygen content and stratification in pieces of water.

Oxygen consumption by fish is a function of its metabolic activity. The properties of fish blood hæmoglobin play an important part in oxygen transport and oxygen consumption (Shepard 1955, Fish 1956, Black 1955). The effect of temperature on respiration has been studied by Downing and Merkens (1957), Job (1955), Pritchard (1955) has reported on the oxygen requirement of some baitfishes. Bose (1949) carried out experiments on oxygen requirements of some economic carps of India. Motwani and Bose (1957) determined the oxygen consumption by the fry of *Labeo rohita*, a major carp of India. Unlike in Bengal and Orissa, in Madras State fry collection and transport is not so important as that of fingerlings and hence the transport of the latter is a problem. Oxygen consumption by some of the economic and uneconomic " Weed fish " have been determined and the results are reported hereunder.

## Material and methods

The fish fingerlings (or fry), after collection from sources, were kept in small cement cistern, for a few days and were transported to smaller containers, a day prior to the commencement of the experiment and starved. The experiments were performed by "sealing" the fish in aspirators or bottles or by using a layer of liquid paraffin in aquarium jars (Viswanathan & Tampi, 1951), (Moore, 1942). Oxygen was determined by the unmodified winkler's method (A.P.H.A. 1956). The duration of experiments was for a fixed period of one or two hours in " sealed bottle " experiments but in the case of aquarium jars layered with paraffin, the experiments were prolonged and determination of oxygen was carried out every hour by withdrawing water by a siphon arrangement. Rate of oxygen consumption during successive hours could be studied in, these experiments. The " asphyxial level " was fixed as the oxygen content in mg/L at the time the fish, after critical gasping movements, upturns, drops down and does not move further.

Oxygen consumption has been calculated per unit weight of the body. The fish were delicately pressed with absorbant towel to remove surface moisture and weighed. In the case of fry (for e.g., Chanos), the method of Motwani and Bose (1953) was more useful, though even thus, wiping each fry was difficult. " Group effect " was studied by using different numbers of fish of similar size in a container of idential size and shape. A number of experiments were carried out to find out the changes in pH and carbon-di-oxide content before and after the experiment and it was found there was just very little change (0·2 units) in these even after considerable period (4 hours).

## Results

Oxygen consumption by some fresh water fishes under laboratory conditions is tabulated in Table No. I. Oxygen consumption rate differs from species to species. *Cirrhina cirrhosa*, a very active fish consumes more oxygen than other carps. But oxygen consumption is greatest in the cichlid fish *Tilapia mossambica*. The scale carp consumes very low quantities of oxygen. Golden carp which is usually not very active consumes less oxygen than mirror carp at comparable temperature.

Asphyxial levels of some of the fish indicated in the Table show that Mirror carp has low asphyxial level. For example at 20·4°C it was just 0·40 mg/l (4·261 per cent saturation). *Tilapia* fry which consume more oxygen than other fish had a high asphyxial level of 0·85 mg/l of oxygen (10·9 per cent saturation) while the adults of the same species were asphyxiated at 0·60 mg/l (7·667 per cent saturation).

## Volume effect

When comparing oxygen consumption by different species, the volume, or rather the amount of dissolved oxygen of water used has to be uniform. It has been found (Table No. II) that for the same fish, oxygen consumption rate increases as the volume of water increases. With decrease in volume of water, oxygen consumption correspondingly drops. When the concentration of total quantity of oxygen present is high, oxygen consumption is also greater. This is true only in the " Oxygen dependent" zone and this effect was not seen in the " non-dependent zone ".

## Size effect

Oxygen consumption per unit weight of fish and time is influenced by the size (weight) of fish. From the data available in Table No. III, it could be seen that fry, per unit weight consume more oxygen than adult fishes.

## Group effect

Quite a number of workers have established the occurrence of " Group effect " in the respiration of fishes. In the same volume of medium, fish consume per unit weight, more oxygen when present singly or in pairs, than when present in groups. This has been borne out by the data in Table No. IV. Other conditions such as temperature, size of fish, etc., were maintained the same. The larger the number of the fish the lower the consumption per fish.

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* Paper presented at the forty-fifth Indian Science Congress at New Delhi, 1959.

**Effect of tranquilizers and narcotizers on oxygen consumption by fish**

Oxygen consumption in fish being a function of its metabolism, the activity of fish influences oxygen consumption. It is well-known that the thyroid controls the metabolism and hence thyroid depressants may be expected to reduce oxygen consumption. Results on the effect of Thiouracil, Urethane and Veronal (Barbitone) are presented in Table No. V. Below 20 p.p.m. Veronal did not show marked reduction in oxygen consumption. Urethane and Thiouracil exerted positive effect at 10·0 p.p.m. It was found that Thiouracil in higher concentration interferred with oxygen determination.

**Effect of salinity**

In transplanting marine or estuarine fish it would be useful to know the oxygen consuming capacity in media of higher and lower salinity. Two experiments were carried out with 36 *chanos* fry. In two hours the oxygen consumed by them in mg. are given below :—

| | 100 *per cent sea water.* | 50 *per cent sea water.* |
|---|---|---|
| I Oxygen consumed by 36 fry in 2 hours in mg. | 4·813 | 3·538 |
| II Do. | 7·525 | 4·963 |

With the lowering of salinity there is a distinct reduction in oxygen consumption. However it is felt more experiments are needed in this line, and are being pursued.

**Discussion**

In experiments on oxygen consumption by fish the pH of the medium, presence of free carbon-di-oxide, etc. (Basu 1949) may affect it. Experiments performed over prolonged periods in "closed" systems therefore do not yield correct results. In our experiments the experiments were carried out for one or two hours during which there is no marked change in the medium. Basu (1951) has shown that in the case of fry of *Labeo* spp. the toxic limit of carbon dioxide is 75 p.p.m. at an oxygen concentration of 1 p.p.m. He had further shown that per unit weight of body, mrigal consumes more oxygen than Catla or Rohu. In our experiments, it is found that golden carp and scale carp consume very low amounts of oxygen, while an active fish like *Cirrhina cirrhosa* consumed higher quantities of oxygen. Mirror carp was found to have a lower asphyxial level than the other fish. This must have a bearing on its transport. In terms of percentage of oxygen saturation, the asphyxial levels are generally below 10 per cent saturation. Downing and Merkens (1957) determined the highest oxygen tension killing fish, for various species and the results varied from species to species. This could be explained on the basis of the work of Fish (1956) on the oxygen dissociation curves of fish blood hæmoglobin. This has also been stressed by Shepard (1955) who found that the capacity of the blood for oxygen transport rapidly decreases as the oxygen uptake is reaching a low level.

Though no attempt has been made to study the effect of temperature on oxygen consumption, results obtained by performing the experiments on Mirror carp and scale carp in Ooty, a hill station (temperature range 18·4—20·6°C) and at Bhavanisagar (26·6 to 32·0°C) shows a clear difference. Oxygen consumption by fish of comparable sizes is greater at the higher ones than at lower temperature. As has been pointed out by Basu (1951), the advantages of transporting fish seed at 20°C are obvious and this can easily be achieved by a small quantity of ice. At this temperature the asphyxial level for Mirror carp was only 0·40 mg/l (4·26 per cent saturation). Oxygen consumption was highest in Tilapia. Fry, just as they consume more oxygen have higher thresholds of oxygen for asphyxiation, as it seen from the fact that *Tilapia* fry the asphyxial level is 0·85 mg/l (10·9 per cent saturation). while for the same adult it is 0·60 mg/l (7·667 per cent saturation). Vaas (1951) found that big fishes "held out longer than small fishes" evidently because of lower asphyxial levels. In confirmity with our results, Shepard (1955) similarly noted that "fry maintained a higher rate of oxygen consumption per unit weight than did either of the other groups. In turn, fingerlings removed proportionately more oxygen than did the yearlings. Large fish did not take up oxygen at as rapid a rate per unit weight as smaller fish." Though Keys (1931) also found larger fish more resistant to asphyxiation due to smaller oxygen demand per unit weight of larger fish, than smaller fish, Pritchard (1955) could not confirm the results. Moore (1942) however observed that larger fishes survived critical oxygen concentration longer than smaller individuals of the same species. Job's work on chanos also shows size effect (Job 1957, p.308) Saha *et al* (1956, p. 131 TableNo. II) tabulated the oxygen consumption by fry of different sizes and weight. It is clear that per unit weight of body per hour, larger fish consumed less oxygen than smaller fish. This is further confirmed by them (i.e., p. 132 Table No. IV).

The "Group effect" noticed by us was also observed by Pritchard (1955) who thinks that fish are more quiescent when tested in groups rather than individually. When large numbers of fish were used the overall level of metabolism is lower. This is seen in TableNo. IV striking results being obtained with *Tilapia* and *E. maculatus*. The above view is supported by Shuett (1933), Schlaifer (1938) and Geyer and Mann (1939). The results presented by Viswanathan and Tampi (1952, p. 152—153) also indicate the operation of "Group effect". This has a bearing on transport of live fish. At present, the number of fish that can be transported in a definite volume of water is arbitrarily chosen. Since the rate of oxygen consumption decreases when fish are present in groups, it can be reasonably expected that larger numbers can be transported, provided of course the residual oxygen in the medium is not reduced to the lethal asphyxial level.

Drugging of fish to enable safer transport seems to be a promissing prospect (Anon. 1954, 1955 and 1957). In our experiments, we found that Thouracil, Urethane and Veronal markedly depressed oxygen consumption by fish. Field trials under the influence of these hyponotics may yield very useful data and are being planned. Zaks and Zamkova (cited Shepard 1955) also noted a decrease in oxygen uptake under the influence of Thiourea.

*Acknowledgment.*

It is a pleasure to acknowledge the criticisms and suggestions made by Dr. S. V. Job, Central Marine Fisheries, Mandapam, as also of Dr. S. Jones, Chief Research Officer, Central Marine Fisheries, Mandapam. This paper is published with the kind permission of the Director of Fisheries, Madras.

TABLE No. I.

*Oxygen consumption by certain Fresh Water Fishes (Mg. per hour per gram weight of body).*

| *Fish.* (1) | *Temperature range oc.* (2) | *Size range cms.* (3) | *Oxygen consumed.* (4) | *Asphyxial level mg/L oxygen.* (5) | *Remarks.* (6) |
|---|---|---|---|---|---|
| *Labeo fimbriatus* .. .. .. .. | 24·8 | 8·0–9·0 | 0·18 | 0·60 (9·59)* | .... |
| | 26·8 | 11·0 | 0·24 | 0·9 (10·72) | .... |
| *Cirrhina cirrhosa* .. .. .. .. | 27·2–40·8 | 6·3 | 0·38–0·46 | .. | .... |
| | 26·6 | 10·9 | 0·35 | 0·74 (6·987) | .... |
| *Catla catla* .. .. .. .. | 28·6 | 28·6 | 0·11 | .. | .... |
| | 28·0 | 12·2 | 0·27 | .. | .... |
| *Barbus carnaticus* .. .. .. | 30·4–30·8 | 11·8–12·5 | 0·19–0·27 | 0·70 (8·03) | .... |
| | 31·4 | 6·5–10·1 | 0·47–0·48 | 0·70 (8·884) | .... |
| *Barbus machocola* .. .. .. | 28·2 | 10·0 | 0·43 | 0·60 (7·64) | .... |
| *Cyprinus caprio* .. .. .. .. *var* (specularis). | 17·4–19·4 | 2·5–3·5 | 0·23–0·32 | .. | .... |
| | 18·4 | 8·2 | 0·13 | .. | .... |
| | 19·8 | 8·2 | 0·20 | .. | .... |
| | 20·0–20·6 | 4·8–5·6 | 0·27–0·34 | 0·40 (4·26) | .... |
| | 26·6–32·0 | 5·8–17·2 | 0·24–0·38 | 0·35 (4·20) | .... |
| *Cyprinus carpio var* (communis) .. | 17·4–19·8 | .. | 0·16–0·18 | .. | .... |
| | 28·2–30·6 | .. | 0·25 | .. | .... |
| *Carrassius carassius* (Golden carp) .. | 18·7–19·6 | 5·8–6·1 | 0·12–0·17 | .. | .... |
| *Etroplus maculatus* .. .. .. | 31·4–31·6 | 2·2 | 0·64 | .. | Single fish. |
| | 31·4–31·6 | 2·2 | 0·24 | .. | Group effect. |
| *Tilapia mossambica* .. .. .. | 31·2 | 8·6 | 0·43 | 0·6 (7·67) | Adult. |
| | 31·4–31·6 | 4·3–4·9 | 0·75–0·71 | .. | Fingerling. |
| | 31·4 | .. | 0·96 | 0·85 (10·90) | Fry in groups. |
| *Cirrhina reba* .. .. .. .. | 26·6 | 10·9 | 0·35 | 0·74 (8·78) | .... |

* per cent saturation,

TABLE No. II.

*Effect of volume of medium on oxygen consumption.*

("Oxygen dependent zone.")

| *Fish.* (1) | | *Volume of water litres.* (2) | *Oxygen consumption mg/g/hour.* (3) |
|---|---|---|---|
| *Cirrhina cirrhosa*— | I | 3·0 | 1·9 (per fish). |
| | | 2·0 | 1·795 (per fish). |
| | II | 2·75 | 0·482 |
| | | 1·75 | 0·410 |
| | III | 2·75 | 0·830 |
| | | 1·75 | 0·455 |
| *Mirror carp*— | I | 3·0 | 0·267 |
| | | 2·0 | 0·250 |
| | II | 3·0 | 0·493 |
| | | 2·0 | 0·377 |

| *Fish.* (1) | | *Volume of water litres.* (2) | *Oxygen consumption mg/g/hour.* (3) |
|---|---|---|---|
| *Mirror carp*—cont. | III | 11·0 | 0·434 |
| | | 2·75 | 0·384 |
| | IV | 11·0 | 0·332 |
| | | 2·75 | 0·311 |
| | V | 11·0 | 0·604 |
| | | 1·0 | 0·556 |
| *Barbas carnaticus* .. .. .. | | 11·0 | 0·9107 |
| | | 5·0 | 0·2404 |
| *Labco fimbriatus* .. .. .. | | 3·0 | 0·639 |
| | | 2·0 | 0·272 |

TABLE No. III.

*Effect of size on oxygen consumption.*

| *Fish.* | *Length cms.* | *Weight. gms.* | *Oxygen consumed mg/hr/g of body weight.* | *Temperature °C.* |
|---|---|---|---|---|
| *Cyprinus carpio var specularis* (Mirror carp) .. .. .. | .. | 48·92 | 0·254 | 30·6–30·8 |
| | .. | 18·40 | 0·324 | 30·6–30·8 |
| | .. | 3·70 | 0·604 | 30·6–30·8 |
| | .. | 14·00 | 0·267 | 27·2 |
| | .. | 16·00 | 0·250 | 27·2 |
| | .. | 6·1 | 0·434 | 27·4–27·6 |
| | .. | 11·0 | 0·384 | 27·4–27·6 |
| | .. | 13·9 | 0·311 | 27·4–27·6 |
| *Barbus carnaticus* .. .. .. .. .. .. .. | 6·5 | 4·48 | 0·482 | 31·4 |
| | 10·1 | .. | 0·470 | |
| | 11·8 | 15·80 | 0·269 | |
| | 12·5 | 16·64 | 0·240 | 30·4–30·8 |
| | 14·1 | .. | 0·182 | |
| *Carassius carassius* .. .. .. .. .. .. .. | 5·8 | 1·63 | 0·169 | 18·7 |
| | 6·1 | 1·92 | 0·156 | 18·7 |
| | 1·92 | .. | 0 250 | 20·2 (per fry) |
| | 2·00 | .. | 0·200 | 20·2 (per fry) |
| *Tilapia mossambica* .. .. .. .. .. .. .. | 8·6 | 16·8 | 0·427 | 31·2–31·6 |
| | 4·9 | 1·12 | 0·710 | 31·2–31·6 |
| | 4·3 | 0·84 | 0·749 | 31·2–31·6 |
| | Fry | 0·10 | 2·000 | 31·2–31·6 |
| *Cata catla* .. .. .. .. .. .. .. .. | 28·6 | 55·00 | 0·111 | 28·6 |
| | 14·2 | 30·00 | 0·193 | 28·6 |
| | 12·2 | 21·50 | 0·273 | 28·0 |
| *Labto fimbriaeus* .. .. .. .. .. .. .. | .. | 11·40 | 0·633 | .. |
| | .. | 18·65 | 0·448 | .. |
| | 2·5 | 0·68 | 0·804 | .. |
| | 4·0 | 1·60 | 0·787 | .. |

TABLE No. IV.

*" Group effect " on oxygen consumption by fresh water fish.*

| *Fish.* (1) | *Number.* (2) | *Oxygen consumption mg/g/hr.* (3) |
|---|---|---|
| *Mirror carp*— | | |
| I | 1 | 0·493 |
| | 6 | 0·347 |
| II | 1 | 0·604 |
| | 4 | 0·324 |
| III | 2 | 0·344 |
| | 8 | 0·326 |
| IV | 2 | 0·575 |
| | 10 | 0·297 |
| *Barbus mahecola*— | | |
| .. | 2 | 0·434 |
| | 4 | 0·325 |
| | 6 | 0·267 |

| *Fish* (1) | *Number.* (2) | *Oxygen consumption mg/g/hr.* (3) |
|---|---|---|
| *Talapia mosambica* (fry) .. .. | 4 | 2·000 |
| | 34 | 0·955 |
| *Etroplus maculatus* (fry) .. .. | 3 | 0·637 |
| | 15 | 0 235 |
| *Golden carp* .. .. .. .. | 1 | 0·300 |
| | 3 | 0·266 |
| *Labeo fimbriatus* (fry) .. .. | 24 | 0·787 |
| | 17 | 0·900 |
| | 2 | 1·800 |

TABLE NO. V.

*Effect of certain chemicals on oxygen consumption.*

| Name of chemical. | Conc. mg./L. | Fish. | Oxygen consumed mg/g/hr. Experimental. | Control (no chemical). | Remarks. |
|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) |
| Thiourocil | 10 | *Mirror carp* | 0·240 | 0·267 | |
| | 10 | Do. | 1·420* | 3·856* | |
| | 10 | Do. | 1·900* | 3·120* | |
| | 10 | Do. | 0·355 | 0·493 | |
| | 10 | *Cirrhina cirrhosa* | 1·640* | 1·900* | |
| Urethane | 10 | Do. | 0·207 | 0·482 | |
| Verenal (Barbitone) | 20 | Do. | 0·131 | 0·390 | |
| | 20 | *Tilapia mossambica* | 0·635 | 0·749 | |
| | 20 | Do. | 0·710 | 0·954 | |
| | 20 | Do. | 0·599 | | |

* Per fish per hour.

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# ON THE FISH LANDINGS AND FISHERY TREND AT CAPE COMORIN

BY

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## Introduction

The fishery potentialities of the Arabian sea, the Indian Ocean and the Bay of Bengal are rich and the unique location of Cape Comorin at the Southern tip of the Indian sub-continent makes it an ideal place for exploiting these vast fishery resources. Geographically Cape Comorin is situated in Latitude 8°6′ N and Longitude 77°60′ E and the fishing village proper is situated on the eastern side of the promontory and extends over one mile along the coastline towards the north. The fish landing place behind the local Catholic Church is fairly protected from the fury of the waves by a group of rocks on the southern side and a rocky headland on the north. Being one of the important fishing centres of Madras State, a systematic collection of the daily statistics of the fish landings at Cape Comorin was made from the year 1957 onwards, as a routine item of work of the Marine Biological Station. The monthly landings and their species composition during the years 1957 and 1958 were already published by Ramanandham and Chacko (1962). The present paper details the fish landings of the place over a six-year period from 1958 to 1963, the present status of the fishing industry at Cape Comorin and the fishery trend in the area.

## Present status of Fishing Industry at Cape Comorin

There are 3,183 fishermen, women and children with 1,115 individuals actively engaged in fishing at Cape Comorin (Chacko and George, 1958). The boat catamarans ranging from 14 ft. to 23 ft. in length and made of 3 to 5 logs lashed together form the only indigenous fishing craft of this place and they total in number to about 500. Eight Pablo type mechanised boats supplied by the State Fisheries department are also operated here from 1959 onwards and they are being operated from Leepuram, a small bay about 2·8 meters north of Cape Comorin, with better anchoring facilities.

Both hook and line fishing and net fishing are carried out successfully throughout the year. The exploitation of the 'Wadge Bank' and "Padukattu Par" is solely through hooks and lines. The fishermen start early morning, purchase the bait on the way from the homeward-bound fishermen, go up to 10 to 12 miles from the shore and return with their catches in the afternoon. A significant portion of the total fish landings is caught through hook fishing. "Boat seines" (Thattumadi) are the most important and efficient of the indigenous tackles used here and are operated from five fathoms upwards right through the year for catching all shoaling fishes. About 250 boat seine nets are used in the village besides the usual type of gill nets like Vala Valai (about 50 Nos.), Katcha Valai and Nethili Valai (about 80 Nos.) and Chala Valai (about 50 Nos.) which are operated only seasonally when shoaling of the particular variety of fish occurs. In recent years Nylon nets have also come into use along with the mechanised boats. The nets are usually operated within a radius of five miles, the fishermen leaving the shore past midnight or early in the morning and landing the fish early in the morning and before noon. During the peak fishing season when shoaling of ribbon fish or white baits takes place in close inshore area, the same fishing unit may undertake two or three consecutive trips the same day.

The varieties of fish usually caught in the different types of nets are as follows :—

| *Hooks and Lines.* | *Boat Seines.* | *Gill and Drift nets.* |
|---|---|---|
| Serranus | Leiognathus | Leiognathus |
| Lethrinus | Caranx | Sharks, Skates and Rays. |
| Lutjanus | Stromateus | Sardinella |
| Aprion | Lactarius | Caranx. |
| Sharks, Skates and Rays. | Pellona | Megalaspis. |
| Caranx | Arius | Stromateus. |
| Megalaspis | Dussumieria | Chorinemus. |
| Chirocentrus | Anchoviella | Chirocentrus |
| Arius | Trichiurus | Arius |
| Cybium | Sciaena | Pellona |
| Diagramma | Pristipoma | Cybium |
| Sciaena | Sphyraena | Anchoviella |
| Sphyraena | Upeneoides | Diagramma |
| Thynnus | Mackerel | Sciaena |
| Belone | Mugil | Pristipoma |
| Elacate | Prawns | Hilsa |
| Albula | | |
| Otolithus | | |

Balistes are caught in Dip nets (Katcha bag).

The important fishing grounds usually exploited by the fishermen are locally known as 'Kothala Madai'. 'Koyilannai Par' 'Uyarathannai Par', 'Velikkannai Par', 'Valayal Par', Padukattu Par', and 'Sura Par' and their approximate location are shown in the map in Annexure I. Excepting the last 2 grounds, all the rest are situated very near to Cape Comorin. The 'Padukattu Par' is about 14 miles from Cape Comorin and the 'Sura Par' (Wadge Bank) is about 35 miles off Cape Comorin in a south-westerly direction and because of the long distance, they are exploited only seasonally in March and April when the sea is rather calm and the wind favourable. To reach the Wadge Bank, the fishermen take almost 12 hours when the wind is favourable and fish there for about 6 hours and the return journey takes another 12 to 16 hours. The catches are mainly rock-cods, perches and sea-breams and all are mostly in a putrid condition. They are cured with plenty of salt and sold in the internal markets. The fishery potentialities of the Wadge Bank have been described by John et. al. (1959). The fishermen of Kovalam, Muttom and the adjoining fishing villages also occasionally land their catches at Cape Comorin, because of the facilities for curing and transport of fish by lorry to interior places.

About 75 to 80 per cent of the fish landings at Cape Comorin are salt cured and only the remaining quantity is sold in fresh condition for local consumption and for supply to other centres like Nagercoil, Palayamcottai, Manalikara, Alur, Thackalay, Maikal Mandapam, Kulasekaram, Trivandrum and Chenganachery. The transport is mostly by bicycles and also by lorries when the distance is much. About 80 per cent of the salt-cured and dried fish is transported by lorry to Tuticorin for export to Ceylon. The rest is sent to internal markets like Madras, Koilpatti, Melapalayam, Valliyur, Tenkasi, Paramakudi, Madurai, Tiruchirappalli, Arkonam, Nazareth and Chenganachery.

**Materials and Methods**

The catches of one-third of the total number of catamarans landing daily at the fishing village were examined in detail for their species composition and the quantity in kilogram of each species caught was noted. The total of the figures so obtained for all the catamarans examined was multiplied by 3 and recorded as the total daily landings of the place for each species. Statistics of daily landings was thus collected over a period of six years from 1958 to 1963.

**Discussion of results**

The total monthly landings in each variety of fish every year during the six-year period 1958–63 are shown in Tables I to VI in annexure. The total annual landings in each veriety and the total average landings in each veriety during the period are shown in Table VII in annexure.

**Annual Landings**

During the six-year period 1958–63, the total annual fish landings at Cape Comorin varied from a minimum of 1,130·347 tonnes in 1962 to a maximum of 2,601·519 tonnes in 1958, the average annual landings during the period being 1,772·821 tonnes. The fishery was above the average during the years 1958, 1959 and 1961 and during the other years it was below average. It will be seen from Table VII that the two major fisheries of the place are *Trichiurus* and *Anchoviella* and the failure of these two fisheries are responsible for the poor fishery in the years 1960, 1962 and 1963. The fishery in general showed a declining trend from 1958 to 1962 excepting for the year 1961 when there was a good fishery of *Anchoviella.*

As many as 35 varieties of fishes are landed in this place and their total annual landings during the six-year period are given in Table VII. In addition to these 35 varieties of fishes Lobsters (*Panulirus sp.*) are also being caught from November to April every year to cater the needs of the freezing factories at Cochin and for subsequent export of frozen lobster tails to U.S.A. and Canada. A preliminary report on the lobster fishery of Kanyakumari district coast has already been published by Ramanandham and Chacko (1962). Miyamato and Shariff (1961) studied the potentialities for lobsters on the south-west coast of India with special reference to the existing craft, fishing gear and method of fishing. Balasubramanian et. al. (1960& 1961) have also given an account of the rock lobster fishing experiments with bottom-set gill nets along the south-west coast of India. Size and sex composition of the catches of the lobsters along the Kanyakumari district coast in 1960–61 have been detailed by Radhakrishnan Nair (1963). The lobster fishery landings and trend during recent years in Kanyakumari district are being published separately (Srinivasan, R. and Ananthanarayanan, R. unpublished) and are therefore excluded from this publication. The names of the varieties in the order of importance according to the quantities landed during the study period are—*Trichiurus, Anchoviella, Lactarius, Caranx, Dussumieria, Serranus, Lethrinus, Arius, Sharks, skates and rays, Sardinella, Lutjanus Cybium, Leiognathus, Sciaena, Aprion, Stromateus, Sphyraena, Chorinemus, Decapterus, Megalaspis, Chirocentrus, Upeneoides, Balistes, Pristipoma, Diagramma Pellona, Mackerel, Drepane, Otolithus, Histiophorous, Albula, Hilsa, Elacate, Mullets,* and *Thynnus.* The first two varieties, namely *Trichiurus* and *Anchoviella*, with average annual landings of 487·784 tonnes and 467·267 tonnes respectively form the 2 major fisheries of the place. *Lactarius* (average 217·370 tonnes), *Caranx* (Av. 156·734 tonnes) and *Dussumieria* (Av. 82·594 tonnes) also form important fishery. The annual fluctuations and proportions of the important species in the fish landings during the six-year period are shown in the histogram in Annexure II.

**Seasonal variations.**

There is fishing right through the year, but the peak season is for five months only from June to October when more than 75 per cent of the total annual landings are caught as detailed in Table VIII in annexure.

It will be seen from this table that the maximum landings are between the months of July and October every year, the monthly maximum ranging from 235·981 tonnes in October 1962 to 893·077 tonnes in September 1961. The poorest fishing months are usually December, January and February, the total monthly catches during the off-season varying from 13·797 tonnes in January 1961 to 29·066 tonnes in January 1963. In 1959, the poorest fishing month was May when only 16·759 tonnes were landed. The important fishery during the peak season in all the years were *Trichiurus, Anchoviella, Lactarius, Caranx,* and *Dussumieria.* In 1963, there was a good fishery of *Arius* also during the peak season.

The maximum, minimum and average annual landings of each variety of fish during the six-year period, their percentage in the total annual landings and the months of their peak fishery are shown in Table IX in annexure in their decreasing order of importance.

It will be seen from this table that *Trichiurus* constitutes the most important fishery amounting to 27·5 per cent of the total landings and next comes *Anchoviella* accounting for 26·0 per cent of the total catches. *Lactarius* (12 per cent), *Caranx* (8·8 per cent), *Dussumieria* (4 per cent), *Serranus* (2·9 per cent), *Lethrinus* (2·1 per cent), *Arius* (2·0 per cent), Sharks, skates and rays (1·9 per cent), *Sardinella* (1·6 per cent), *Lutjanus* (1·2 per cent), *Cybium* (1·2 per cent), *Leiognathus* (1·1 per cent), and *Sciaena* (1 per cent) constitute the other important varieties landed in significant quantities. All other varieties caught put together amount to about 6 per cent only and are individually less than 1 per cent of the total landings. The first five varieties, namely, *Trichiurus*, *Anchoviella*, *Lactarius*, *Caranx* and *Dussumieria* account for 78·3 per cent of the total landings. All these five varieties are landed in large quantities during the peak fishery season between June and October, though they are also seen in small quantities in the off-season catches.

In 1958, *Anchoviella* (800·977 tonnes ), *Caranx* (397·647 tonnes), *Cybium* (36·233 tonnes), *Stromateus* (17·196) tonnes), *Decapterus* (21·898 tonnes), *Balistes* (16·363 tonnes) and *Histiophorus* (1·478 tonnes) were landed in maximum quantities during the six-year period. In 1959, *Sphyraena* (13·571 tonnes), *Chorinemus* (13·579 tonnes), and Mullets (0·555 tonnes) were landed in max. quantities. In 1960, *Dussumieria* (120·276 tonnes), *Sardinella* (49·729 tonnes), Megalaspis (10·122 tonnes), Mackerel (7·242 tonnes), *Otolithus* (2·346 tonnes), and *Elacate* (0·757 tonnes) were landed in max. quantities. In 1961, *Trichiurus* (755·387 tonnes), *Lactarius* (337·662 tonnes), Leiognathus (37·490 tonnes), *Sciaena* (30·236 tonnes), *Pristipoma* (9·084 tonnes), *Pellona* (3·098 tonnes) and *Drepane* (4·263 tonnes), were landed in max. quantities. In 1962, which was the poorest landing year in the six-year period, *Aprion* (44·658 tonnes) and *Diagramma* (5·759 tonnes) were landed in max. quantities. In 1963, *Serranus* (82·686 tonnes), *Lethrinus* (102·377 tonnes), Arius (61·923 tonnes), *Lutjanus* (52·319 tonnes), *Chirocentrus* (10·434 tonnes), *Upeneoides* (7·443 tonnes), *Albula* (1·407 tonnes), *Hilsa* (0·921 tonnes) and *Thynnus* (0·174 tonnes) were landed in max. quantities.

In 1958, the catches of *Lutjanus*, *Megalaspis*, *Upeneoides*, *Pellona*, Mackerel, *Albula*, *Hilsa*, *Elacate* and *Thynnus* were the lowest during the six-year period. In 1959, catches of *Sardinella*, *Decapterus*, *Chirocentrus*, *Pristipoma*, *Albula*, *Hilsa* and Tuna were the lowest during the period. In 1960, catches of *Serranus*, *Lethrinus*, *Leiognathus*, *Aprion*, *Sphyraena*, *Pristipoma*, *Diagramma*, *Hilsa* and Tuna were the lowest for the six-year period. In 1961, *Anchoviella*, *Dussumieria*, *Arius*, *Cybium*, Mullets and Tuna were the lowest for the six-year period. In 1962, *Trichiurus*, *Lactarius*, *Caranx* Sharks, skates and rays, *Stromateus*, *Chorinemus*, *Drepane*, *Otolithus*, and Mullets were the lowest for the six-year period. In 1963, *Sciaena*, *Decapterus*, *Balistes*, *Mackerel*, *Drepane*, *Otolithus* and *Histiophorus* recorded the lowest catches for the period of study. *Decapterus* was not landed during the year 1959, 1961 and 1963. *Pristipoma* was not seen in the catches in 1959 and 1960. Mackerel was not landed in 1958 and 1963. *Drepane* and *Otolithus* were not caught in 1962 and 1963. *Albula* was not landed in 1958 and 1959. Hilsa was not landed in 1958, 1959 and 1960. Mullets were not caught in 1961 and 1962 and Tuna was not caught till 1961.

## Fishery Calendar

Every year, the months of June to October form the peak fishing season, when the following varieties are landed in fairly good quantities—*Trichiurus*, *Anchoviella*, *Lactarius*, *Caranx*, *Dussumieria*, Sharks, skates and rays, *Sardinella*, *Stromateus*, *Spyraena*, *Decapterus* and *Drepane*. During the off-season the following varieties are landed—*Serranus*, *Lethrinus*, *Lutjanus*, *Arius*, *Cybium*, *Leiognathus*, *Sciaena*, *Aprion*, *Chorinemus*, *Megalaspis*, *Chirocentrus*, *Upeneoides*, *Balistes*, *Pristopoma*, *Pellona*, *Otolithus* and *Histiophorus*.

A fishery calendar for the Kanyakumari district coast was already prepared by Chacko and George (1958 loc. cited). A more exhaustive fishery calendar for Cape Comorin has been worked out based on the fisheries of the six-year period 1958–1963 and is shown in Table X in annexure. The names of fishes have been arranged in thislist in the order of importance according to the quantities landed during each month. It will be seen from this calendar that seer is landed in good quantities from November to February, the maximum being in the months of December and January. *Lethrinus*, *Serranus*, *Lutjanus*, and *Aprion* form the major fishery in the catches during the months from February to May. Arius is predominant in the catches in December and April. *Caranx* is landed right through the year, the maximum being during the months of May to October. *Sardinella* is available right through the year with 2 peaks, one in May and another in November. *Anchoviella* has season from June to November and *Trichiurus* from June to October. *Lactarius* is landed in good quantities from September to November and Rainbow-Sardines from June to September. Pomfrets and Sharks, rays and skates are landed right through the year.

## Relationship to Fishing Effort

The monthly averages and annual averages of the number of catamarans that went for fishing every day during the six-year period 1958–63 are shown in Table XI in annexure.

It will be seen from this table that only about 100 catamarans are engaged daily in fishing on the average during the off-season and the number of catamarans are nearly doubled during the peak fishing season from June to October every year. There has also been a steady decline in the number of catamarans year after year from 1958 to 1960 and in 1962 and the position has slightly improved in 1963. This closely follows the annual fishery trend also and during the year 1961, when there was a good fishery of Anchoviella, the number of catamarans had actually increased. Though there are as many as 500 catamarans in the village all of them do not go for fishing simultaneously and only a maximum of 300 catamarans/day on the average were found to go for fishing even during the peak fishing season. The general tendency had been for more number of catamarans to go for fishing whenever the catches had been good and this would suggest an apparent direct proportionate relationship between the number of the catamarans and the landings. But a more close scrutiny of the monthly variations in the catching efforts and the landings revealed that landings were not directly proportionate to the number of catamarans engaged in fishing.

## Fishery Trend

The total annual landings decreased generally from the year 1958 to 1960, increased in 1961, but again decreased in 1962 to the lowest figure for the six-year period and again showed an improvement during the year 1963. The same trend is reflected in the *Trichiurus* fishery which is the most important fishery of Cape Comorin. From an annual landings of 724·100 tonnes in 1958, the *Trichiurus* catches steadily decreased to about 233·249 tonnes in 1960, recorded the maximum catches of 755·387 tonnes in 1961, and the minimum of 233·119 tonnes in 1962 and the catches improved in 1963. The second important fishery of the place, namely, *Anchoviella* also followed the same trend, commencing from a maximum of 800·977 tonnes in 1958, gradually declining year after year and touching the minimum catches of 306·902 tonnes in 1961. There has been no further decline of the white bait fishery after 1961 and the annual landings remain more or less steady at the figure of about 350 tonnes. The *Lactarius* fishery, which is 3rd in importance was more or less steady during the entire period of study with an average annual landings of 217·370 tonnes and recorded a maximum of 337·370 tonnes in 1961 followed by a minimum of 104·064 tonnes only in 1962. *Caranx* has declined considerably during the years 1962 and 1963, when compared with the previous years. *Dussumieria* recorded a steep-fall in 1961 and is since showing signs of gradual revival. The landings of *Serranus*, *Lethrinus*, *Lutjanus*, *Arius* and *Cybium* are found on the increase during the recent year . *Sardinella* is on the decline.

All the fishery trend referred above may be due to natural causes like the annual fluctuations in the fishery only, since there has been not much appreciable change in the catching effort year after year. Lobsters (*Panulirus sp.*) have gained increasing importance as a commercial fishery during the study period, because of their demand in the freezing plants at Cochin for export to U.S.A. and Canada. The attractive prices offered by these companies for the lobsters, have tended to increase lobster-fishing at Cape Comorin as in other places in Kanyakumari district during the months of November to April every year. The lobster fishery trend in Kanyakumari district is being discussed in detail and published separately (Srinivasan, R and Anantanarayanan, R. un-published.).

The months during which the important fisheries of Cape Comorin had their peak seasons during the different years of the six-year period are shown in Table XII in annexure.

From this table it will be seen that the peak seasons for the two important and major fisheries of the place, namely *Trichiurus* and *Anchoviella* continue to be the months from June to October, though in recent years the trend has been towards later commencing of the fishery in July or even in August. *Lactarius* continues to be caught in good quantities in September and October. Rainbow-Sardines though normally expected in the months of June to October every year seem to have shorter duration of fishery for two months only in June and July in recent years. *Serranus*, *Lethrinus* and *Lutjanus* have a trend towards extended and bigger fishery year after year. The perches are now caught from December to July and in larger amounts. *Arius* which seemed to have two peak seasons one in January-February and another in July-October at the beginning of the study period, had only one fishery from June to September in 1962 and from June to December in 1963. *Sardinella* continues to have two seasons from March to May and October to December, though in 1963, the fishery in November-December only was significant. *Cybium* continues to be a good fishery from October to February every year.

### *Summary.*

The present status of the fishing industry at Cape Comorin is briefly described. The total monthly and annual landings of the 35 different varieties of fishes caught at Cape Comorin during the six-year period 1958 to 1963 are detailed and the annual and seasonal variations in the landings and the fishery trend in the area are discussed. *Trichiurus* and *Anchoviella* with average annual landings of 487·784 tonnes and 467·267 tonnes respectively from the two major fisheries of the place and account for 27·5 per cent and 26 per cent respectively of the total catches. *Lactarius* (average annual landings 217·370 tonnes and 12 per cent of the total catches), *Caranx* (av. annual landings 156·734 tonnes and 8·8 per cent of the total catches) and *Dussumieria* (av. annual landings 82·59 tonnes and 4 per cent of the total catches), *Serranus* (av. 50·805 tonnes and 2·9 per cent of the total catches), *Lethrinus* (av. 35·427 tonnes and 2·0 per cent of total catches). Sharks, skates and rays (av. 33·847 tonnes and 1·9 per cent of total catches), *Sardinella* (av. 27·899 tonnes and 1·6 per cent of total catches), *Lutjanus* (av. 22·009 tonnes and 1·2 per cent of total catches) and Seer (av. 21·939 tonnes and 1·2 per cent of total catches) constitute the other important varieties landed at Cape Comorin in significant quantities. Though fishing is done at Cape Comorin right through the year, the peak fishing season is for five months only from June to October every year when more than 75 per cent of the total annual landings are caught. *Trichiurus*, *Anchoviella*, *Lactarius*, *Caranx*, *Dussumieria*, Sharks, Skates and rays, *Sardinella*, *Stromateus* and *Sphyraena* are the predominent catches during the peak season. During the off-season, *Serranus*, *Lethrinus*, *Lutjanus*, *Arius*, *Cybium*, *Sciaena*, *Aprion* and *Chorinemus* are caught in fairly good quantities. Based on the fish landings of the different varieties during the six-year period, an exaustive fishery calendar for Cape Comorin has been worked out.

The fishery in general showed a declining trend from the year 1958 to 1962 excepting for 1961 when there was a good fishery of white baits and signs of gradual recovery were noted during the year 1963. The same trend was noticed in the catches of *Trichiurus* and *Anchoviella*, the two major fisheries of the place. *Lactarius* was found to be steady, while *Caranx* and *Sardinella* had declined considerably during 1962 and 1963. Rainbow sardines recorded a steep fall in 1961 but has since shown signs of gradual revival. Perches, Arius and Seer landings show an increasing trend during recent years. The *Anchoviella*

and *Trichiurus* fishery trend to commence late in July or August only during recent years instead of in June. Rainbow sardines trend to have a fishery of shorter duration while the perches have a trend towards extended and bigger fishery during recent years. Since there has not been appreciable change in the catching effort at Cape Comorin during the six-year period, the fishery trend in the area may be mainly due to natural causes only.

*Acknowledgments.*

Our thanks are due to the Director of Fisheries, Madras, for his kind permission to publish this paper.

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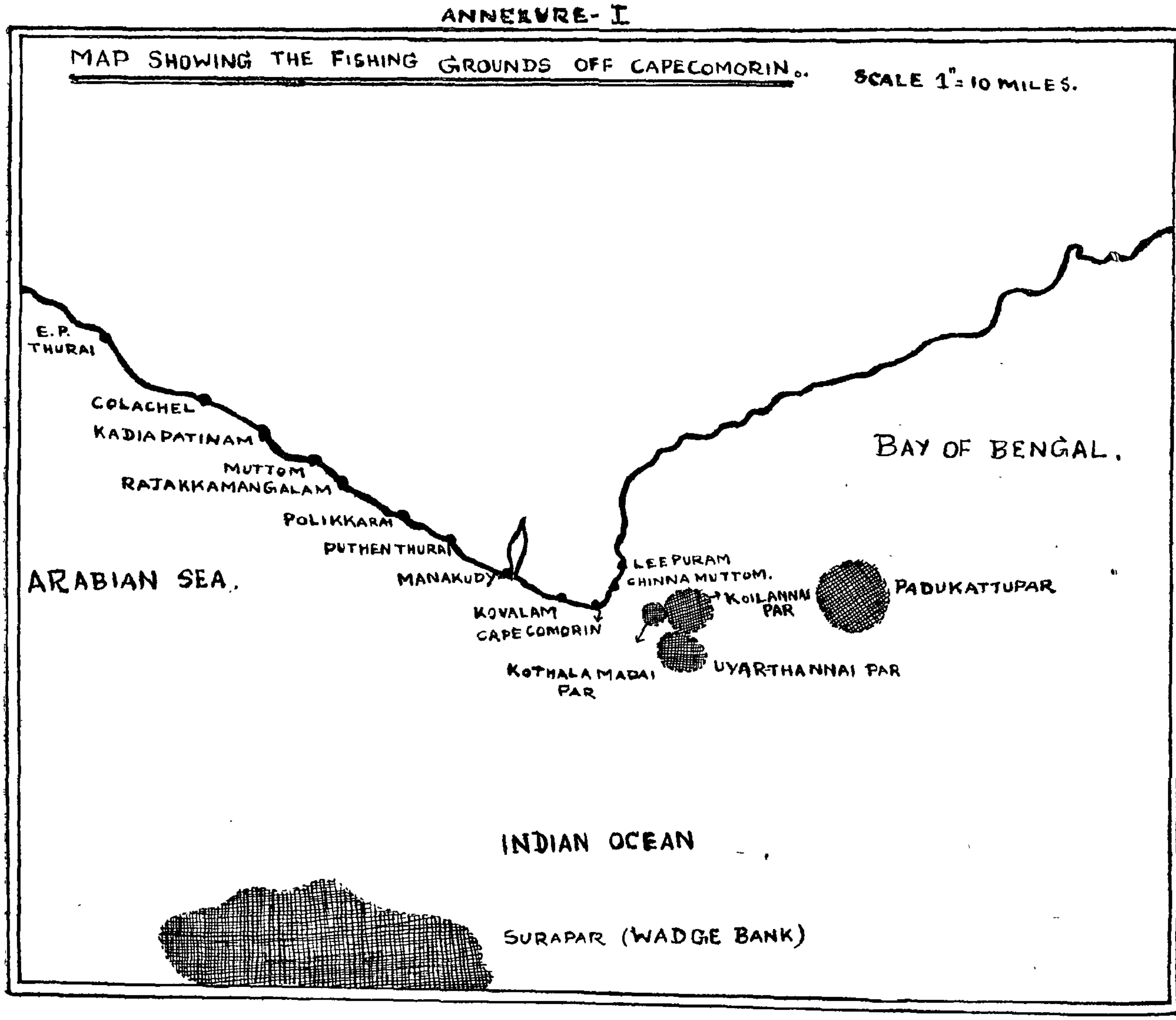
ANNEXURE- I


MAP SHOWING THE FISHING GROUNDS OFF CAPECOMORIN.
SCALE 1" = 10 MILES.
E.P. THURAI
COLACHEL
KADIAPATINAM
MUTTOM
RAJAKKAMANGALAM
POLIKKARAM
PUTHENTHURAI
MANAKUDY
ARABIAN SEA.
KOVALAM
CAPE COMORIN
LEEPURAM
CHINNA MUTTOM.
KOILANNAI PAR
PADUKATTUPAR
BAY OF BENGAL.
KOTHALAMADAI PAR
UYARTHANNAI PAR
INDIAN OCEAN
SURAPAR (WADGE BANK)

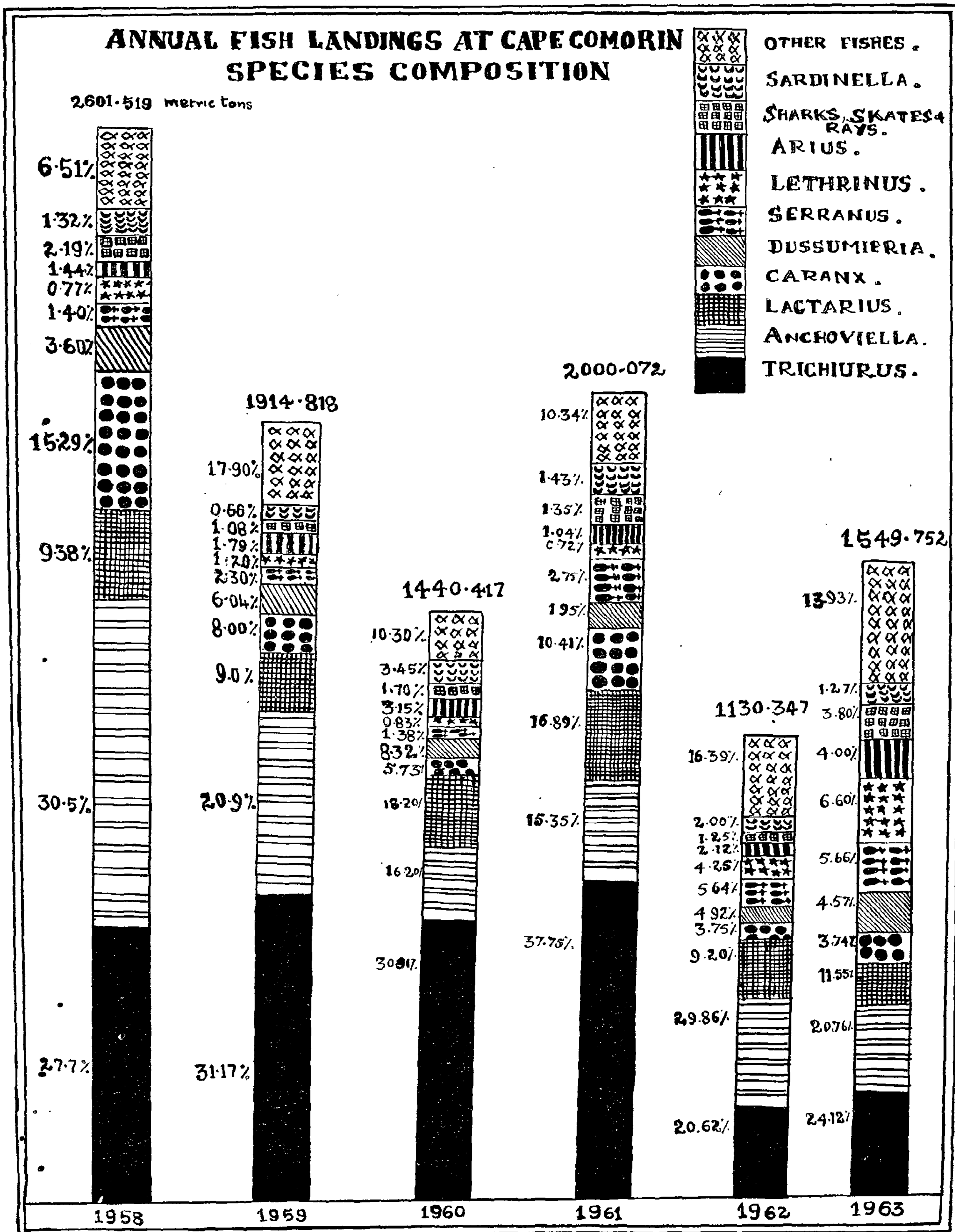

ANNUAL FISH LANDINGS AT CAPE COMORIN
SPECIES COMPOSITION
OTHER FISHES.
SARDINELLA.
SHARKS, SKATES & RAYS.
ARIUS.
LETHRINUS.
SERRANUS.
DUSSUMIERIA.
CARANX.
LACTARIUS.
ANCHOVIELLA.
TRICHIURUS.
2601·519 metric tons
6·51%
1·32%
2·19%
1·44%
0·77%
1·40%
3·60%
15·29%
9·38%
30·5%
27·7%
1914·818
17·90%
0·66%
1·08%
1·79%
1·70%
2·30%
6·04%
8·00%
9·0%
20·9%
31·17%
1440·417
10·30%
3·45%
1·70%
3·15%
0·83%
1·38%
8·32%
5·73%
18·20%
16·20%
30·81%
2000·072
10·34%
1·43%
1·35%
1·04%
0·72%
2·75%
1·95%
10·41%
16·89%
15·35%
37·75%
1130·347
16·39%
2·00%
1·25%
2·12%
4·25%
5·64%
4·92%
3·75%
9·20%
29·86%
20·62%
1549·752
13·93%
1·27%
3·80%
4·00%
6·60%
5·66%
4·57%
3·74%
11·55%
20·76%
24·12%
1958
1959
1960
1961
1962
1963

TABLE 1.

*Showing the total monthly landings in each variety of fish during the year 1958 in tonnes at Cape Comorin.*

| *Serial number and varieties.* | *January.* | *February.* | *March.* | *April.* | *May.* | *June.* | *July.* | *August.* | *September.* | *October.* | *November.* | *December.* | *Total.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) |
| 1 Anchoviella .. .. | 2·591 | 1·182 | 0·068 | 1·182 | 0·045 | 118·182 | 127·727 | 228·182 | 190·909 | 122·727 | 7·273 | 0·909 | 800·977 |
| 2 Trichiurus .. .. | 0·591 | 0·773 | 0·136 | 0·034 | 0·341 | 113·636 | 356·816 | 131·818 | 100·000 | 10·455 | 9·091 | 0·409 | 724·100 |
| 3 Caranx .. .. | 5·227 | 1·818 | 0·773 | 0·955 | 29·545 | 52·955 | 27·955 | 227·273 | 20·939 | 24·091 | 4·308 | 1·818 | 397·647 |
| 4 Lactarius .. .. | 1·636 | 0·727 | 0·432 | 0·091 | 2·318 | 0·045 | .. | 1·818 | 209·091 | 25·909 | 1·364 | 0·682 | 244·113 |
| 5 Dussumieria .. .. | 0·295 | 0·045 | .. | .. | .. | 0·682 | 80·000 | .. | 11·273 | 1·409 | 0·682 | 0·136 | 94·522 |
| 6 Sharks, skates and rays. | 5·568 | 1·705 | 1·314 | 1·314 | 1·705 | 0·955 | 3·455 | 12·727 | 22·727 | 1·932 | 2·545 | 1·136 | 57·083 |
| 7 Serranus .. .. | 3·068 | 0·955 | 3·864 | 7·159 | 4·318 | 14·091 | 1·727 | 2·273 | 0·273 | 0·136 | 0·227 | 0·080 | 38·171 |
| 8 Cybium .. .. | 6·727 | 8·182 | 0·386 | 0·205 | 0·114 | .. | .. | 0·164 | 1·364 | 4·091 | 7·273 | 7·727 | 36·233 |
| 9 Sardinella .. | .. | .. | 5·795 | 7·091 | 2·955 | .. | 0·455 | 16·364 | .. | 1·682 | 0·136 | .. | 34·478 |
| 10 Arius .. .. .. | 2·682 | 3·523 | 1·114 | 0·091 | 0·136 | 0·795 | 4·227 | 5·273 | 0·864 | 5·909 | 1·591 | 0·909 | 27·114 |
| 11 Decapterus .. .. | .. | .. | .. | .. | .. | .. | .. | .. | 21·898 | .. | .. | .. | 21·898 |
| 12 Lethrinus .. .. | 0·614 | 5·455 | 6·591 | 1·591 | 1·136 | 0·682 | 0·273 | 3·955 | 0·114 | 0·032 | 0·136 | 0·080 | 20·659 |
| 13 Stromateus .. .. | 1·114 | 1·227 | 0·091 | 0·205 | 0·091 | 1·136 | 0·250 | 6·818 | 3·727 | 0·364 | 1·818 | 0·355 | 17·196 |
| 14 Sciaena .. .. | 2·636 | 0·341 | 0·914 | 0·273 | 0·795 | 0·159 | 0·227 | 1·455 | 0·136 | 1·409 | 0·682 | 4·091 | 13·118 |
| 15 Sphyraena .. .. | 0·386 | 0·773 | 0·080 | 0·091 | 0·136 | 0·091 | 0·102 | .. | 7·273 | 1·591 | 0·909 | 0·682 | 12·114 |
| 16 Leiognathus .. .. | 4·318 | 3·977 | 0·318 | 0·045 | 0·045 | 0·045 | 0·182 | .. | .. | 0·318 | 0·682 | 1·818 | 11·748 |
| 17 Balistes .. .. | .. | 3·636 | 4·727 | 2·000 | .. | .. | .. | .. | .. | .. | .. | .. | 10·363 |
| 18 Chorinemus .. .. | 1·591 | 1·227 | 1·091 | 2·955 | 2·045 | 0·091 | 0·091 | .. | .. | 0·068 | 0·114 | 0·114 | 9·307 |
| 19 Aprion .. .. | .. | .. | 2·273 | 5·045 | 1·705 | .. | .. | .. | .. | .. | .. | .. | 9·023 |
| 20 Lutjanus .. .. | 0·114 | 0·398 | 0·500 | 1·659 | 0·682 | 0·159 | .. | .. | .. | .. | .. | .. | 3·512 |
| 21 Prisptipoma .. | 0·795 | 1·864 | 0·459 | 0·068 | 0·080 | .. | .. | .. | .. | .. | .. | .. | 3·266 |
| 22 Drepane .. .. | .. | .. | .. | .. | 0·500 | 0·909 | 0·261 | 0·773 | .. | .. | 0·318 | .. | 2·761 |
| 23 Chirocentrus .. | 0·500 | 0·568 | 0·125 | .. | .. | .. | 0·023 | .. | 0·549 | .. | 0·727 | 0·077 | 2·569 |
| 24 Megalaspis .. .. | 0·795 | 0·455 | 0·549 | 0·227 | .. | .. | .. | .. | .. | .. | 0·182 | 0·455 | 2·663 |
| 25 Upeneoides .. .. | 0·182 | 0·364 | 0·614 | .. | .. | .. | 0·080 | .. | .. | 0·291 | 0·818 | 0·068 | 2·417 |
| 26 Histiophorus.. .. | 0·091 | .. | .. | 0·023 | .. | .. | .. | .. | .. | .. | 0·909 | 0·455 | 1·478 |
| 27 Otolithus .. .. | 0·227 | 0·318 | 0·341 | 0·034 | 0·045 | .. | 0·182 | .. | .. | 0·114 | .. | 0·045 | 1·306 |
| 28 Diagramma .. .. | .. | .. | 0·159 | 0·273 | 0·159 | 0·182 | 0·227 | 0·036 | .. | 0·023 | 0·023 | 0·023 | 1·105 |
| 29 Pellona .. .. | .. | 0·125 | 0·068 | .. | 0·080 | .. | .. | .. | .. | .. | .. | .. | 0·273 |
| 30 Mugil .. .. | .. | .. | .. | 0·250 | .. | .. | .. | .. | .. | .. | .. | .. | 0·250 |
| 31 Elacate .. .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 0·055 | .. | 0·055 |
| Total weight .. | 41·748 | 39·638 | 32·802 | 32·861 | 48·976 | 304·795 | 604·180 | 438·929 | 591·107 | 202·551 | 41·863 | 22·069 | 2,601·519 |

# TABLE II.

*Showing the total monthly landings in each variety of fish during the year 1959 in tonnes at Cape Comorin.*

| Serial number and varieties. | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. | Total. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) |
| 1 Trichiurus .. .. | 0·114 | .. | .. | .. | 0·227 | 1·591 | 0·545 | 40·909 | 490·909 | 70·727 | 2·727 | 0·068 | 607·090 |
| 2 Lactarius .. .. | 0·549 | 0·091 | 0·182 | 0·227 | 0·114 | 3·636 | 0·909 | 0·909 | 30·909 | 127·273 | 11·364 | 0·818 | 176·981 |
| 3 Leiognathus .. | 3·864 | 7·955 | 1·068 | 0·227 | 0·136 | 0·227 | 0·318 | 0·114 | 0·682 | 0·273 | 2·727 | 5·227 | 22·818 |
| 4 Caranx .. .. | 2·159 | 4·545 | 1·636 | 1·136 | 2·045 | 35·227 | 5·000 | 10·000 | 56·818 | 25·455 | 5·455 | 2·045 | 151·521 |
| 5 Dussumieria .. | 0·045 | 0·091 | 0·159 | 0·909 | 0·114 | 14·545 | 40·227 | 27·273 | 17·045 | 9·545 | 1·818 | 4·091 | 115·862 |
| 6 Anchoviella .. .. | 0·409 | | .. | .. | 0·549 | 1·364 | 37·727 | 159·091 | 177·273 | 172·727 | 8·182 | 3·864 | 561·186 |
| 7 Serranus .. .. | 0·114 | 3·977 | 18·864 | 10·455 | 0·682 | 1·250 | 5·000 | 2·273 | 1·364 | 1·159 | 0·045 | .. | 45·183 |
| 8 Arius .. .. .. | 5·909 | 0·549 | 0·136 | 0·682 | 0·455 | 0·227 | 2·273 | .. | 15·000 | 0·091 | 7·273 | 1·818 | 34·463 |
| 9 Cybium .. .. | 7·955 | 8·864 | 2·045 | 0·182 | 0·682 | 0·205 | 0·182 | 0·136 | 0·455 | 2·727 | 5·000 | 2·273 | 30·706 |
| 10 Lutjanus .. .. | 0·045 | 0·136 | 0·364 | 4·545 | 0·519 | 0·091 | 0·795 | 0·023 | 0·023 | .. | .. | 0·091 | 6·632 |
| 11 Lethrinus .. .. | 0·136 | 3·068 | 5·227 | 7·727 | 1·705 | 0·682 | 2·045 | 1·136 | 0·500 | 0·205 | 0·500 | 0·682 | 23·613 |
| 12 Sharks, skates and rays. | 2·727 | 1·000 | 1·136 | 1·591 | 1·136 | 0·591 | 1·250 | 1·364 | 2·045 | 3.727 | 1·909 | 2·364 | 20·840 |
| 13 Aprion .. .. | .. | 0·909 | 12·955 | 5·455 | 0·045 | .. | .. | .. | .. | .. | .. | .. | 19·364 |
| 14 Sciaena .. .. | 0·636 | 0·523 | 0·295 | 0·549 | 0·636 | 0·682 | 0·682 | 0·795 | 2·500 | 2·955 | 2·273 | 4·091 | 16·617 |
| 15 Chorinemus .. .. | 1·182 | 1·705 | 2·636 | 1.591 | 3·068 | 0·045 | 0·091 | 0·034 | .. | .. | 0·500 | 2·727 | 13·579 |
| 16 Sardinella .. .. | .. | .. | 0·659 | 4·091 | 3·864 | 0·045 | 0·159 | .. | 0·273 | 1·136 | 1·364 | 1·182 | 12·773 |
| 17 Stromateus .. .. | 2·023 | 4·091 | 0·432 | 0·159 | 0·136 | 0·795 | 0·409 | 0·500 | 1·136 | 0·549 | 0·182 | 0·549 | 10·961 |
| 18 Megalaspis, sp. .. | 0·136 | 0·636 | 0·227 | 0·114 | .. | .. | .. | 0·409 | .. | .. | 2·955 | 3·409 | 7·886 |
| 19 Sphyraena .. .. | 0·591 | 0·318 | 1·159 | 0·409 | 0·273 | 1·364 | 0·386 | 0·455 | 1·591 | 6·818 | 0·023 | 0·364 | 13·751 |
| 20 Balistes .. .. | .. | 2·955 | 2·432 | .. | .. | .. | .. | .. | .. | .. | .. | .. | 5·387 |
| 21 Upeneoides .. .. | .. | 0·341 | 0·091 | 0·114 | .. | .. | .. | .. | 0·549 | 0·955 | 2·955 | .. | 5·005 |
| 22 Diagramma .. | 0·045 | 0·409 | 0·273 | 0·386 | 0·136 | 0·455 | 1·318 | 0·273 | 0·136 | .. | 0·023 | .. | 3·454 |
| 23 Drepane .. .. | 0·409 | 0·068 | .. | .. | 0·023 | .. | .. | .. | 1·364 | .. | .. | 0·182 | 2·046 |
| 24 Chirocentrus .. .. | 0·549 | 0·318 | 0·114 | .. | 0·068 | 0·023 | 0·068 | 0·068 | 0·409 | 0·045 | .. | 0·182 | 1·844 |
| 25 Otolithus .. .. | .. | 0·023 | .. | 0·068 | .. | .. | .. | .. | .. | 1·318 | 0·068 | .. | 1.477 |
| 26 Pellona .. .. | .. | .. | .. | .. | 0·114 | .. | .. | .. | .. | .. | .. | 1·364 | 1·478 |
| 27 Mackerel .. .. | .. | .. | .. | .. | .. | .. | .. | 0·682 | .. | .. | 0·091 | .. | 0·773 |
| 28 Histiophorus .. | 0·227 | 0·170 | 0·091 | .. | .. | .. | .. | .. | .. | 0·034 | 0·227 | .. | 0·749 |
| 29 Mugil .. .. | .. | 0·023 | .. | .. | 0·032 | .. | .. | .. | .. | .. | 0·500 | .. | 0·555 |
| 30 Elacate .. .. | 0·023 | 0·114 | .. | .. | .. | .. | .. | 0·041 | 0·023 | .. | 0·009 | 0·014 | 0·224 |
| Total weight .. | 29·847 | 42·929 | 52·181 | 40·617 | 16·759 | 63·045 | 99·384 | 246·485 | 801·004 | 426·992 | 58·170 | 37·405 | 1,914·818 |

TABLE III.

*Showing the total monthly landings in each variety of fish during the year 1960 in tonnes at Cape Comorin.*

| *Serial number and varieties.* (1) | *January.* (2) | *February.* (3) | *March.* (4) | *April.* (5) | *May.* (6) | *June.* (7) | *July.* (8) | *August.* (9) | *September.* (10) | *October.* (11) | *November.* (12) | *December.* (13) | ***Total.*** (14) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Anchoviella .. .. | 0·341 | 0·273 | 0·091 | 0·409 | 0·686 | 56·336 | 52·773 | 78·026 | 104·805 | 142·616 | 3·850 | 5·002 | 445·208 |
| 2 Lactarius .. .. | 0·455 | 0·136 | 0·091 | 0·909 | 0·182 | 0·090 | 0·470 | 0·869 | 21·145 | 237·481 | 0·072 | 0·422 | 262·322 |
| 3 Trichiurus .. .. | 0·068 | 0·136 | 0·091 | 0·091 | 0·068 | .. | 32·055 | 137·502 | 2·085 | 60·757 | 0·301 | 0·093 | 233·247 |
| 4 Dussumieria .. .. | 0·159 | 0·045 | 1·132 | 2·727 | 1·132 | 29·561 | 29·729 | 43·466 | .. | 3·875 | 2·530 | 5·920 | 120·276 |
| 5 Caranx .. .. | 0·409 | 0·686 | 1·591 | 1·818 | 10·909 | 9·916 | 19·111 | 7·088 | 25·440 | 2·481 | 1·375 | 1·678 | 82·502 |
| 6 Sardinella .. .. | .. | .. | 3·182 | 9·091 | 13·864 | .. | 0·120 | .. | 0·043 | 9·859 | 12·157 | 0·413 | 49·729 |
| 7 Arius .. .. | 3·636 | 1·591 | 0·686 | 0·636 | 0·364 | 1·714 | 10·677 | 0·576 | 21·101 | 1·527 | 0·499 | 2·352 | 45·359 |
| 8 Sharks, skates and rays. | 2·386 | 1·818 | 2·273 | 1·182 | 0·273 | 0·629 | 7·872 | 1·537 | 1·273 | 2·336 | 1·792 | 1·173 | 24·544 |
| 9 Sciæna .. .. | 3·295 | 0·686 | 0·341 | 0·727 | 0·182 | 0·164 | 0·283 | 0·224 | 2·472 | 6·436 | 2·826 | 6·239 | 23·875 |
| 10 Decapterus .. .. | .. | .. | .. | .. | .. | .. | .. | 20·008 | .. | .. | .. | .. | 20·008 |
| 11 Cybium .. .. | 0·386 | 1·227 | 0·795 | 0·432 | 0·068 | .. | .. | 0·446 | 1·099 | 6·624 | 5·455 | 2·774 | 19·306 |
| 12 Serranus .. .. | 0·568 | 0·341 | 7·955 | 6·591 | 0·636 | 1·294 | 1·006 | 0·085 | 1·429 | 0·025 | .. | .. | 19·930 |
| 13 Lethrinus .. .. | 1·250 | 1·132 | 5·909 | 1·818 | 0·500 | 0·184 | 0·494 | 0·072 | 0·057 | .. | 0·123 | 0·461 | 12·000 |
| 14 Chorinemus .. .. | 2·273 | 2·500 | 3·409 | 2·203 | 0·636 | .. | .. | .. | .. | 0·002 | 0·048 | 0·050 | 11·121 |
| 15 Stromateus .. .. | 0·227 | 0·549 | 0·182 | 0·182 | 0·136 | 0·622 | 2·603 | 0·135 | 1·177 | 1·753 | 4·185 | 0·665 | 12·416 |
| 16 Megalaspis .. .. | 1·636 | 0·909 | 0·818 | 0·455 | 0·045 | .. | 0·029 | .. | .. | 0·442 | 5·060 | 0·728 | 10·122 |
| 17 Mackerel .. .. | .. | .. | .. | .. | .. | .. | 0·316 | 6·237 | .. | .. | 0·689 | .. | 7·242 |
| 18 Leiognathus .. | 0·686 | 0·909 | 0·686 | 0·909 | 0·227 | 0·735 | 0·225 | 0·065 | 0·093 | 0·406 | 0·574 | 1·423 | 6·938 |
| 19 Lutjanus .. .. | .. | 0·295 | 3·182 | 2·364 | 0·091 | 0·061 | 0·236 | 0·338 | .. | 0·016 | .. | .. | 6·583 |
| 20 Aprion .. .. | .. | .. | 2·955 | 2·955 | .. | .. | .. | .. | .. | .. | .. | .. | 5·910 |
| 21 Chirocentrus .. .. | 0·614 | 0·091 | 0·227 | 0·091 | .. | .. | .. | .. | 0·481 | 1·425 | 0·161 | 0·022 | 3·118 |
| 22 Sphyræna .. .. | 0·068 | 0·027 | 0·182 | 0·159 | 0·023 | 0·153 | 0·342 | 0·640 | 1·237 | 1·125 | 0·295 | 0·132 | 4·383 |
| 23 Upeneoides .. .. | .. | .. | .. | 0·295 | .. | .. | .. | .. | 0·329 | 2·55 | 0·222 | 0·064 | 3·465 |
| 24 Otolithus .. .. | 0·273 | 0·455 | 0·273 | 0·591 | 0·091 | 0·007 | 0·086 | 0·020 | .. | 0·550 | .. | .. | 2·346 |
| 25 Balistes .. .. | .. | 1·000 | 0·909 | 0·205 | .. | .. | .. | .. | .. | .. | .. | .. | 2·114 |
| 26 Pellona .. .. | 0·795 | 0·227 | 0·091 | 0·182 | .. | 0·334 | 0·080 | .. | .. | .. | .. | .. | 1·709 |
| 27 Histiophorus .. | 0·091 | 0·091 | .. | .. | .. | .. | .. | .. | .. | 0·164 | 0·675 | 0·227 | 1·248 |
| 28 Drepane .. .. | 0·068 | .. | .. | .. | .. | .. | 0·581 | .. | .. | .. | 0·449 | .. | 1·098 |
| 29 Diagramma .. .. | .. | 0·136 | 0·227 | 0·045 | .. | 0·80 | 0·342 | 0·121 | .. | .. | .. | .. | 0·951 |
| 30 Albula .. .. | .. | .. | .. | .. | .. | 0·139 | 0·244 | 0·387 | .. | .. | .. | .. | 0·770 |
| 31 Elacate .. .. | .. | 0·068 | .. | 0·045 | .. | 0·102 | 0·067 | 0·280 | .. | 0·195 | .. | .. | 0·757 |
| 32 Mugil .. .. | .. | 0·027 | 0·068 | .. | 0·023 | .. | .. | .. | .. | .. | .. | .. | 0·118 |
| Total weight .. | 19·684 | 15·355 | 37·346 | 37·112 | 30·136 | 102·121 | 159·441 | 298·122 | 185·272 | 482·652 | 43·338 | 29·838 | 1,440·417 |

TABLE IV.

*Showing the total monthly landings in each variety of fish during the year 1961 in tonnes at Cape Comorin.*

| *Serial number and varieties.* | *January.* | *February.* | *March.* | *April.* | *May.* | *June.* | *July.* | *August.* | *September.* | *October.* | *November.* | *December.* | *Total.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) |
| 1 Trichiurus .. .. | .. | .. | 0·543 | 0·309 | 0·932 | 6·162 | 40·979 | 224·643 | 441·644 | 32·208 | 2·237 | 5·730 | 755·387 |
| 2 Lactarius .. .. | 0·466 | 0·283 | 1·332 | 16·785 | 9·906 | .. | .. | 0·264 | 245·106 | 50·933 | 1·999 | 0·588 | 337·662 |
| 3 Anchoviella .. .. | 0·115 | .. | .. | 2·427 | 1·249 | 14·619 | 25·815 | 75·357 | 126·321 | 56·439 | 4·556 | .. | 306·902 |
| 4 Caranx .. .. | 0·720 | 1·055 | 2·010 | 3·726 | 9·761 | 14·288 | 3·759 | 107·331 | 52·576 | 9·522 | 1·591 | 1·869 | 208·208 |
| 5 Lutjanus .. .. | 0·625 | 4·254 | 27·057 | 8·517 | 0·585 | 0·252 | 0·477 | 0·489 | 0·231 | 0·129 | 0·353 | 0·468 | 43·437 |
| 6 Serranus .. .. | 0·257 | 10·236 | 16·020 | 10·260 | 6·720 | 4·216 | 4·248 | 0·258 | 0·078 | .. | 0·612 | 0·105 | 55·010 |
| 7 Dussumieria .. .. | 0·286 | 0·144 | 0·843 | 3·033 | 0·471 | 28·872 | 0·048 | .. | 2·919 | 1·971 | 0·258 | 0·030 | 38·875 |
| 8 Leiognathus .. | 1·220 | 3·910 | 1·284 | 19·701 | 2·262 | .. | .. | 1·050 | 2·613 | 0·696 | 1·709 | 3·045 | 37·490 |
| 9 Sciæna .. .. | 0·343 | 1·164 | 2·127 | 3·279 | 0·555 | 1·149 | 1·077 | 2·667 | 10·179 | 2·448 | 2·125 | 3·123 | 30·236 |
| 10 Sardinella .. .. | 0·080 | 1·278 | 0·081 | 7·239 | 16·565 | 0·375 | .. | .. | 0·189 | 2·727 | .. | .. | 28·534 |
| 11 Sharks, skates and rays. | 0·929 | 1·188 | 3·825 | 2·709 | 1·044 | 3·225 | 3·994 | 3·555 | 3·048 | 1·800 | 1·458 | 0·864 | 27·099 |
| 12 Arius .. .. | 1·944 | 1·296 | 6·515 | 1·593 | 2·516 | 2·163 | 2·163 | 1·005 | .. | 0·144 | 2·007 | 1·305 | 20·651 |
| 13 Lethrinus .. .. | 0·870 | 5·475 | 1·245 | 1·401 | 1·227 | 1·500 | 0·796 | 0·501 | 0·132 | 0·256 | 0·598 | 0·282 | 14·283 |
| 14 Stromateus .. .. | 0·035 | .. | 0·729 | 0·612 | 0·081 | 0·111 | 5·100 | 4·758 | .. | 0·723 | 0·438 | 0·078 | 12·661 |
| 15 Sphyræna .. .. | 0·240 | 1·106 | 0·054 | 2·325 | 0·156 | 0·231 | 0·755 | 0·300 | 2·097 | 4·780 | 0·329 | 0·087 | 12·460 |
| 16 Cybium .. .. | 1·235 | 4·233 | .. | .. | .. | .. | .. | .. | 1·158 | 0·394 | 0·630 | 4·170 | 11·820 |
| 17 Aprion .. .. | .. | 0·717 | 5·235 | 3·378 | .. | .. | .. | .. | .. | .. | .. | .. | 9·330 |
| 18 Pristipoma .. .. | .. | 0·564 | 5·103 | 1·296 | 0·507 | .. | .. | .. | 0·912 | .. | 0·081 | 0·621 | 9·084 |
| 19 Chorinemus .. .. | 1·259 | 0·849 | 1·074 | 1·344 | 0·822 | 0·258 | 0·060 | 0·105 | .. | 0·021 | 0·084 | 1·104 | 6·980 |
| 20 Chirocentrus .. .. | 0·245 | 0·900 | 0·126 | 0·177 | 0·015 | .. | .. | 1·755 | 0·894 | 2·201 | 0·131 | 0·258 | 6·652 |
| 21 Megalaspis .. .. | 0·927 | 0·195 | 0·687 | 0·288 | .. | 0·048 | .. | .. | .. | 1·270 | 1·045 | 1·758 | 6·218 |
| 22 Upeneoides .. .. | .. | 0·267 | 1·443 | 0·762 | .. | .. | .. | .. | 1·890 | 1·818 | 0·321 | 0·095 | 6·596 |
| 23 Drepane .. .. | .. | .. | .. | .. | .. | 0·054 | 0·261 | 2·919 | 0·981 | 0·048 | .. | .. | 4·263 |
| 24 Pellona .. .. | 0·375 | .. | 1·239 | 0·441 | 0·423 | .. | .. | 0·328 | .. | .. | .. | 0·276 | 3·082 |
| 25 Otolithus .. .. | 1·366 | .. | 0·969 | .. | .. | .. | 0·045 | .. | .. | .. | .. | .. | 2·380 |
| 26 Diagramma .. .. | 0·226 | 0·630 | 0·195 | 0·102 | 0·162 | 0·276 | 0·105 | 0·420 | .. | .. | 0·018 | .. | 2·134 |
| 27 Balistes .. .. | .. | 0·879 | 0·222 | 0·078 | .. | .. | .. | .. | .. | .. | .. | .. | 1·179 |
| 28 Histiophorus .. | 0·034 | 0·381 | .. | .. | .. | .. | .. | .. | .. | .. | .. | 0·027 | 0·442 |
| 29 Mackerel .. .. | .. | .. | .. | 0·366 | .. | .. | .. | .. | .. | .. | .. | .. | 0·366 |
| 30 Albula .. .. | .. | .. | .. | .. | .. | .. | .. | 0·120 | 0·159 | .. | .. | .. | 0·279 |
| 31 Hilsa .. .. | .. | .. | .. | .. | .. | .. | .. | 0·222 | .. | .. | .. | .. | 0·222 |
| 32 Elacate .. .. | .. | 0·036 | .. | .. | .. | 0·114 | .. | .. | .. | .. | .. | .. | 0·150 |
| Total weight .. | 13·797 | 41·040 | 79·418 | 92·148 | 53·959 | 79·913 | 89·682 | 428·047 | 893·077 | 180·528 | 22·580 | 25·883 | 2,000·072 |

TABLE V.

*Showing the total monthly landings in each variety of fish during the year 1962 in tonnes at Cape Comorin.*

| *Serial number and varieties.* | *January.* | *February.* | *March.* | *April.* | *May.* | *June.* | *July.* | *August.* | *September.* | *October.* | *November.* | *December.* | *Total.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) |
| 1 Anchoviella .. .. | .. | .. | 0·585 | 0·108 | 0·150 | 5·322 | 18·300 | 66·525 | 152·684 | 88·717 | 4·547 | 0·498 | 337·436 |
| 2 Trichiurus .. .. | 0·136 | 0·045 | 0·315 | 0·093 | 0·333 | 1·701 | 61·827 | 153·987 | 2·472 | 11·913 | 0·180 | 0·117 | 233·119 |
| 3 Lactarius .. .. | 0·090 | 0·033 | 0·009 | 0·012 | 0·063 | 0·024 | .. | 1·296 | 2·364 | 99·552 | 0·354 | 0·267 | 104·064 |
| 4 Serranus .. .. | 0·114 | 6·018 | 21·392 | 8·211 | 10·875 | 9·909 | 3·855 | 1·395 | 0·732 | 0·024 | .. | 1·326 | 63·851 |
| 5 Dussumieria .. .. | .. | .. | 1·074 | .. | 0·036 | 0·684 | 45·024 | 0·323 | 4·332 | 1·176 | 1·644 | 1·284 | 55·577 |
| 6 Lethrinus .. .. | 0·404 | 7·812 | 14·508 | 18·609 | 1·119 | 1·299 | 0·402 | 0·411 | 0·102 | 0·195 | 0·618 | 7·587 | 53·066 |
| 7 Aprion .. .. | .. | 2·073 | 21·564 | 14·028 | 6·993 | .. | .. | .. | .. | .. | .. | .. | 44·658 |
| 8 Caranx .. .. | 0·414 | 0·333 | 0·846 | 0·597 | 1·569 | 14·109 | 2·814 | 5·264 | 5·418 | 7·169 | 2·666 | 1·293 | 42·492 |
| 9 Arius .. .. | 1·347 | 0·531 | 1·503 | 1·422 | 0·162 | 3·285 | 2·370 | 3·171 | 4·284 | 1·353 | 0·807 | 2·814 | 23·049 |
| 10 Sardinella .. .. | .. | .. | .. | 0·843 | 4·690 | 6·861 | 2·061 | .. | 4·838 | 0·804 | 1·524 | 0·696 | 22·317 |
| 11 Sciaena .. .. | 9·054 | 0·651 | 0·447 | 0·153 | 0·276 | 0·039 | 0·315 | 0·282 | 2·658 | 5·139 | 0·699 | 1·401 | 21·114 |
| 12 Lutjanus .. .. | 0·132 | 1·593 | 7·062 | 5·091 | 3·042 | 0·243 | 0·264 | 0·090 | 0·572 | 0·290 | 0·549 | 0·644 | 19·572 |
| 13 Cybium .. .. | 5·289 | 0·456 | 0·030 | .. | 0·027 | .. | .. | 0·039 | 0·474 | 1·920 | 2·790 | 5·286 | 16·311 |
| 14 Leiognathus .. .. | 0·770 | 1·431 | 2·329 | 0·579 | 0·147 | 0·126 | .. | .. | .. | .. | 2·726 | 2·196 | 10·305 |
| 15 Sphyraena .. .. | 0·009 | 0·090 | 0·102 | 0·016 | 0·186 | 0·237 | 0·510 | 0·042 | 0·753 | 6·000 | 1·311 | 1·008 | 10·296 |
| 16 Sharks, skates and rays. | 2·247 | 1·080 | 1·194 | 0·615 | 0·477 | 2·118 | 1·188 | 0·687 | 0·366 | 1·155 | 0·819 | 1·692 | 13·338 |
| 17 Stromateus .. .. | 1·185 | 1·935 | 0·864 | 1·314 | 0·111 | 0·099 | 0·204 | 0·150 | 0·081 | 2·057 | 0·309 | 1·209 | 9·518 |
| 18 Chirocentrus .. | 0·567 | 0·169 | 0·446 | 0·516 | 0·027 | 0·027 | .. | .. | 0·420 | 1·902 | 3·852 | 0·981 | 8·907 |
| 19 Balistes .. .. | 1·152 | 3·765 | 1·704 | 0·435 | .. | .. | .. | .. | .. | .. | .. | .. | 7·056 |
| 20 Diagramma .. .. | 0·015 | 0·081 | 0·177 | 4·311 | 0·015 | 0·075 | 0·072 | 0·002 | 0·297 | .. | .. | 0·614 | 5·759 |
| 21 Chorinemus .. .. | 0·990 | 0·369 | 0·713 | 0·375 | 0·060 | 0·618 | 0·042 | 0·036 | .. | 0·210 | 0·579 | 1·709 | 5·701 |
| 22 Megalaspis .. .. | 0·168 | .. | 0·948 | 0·792 | 0·057 | 0·021 | .. | .. | 0·105 | 1·476 | 0·387 | 0·831 | 4·785 |
| 23 Mackerel .. .. | .. | .. | .. | .. | 0·117 | .. | 0·342 | .. | 1·083 | 2·154 | 0·950 | 0·096 | 4·742 |
| 24 Pristipoma .. .. | 0·942 | 0·012 | 0·171 | 0·165 | .. | .. | 0·333 | .. | .. | 1·728 | 0·426 | 0·702 | 4·479 |
| 25 Upeneoides .. .. | 0·018 | .. | 0·099 | 0·027 | 0·087 | .. | .. | .. | 2·121 | 1·047 | 0·339 | 0·321 | 4·059 |
| 26 Pellona .. .. | .. | .. | .. | .. | 0·099 | .. | .. | 0·067 | .. | .. | .. | 1·032 | 1·198 |
| 27 Hilsa .. .. | .. | .. | .. | 0·108 | 0·478 | 0·204 | .. | .. | .. | .. | .. | .. | 0·790 |
| 28 Decapterus .. .. | .. | .. | .. | .. | .. | .. | 0·606 | .. | .. | .. | .. | .. | 0·606 |
| 29 Histiophorus .. | 0·060 | .. | .. | .. | .. | .. | .. | .. | .. | .. | 0·228 | 0·306 | 0·594 |
| 30 Elacate .. .. | .. | .. | 0·024 | .. | .. | 0·030 | 0·207 | 0·033 | .. | .. | .. | .. | 0·114 |
| 31 Thynnus .. .. | .. | .. | 0·057 | 0·021 | .. | 0·015 | .. | .. | .. | .. | .. | .. | 0·093 |
| 32 Albula .. .. | .. | .. | .. | 0·012 | 0·012 | 0·057 | .. | .. | .. | .. | .. | .. | 0·081 |
| **Total weight** .. | 26·134 | 28·477 | 77·643 | 58·503 | 31·208 | 47·103 | 140·556 | 233·900 | 166·138 | 235·981 | 28·304 | 35·910 | 1,130·347 |

TABLE VI.

*Showing the total monthly landings in each variety of fish during the year 1963 in Tonnes at Cape Comorin.*

| Serial number and varieties. | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. | Total. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) |
| 1 Trichiurus | 0·097 | 0·291 | 0·578 | 0·594 | 1·962 | 2·601 | 25·210 | 313·341 | 24·855 | 3·100 | 0·786 | 0·345 | 373·760 |
| 2 Anchoviella | 0·077 | 0·063 | .. | .. | 2·967 | 29·175 | 46·965 | 37·335 | 164·049 | 65·276 | 5·985 | .. | 351·892 |
| 3 Lactarius | 0·111 | 0·229 | 1·083 | 0·678 | 0·522 | 0·564 | 0·882 | 5·331 | 57·828 | 102·035 | 8·766 | 1·050 | 179·079 |
| 4 Lethrinus | 11·788 | 14·567 | 23·361 | 25·422 | 14·583 | 2·955 | 2·364 | 0·639 | 0·495 | 0·723 | 1·103 | 4·395 | 102·377 |
| 5 Serranus | 3·617 | 11·418 | 17·796 | 15·846 | 10·608 | 15·669 | 3·495 | 1·518 | 0·498 | 0·193 | 1·659 | 0·189 | 82·686 |
| 6 Dussumieria | 0·126 | 0·273 | 0·552 | 0·195 | 0·567 | 45·822 | 10·146 | 0·501 | 6·705 | 0·915 | 3·510 | 1·140 | 70·452 |
| 7 Arius | 0·654 | 0·585 | 0·759 | 0·843 | 0·732 | 2·958 | 6·060 | 2·052 | 2·376 | 31·749 | 2·610 | 10·554 | 61·923 |
| 8 Caranx | 1·450 | 1·287 | 2·364 | 1·653 | 1·908 | 5·442 | 7·149 | 8·631 | 7·797 | 14·424 | 4·124 | 1·809 | 58·038 |
| 9 Lutjanus | 1·638 | 5·523 | 19·587 | 14·920 | 10·449 | 0·192 | 0·033 | 0·009 | .. | 0·075 | 0·093 | .. | 52·319 |
| 10 Sharks, skates and rays. | 3·689 | 2·400 | 2·409 | 2·201 | 2·505 | 3·456 | 15·345 | 17·830 | 4·777 | 10·735 | 1·563 | 3·267 | 60·177 |
| 11 Leiognathus | 1·797 | 2·132 | 2·010 | 1·200 | 0·555 | 0·300 | 0·345 | .. | .. | 1·812 | 10·995 | 7·446 | 28·592 |
| 12 Sardinella | 0·057 | .. | 0·018 | 0·867 | 3·645 | 4·775 | .. | .. | 0·048 | 5·634 | 4·113 | 0·411 | 19·568 |
| 13 Cybium | 1·527 | 0·420 | 0·567 | 0·126 | 0·249 | 0·114 | 2·817 | 0·321 | 0·435 | 2·306 | 3·900 | 4·479 | 17·261 |
| 14 Aprion | .. | .. | 6·432 | 7·917 | 2·772 | .. | .. | .. | .. | .. | .. | .. | 17·121 |
| 15 Stromateus | 0·360 | 0·006 | 0·588 | 3·064 | 0·987 | 3·897 | 0·612 | 0·069 | 2·246 | 1·671 | 0·435 | 0·669 | 14·604 |
| 16 Chironcentrus | 0·161 | 0·262 | 0·462 | 0·105 | 0·159 | 0·477 | 0·087 | .. | 0·186 | 0·837 | 7·329 | 0·369 | 10·434 |
| 17 Megalaspis | 2·249 | 0·249 | 1·278 | 0·711 | 0·381 | .. | .. | .. | .. | 0·798 | 1·872 | 3·501 | 9·039 |
| 18 Sciæno | 0·594 | 0·192 | 0·177 | 0·429 | 0·138 | 1·309 | 0·795 | 0·327 | 1·236 | 1·677 | 0·216 | 1·950 | 8·040 |
| 19 Sphyræna | 0·123 | 0·159 | .. | 0·102 | 0·381 | 0·576 | 0·264 | 0·090 | 0·855 | 2·430 | 0·810 | 0·405 | 6·195 |
| 20 Chorinemus | 0·342 | 0·846 | 1·263 | 0·738 | 0·387 | 0·168 | 0·036 | 0·137 | 0·027 | 0·555 | 0·471 | 1·122 | 6·092 |
| 21 Upeneoides | .. | .. | 0·135 | 0·696 | 0·027 | 0·150 | .. | 0·063 | 2·718 | 2·739 | 0·483 | 0·432 | 7·443 |
| 22 Pristipoma | 0·441 | 0·243 | 0·306 | 0·108 | .. | 0·051 | 0·060 | 0·246 | 0·263 | 0·822 | 0·516 | 1·068 | 4·124 |
| 23 Pellona | .. | .. | .. | 0·060 | 0·045 | .. | 0·206 | .. | .. | .. | 1·355 | 1·185 | 2·851 |
| 24 Diagramma | 0·099 | 0·063 | .. | .. | 0·087 | 0·120 | .. | 0·351 | 0·834 | 0·084 | 0·039 | .. | 1·677 |
| 25 Albula | .. | .. | 0·033 | .. | .. | .. | 0·777 | 0·387 | .. | 0·186 | 0·024 | .. | 1·407 |
| 26 Hilsa | .. | .. | 0·036 | 0·219 | 0·315 | 0·102 | 0·249 | .. | .. | .. | .. | .. | 0·921 |
| 27 Balistes | 0·069 | .. | 0·459 | 0·042 | .. | .. | .. | .. | .. | .. | .. | .. | 0·570 |
| 28 Elacate | .. | .. | 0·222 | 0·048 | .. | 0·228 | .. | .. | .. | .. | .. | .. | 0·498 |
| 29 Histiophorus | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 0·099 | 0·090 | 0·189 |
| 30 Mugil | .. | .. | .. | 0·132 | 0·057 | .. | .. | .. | .. | .. | .. | .. | 0·189 |
| 31 Thynnus | .. | .. | .. | .. | .. | .. | .. | 0·174 | .. | .. | .. | .. | 0·174 |
| Total weight | 29·066 | 41·008 | 82·655 | 78·916 | 56·088 | 121·101 | 123·879 | 377·352 | 278·228 | 250·776 | 62·847 | 45·876 | 1,549·752 |

TABLE VII.

*Showing the annual landings in Tonnes of different varieties of fishes at Cape Comorin during the year 1958 to 1963.*

| *Serial number and name of fish.* | 1958. | 1959. | 1960. | 1961. | 1962. | 1963. | *Total.* | *Average.* |
|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| 1 Trichiurus .. .. | 724·100 | 607·090 | 233·249 | 755·387 | 233·119 | 373·760 | 2,926·705 | 487·784 |
| 2 Anchoviella .. .. | 800·977 | 561·186 | 445·208 | 306·902 | 337·436 | 351·892 | 2,803·601 | 467·267 |
| 3 Lactarius .. .. | 244·113 | 176·981 | 262·322 | 337·662 | 104·064 | 179·079 | 1,304·221 | 217·370 |
| 4 Caranx .. .. | 397·647 | 151·521 | 82·502 | 208·208 | 42·492 | 58·038 | 940·408 | 156·734 |
| 5 Dussumieria .. | 94·522 | 115·862 | 120·276 | 38·875 | 55·577 | 70·452 | 495·564 | 82·594 |
| 6 Serranus .. .. | 38·171 | 45·183 | 19·930 | 55·010 | 63·851 | 82·686 | 304·831 | 50·805 |
| 7 Lethrinus .. .. | 20·659 | 23·613 | 12·000 | 14·283 | 53·066 | 102·377 | 225·998 | 37·666 |
| 8 Arius .. .. | 27·114 | 34·463 | 45·359 | 20·651 | 23·049 | 61·923 | 212·559 | 35·427 |
| 9 Sharks, skates and rays. | 57·083 | 20·840 | 24·544 | 27·099 | 13·338 | 60·177 | 203·081 | 33·847 |
| 10 Sardinella .. .. | 34·478 | 12·773 | 49·729 | 28·534 | 22·371 | 19·568 | 167·399 | 27·899 |
| 11 Lutjanus .. .. | 3·512 | 6·632 | 6·583 | 43·437 | 19·572 | 52·319 | 132·055 | 22·009 |
| 12 Cybium .. .. | 36·233 | 30·706 | 19·930 | 55·010 | 63·851 | 82·686 | 304·831 | 50·805 |
| 13 Leiognathus .. | 11·748 | 22·818 | 6·938 | 37·490 | 10·305 | 28·592 | 117·891 | 19·648 |
| 14 Sciæna .. .. | 13·118 | 16·617 | 23·875 | 30·236 | 21·114 | 8·040 | 113·000 | 18·893 |
| 15 Aprion .. .. | 9·023 | 19·364 | 5·910 | 9·330 | 44·658 | 17·121 | 105·406 | 17·559 |
| 16 Stromateus .. .. | 17·196 | 10·961 | 12·416 | 12·661 | 9·518 | 14·604 | 77·356 | 12·893 |
| 17 Sphyræna .. .. | 12·114 | 13·751 | 4·383 | 12·460 | 10·296 | 6·195 | 59·199 | 9·866 |
| 18 Chorinemus .. .. | 9·307 | 13·579 | 11·121 | 6·980 | 5·701 | 6·092 | 52·780 | 8·797 |
| 19 Decapterus .. .. | 21·898 | .. | 20·008 | .. | 0·606 | .. | 42·512 | ·085 |
| 20 Megalaspis .. .. | 2·663 | 7·886 | 10·122 | 6·218 | 4·785 | 9·039 | 40·713 | 6·785 |
| 21 Chirocentrus .. .. | 2·569 | 1·844 | 3·118 | 6·652 | 8·907 | 10·434 | 33·524 | 5·587 |
| 22 Upeneoides .. .. | 2·417 | 5·005 | 3·465 | 6·596 | 4·059 | 7·443 | 28·985 | 4·831 |
| 23 Balistes .. .. | 10·363 | 5·387 | 2·114 | 1·179 | 7·056 | 0·570 | 26·669 | 4·445 |
| 24 Pristipoma .. .. | 3·266 | .. | .. | 9·084 | 4·479 | 4·124 | 20·953 | 3·492 |
| 25 Diagramma .. .. | 1·105 | 3·454 | 0·951 | 2·134 | 5·759 | 1·677 | 15·080 | 2·513 |
| 26 Mackerel .. .. | .. | 0·773 | 7·242 | 0·366 | 4·742 | .. | 13·123 | 2·187 |
| 27 Pellona .. .. | 0·273 | 1·478 | 1·709 | 3·082 | 1·198 | 2·851 | 10·591 | 1·765 |
| 28 Drepane .. .. | 2·761 | 2·046 | 1·098 | 4·263 | — | .. | 10·168 | 1·694 |
| 29 Otolithus .. .. | 1·306 | 1·477 | 2·346 | 2·380 | — | .. | 7·509 | 1·251 |
| 30 Histiophorus .. | 1·478 | 0·749 | 1·248 | 0·442 | 0·594 | 0·189 | 4·700 | 0·783 |
| 31 Albula .. .. | .. | .. | 0·770 | 0·279 | 0·081 | 1·407 | 2·537 | 0·423 |
| 32 Hilsa .. .. | .. | .. | .. | 0·222 | 0·790 | 0·921 | 1·933 | 0·322 |
| 33 Elacate .. .. | 0·055 | 0·224 | 0·757 | 0·150 | 0·114 | 0·498 | 1·798 | 0·299 |
| 34 Mullets .. .. | 0·250 | 0·555 | 0·118 | .. | — | 0·189 | 1·112 | 0·185 |
| 35 Thynnus .. .. | .. | .. | .. | .. | 0·093 | 0·174 | ·267 | 0·044 |
| Total .. | 2,601·519 | 1,914·818 | 1,440·417 | 2,000·072 | 1,130·347 | 1,549·752 | 10,636·925 | 1,772·821 |

TABLE VIII.

*Showing the total and peak season landings, maximum and minimum monthly landings and the important peak season fishery during six year period.*

| *Year.* | *Total landing in tonnes.* | *Landings from June to October in tonnes.* | *Maximum monthly landings in tonnes/month.* | *Minimum monthly landings in tonnes/month.* | *Important fishery during peak season.* |
|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) |
| 1958 .. .. .. .. | 2,601·519 | 2,141·262 | 604·180 (July). | 22·069 (December). | Anchoviella, Trichiurus, Caranx, Lactarius and Dussumieria. |
| 1959 .. .. .. .. | 1,914·818 | 1,636·910 | 801·004 (September). | 16·759 (May). | Trichiurus, Anchoviella, Lactarius, Caranx and Dussumieria. |
| 1960 .. .. .. .. | 1,440·417 | 1,227·608 | 482·652 (October). | 15·355 (February). | Anchoviella, Lactarius, Trichiurus, Dussumieria and Caranx. |
| 1961 .. .. | 2,000·072 | 1,671·247 | 893·077 (September) | 13·797 (January) | Trichiurus, Lactarius, Anchoviella and Caranx. |
| 1962 .. .. .. .. | 1,130·347 | 823·678 | 235·981 (October). | 26·134 (January). | Anchoviella, Trichiurus Lactarius, Dussumieria and Caranx. |
| 1963 .. .. .. .. | 1,549·752 | 1,152·108 | 379·352 (August). | 29·066 (January). | Trichiurus, Anchoviella, Lactarius, Dussumieria, Arius and Caranx. |

TABLE IX.

*Showing the maximum, minimum and average annual landings, percentage of total landings and the months of peak fishery of each variety of fish during six-year period.*

| *Serial number and name of fish.* | *Average annual landings in tonnes.* | *Approximate-percentage of total landings.* | *Range of landings in tonnes.* | | *Months of peak fishery.* |
|---|---|---|---|---|---|
| | | | *Maximum. year.* | *Minimum. year.* | |
| (1) | (2) | (3) | (4) | (5) | (6) |
| 1 Trichiurus .. .. .. | 487·784 | 27·5 | 755·387 (1961). | 233·119 (1962). | July to October. Available in small quantities almost right through the year. |
| 2 Anchoviella .. .. | 467·267 | 26·0 | 800·977 (1958). | 306·902 (1961). | July to October. |
| 3 Lactarius .. .. .. | 217·370 | 12·0 | 337·662 (1961). | 104·064 (1962). | September to October. Small quantities right through the year. |
| 4 Caranx .. .. .. | 156·734 | 8·8 | 397·647 (1958). | 42·492 (1962). | June to October. Small quantities right through the year. |
| 5 Dussumieria .. .. | 82·594 | 4·0 | 120·276 (1960). | 38·875 (1961). | June to September. |
| 6 Serranus .. .. .. | 50·805 | 2·9 | 82·686 (1963). | 19·930 (1960). | February to June. |
| 7 Lethrinus .. .. .. | 37·666 | 2·1 | 102·377 (1963). | 12·000 (1960). | February to May. |
| 8 Arius .. .. .. | 35·427 | 2·0 | 61·923 (1963). | 20·651 (1961). | September to December. |
| 9 Sharks, skates and rays. | 33·847 | 1·9 | 60·177 (1963). | 13·338 (1962). | July to October, Almost right through the year in small quantities. |
| 10 Sardinella .. .. .. | 27·899 | 1·6 | 49·729 (1960). | 12·773 (1959). | July to October. In small quantities right through the year. |
| 11 Lutjanus .. .. .. | 22·009 | 1·2 | 52·319 (1963). | 3·512 (1958). | February to May. |

TABLE IX—*cont.*

*Showiug the maximum, minimum and average annual landings, percentage of total landings and the months of peak fishery of each variety of fish during six-year period*—cont.

| *Serial number and name of fish.* | *Average annual landings in tonnes.* | *Approximate percentage of total landings.* | *Range of landings in tonnes.* Maximum. year. | *Range of landings in tonnes.* Minimum. year. | *Months of peak fishery.* |
|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) |
| 12 Cybium .. .. .. | 21·939 | 1·2 | 36·235 (1958). | 11·820 (1961). | October to February. |
| 13 Leiognathus .. .. | 19·648 | 1·1 | 37·490 (1961). | 6·938 (1960.) | November to April. |
| 14 Sciaena .. .. .. | 18·833 | 1·0 | 30·236 (1961). | 8·040 (1963). | September to January. |
| 15 Aprion .. .. .. | 17·559 | 0·99 | 44·658 (1962). | 5·910 (1960). | February to April. |
| 16 Stromateus .. .. | 12·893 | 0·72 | 17·196 (1958). | 9·518 (1962). | July to September. In small quantities right through the year. |
| 17 Sphyraena .. .. .. | 9·866 | 0·55 | 13·751 (1959). | 4·383 (1960). | September to October. Right through the year in small quantities. |
| 18 Chorinemus .. .. | 8·797 | 0·49 | 13·579 (1959). | 5·701 (1962). | December to May. |
| 19 Decapterus.. .. .. | 7·085 | 0·39 | 21·898 (1958). | Nil. (1959, 1961 and 1963). | August to September. |
| 20 Megalaspis .. .. .. | 6·785 | 0·38 | 10·122 (1960). | 2·663 (1958). | October to April. |
| 21 Chirocentrus .. .. | 5·587 | 0·31 | 10·434 (1963). | 1·844 (1959). | October to December. |
| 22 Upeneoides .. .. .. | 4·831 | 0·27 | 7·443 (1963). | 2·417 (1958). | September to December and February to April. |
| 23 Balistes .. .. .. | 4·445 | 0·25 | 10·363 (1958). | 0·57 (1963). | January to April. |
| 24 Pristipoma .. .. | 3·942 | 0·22 | 9·084 (1961). | Nil. (1959 and 1960). | October to May. |
| 25 Diagramma .. .. | 2·513 | 0·14 | 5·759 (1961). | 0·951 (1960). | No marked season. Right through the year. |
| 26 Mackerel .. .. .. | 2·187 | 0·12 | 7·242 (1960). | Nil. (1958 and 1963). | August to November. |
| 27 Pellona .. .. .. | 1·765 | 0·09 | 3·098 (1961). | 0·273 (1958). | November to May. |
| 28 Drepane .. .. .. | 1·694 | 0·09 | 4·263 (1961). | Nil. (1962 and 1963). | June to October. |
| 29 Otolithus .. .. .. | 1·251 | 0·07 | 2·346 (1960). | Nil. (1962 and 1963). | January to October. |
| 30 Histiophorus .. .. | 0·783 | 0·04 | 1·478 (1958). | 0·189 (1963). | November to February. |
| 31 Albula .. .. .. | 0·423 | 0·02 | 1·407 (1963). | Nil. (1958 and 1959). | No marked season. |
| 32 Hilsa .. .. .. | 0·322 | 0·02 | 0·921 (1963). | Nil. (1958, 1959 and 1960). | March to August. |
| 33 Elacate .. .. .. | 0·299 | 0·01 | 0·757 (1960). | 0·065 (1958). | No marked season. |
| 34 Mullets .. .. .. | 0·185 | 0·01 | 0·555 (1959). | Nil. (1961 and 1962). | April to May. |
| 35 Thynnus .. .. .. | 0·044 | .. | 0·174 (1958). | Nil. (1958, 1959, 1960 and 1961). | August. |

TABLE X.

*Showing the Fishery Calendar for Cape Comorin.*

| *Serial number.* (1) | *January.* (2) | *February.* (3) | *March.* (4) | *April.* (5) | *May.* (6) | *June.* (7) |
|---|---|---|---|---|---|---|
| 1 | Cybium .. | Lethrinus .. | Serranus .. | Serranus .. | Caranx .. | Anchoviella. |
| 2 | Sharks, skates and rays. | Serranus .. | Lutjanus .. | Lethrinus .. | Sardinella .. | Caranx. |
| 3 | Arius .. | Aprion .. | Lethrinus .. | Lutjanus .. | Serranus .. | Trichiurns. |
| 4 | Sciaena sp. .. | Cybium .. | Aprion .. | Aprion .. | Lethrinus .. | Dussumieria. |
| 5 | Lethrinus .. | Leiognathus .. | Sardinella .. | Sardinella .. | Lutjanus .. | Serranus. |
| 6 | Leiognathus .. | Balistes .. | Arius .. | Leiognathus .. | Lactarius .. | Arius. |
| 7 | Caranx .. | Lutjanus .. | Sharks, skates and rays. | Lactarius .. | Chorinemus .. | Sharks, skates and rays. |
| 8 | Serranus .. | Caranx .. | Caranx .. | Caranx .. | Anchoviella .. | Lethrinus. |
| 9 | Chorinemus .. | Arius .. | Chorinemus .. | Sharks, skates and rays. | Aprion. .. | Sardinella. |
| 10 | Stromateus .. | Sharks, skates and rays. | Balistes .. | Chorinemus .. | Trichiurus .. | Stromateus. |
| 11 | Megalaspis .. | Stromateus .. | Leiognathus .. | Dussumieria .. | Sciaena .. | Lactarius. |
| 12 | Lactarius .. | Chorinemus .. | Megalaspis .. | Arius .. | Leiognathus .. | Sciaena. |
| 13 | Anchoviella .. | Sciaena .. | Pristipoma .. | Sciaena .. | Arius .. | Sphyraena. |
| 14 | Lutjanus .. | Sardinella .. | Cybium .. | Stromateus .. | Dussumieria .. | Lutjanus. |
| 15 | Sardinella .. | Pristipoma .. | Dussumieria .. | Diagramma .. | Cybium .. | Leiognathus. |
| 16 | Chirocentrus .. | Sphyraena .. | Lactarius .. | Anchoviella .. | Stromateus .. | Diagramma. |
| 17 | Aprion .. | Megalaspis .. | Sciaena .. | Sphyraena .. | Pellona .. | Drepane. |
| 18 | Pristipoma .. | Chirocentrus .. | Stromateus .. | Megalaspis .. | Drepane .. | Chorinemus. |
| 19 | Trichiurus .. | Anchoviella .. | Upeneoides .. | Balistes .. | Sphyraena .. | Chirocentrus. |
| 20 | Dussumieria .. | Trichiurus .. | Anchoviella .. | Upenoides. .. | Pristipoma .. | .... |
| 21 | Pellona .. | Lactarius .. | Trichiurus .. | Cybium .. | Hilsa .. | .... |
| 22 | Balistes .. | Diagramma .. | Diagramma .. | Trichiurus .. | .... | .... |
| 23 | Otolithus .. | Histioephorus .. | Pellona .. | Pellona .. | .... | .... |
| 24 | Sphyraena .. | Upenoides .. | Sphyraena .. | Chirocentrus .. | .... | .... |
| 25 | .... | Otolithus .. | Chirocentrus | Pristipoma .. | .... | .... |
| 26 | .... | .... | Otolithus .. | Otolithus .. | .... | .... |

| *Serial number.* | *July.* (8) | *August.* (9) | *September.* (10) | *October.* (11) | *November.* (12) | *December.* (13) |
|---|---|---|---|---|---|---|
| 1 | Trichiurus .. | Trichiurus .. | Trichiurus .. | Anchoviella .. | Anchoviella .. | Cybium. |
| 2 | Anchoviella .. | Anchoviella .. | Anchoviella .. | Lactarius .. | Lactarius .. | Leiognathus. |
| 3 | Dussumieria .. | Caranx .. | Lactarius .. | Trichiurus .. | Sardinella .. | Arius. |
| 4 | Caranx .. | Dussumieria .. | Caranx .. | Caranx .. | Cybium .. | Sciaena. |
| 5 | Sharks, skates and rays. | Sharks, skates and rays. | Dussumieria .. | Arius .. | Leiognathus .. | Lethrinus. |
| 6 | Arius .. | Decapterus .. | Arius .. | Sphyraena .. | Caranx .. | Dussumieria. |
| 7 | Serranus .. | Sardinella .. | Sharks, skates and rays. | Sharks, skates and rays. | Trichiurus .. | Caranx. |
| 8 | Stromateus .. | Arius .. | Decapterus .. | Sardinella .. | Arius .. | Megalaspis. |
| 9 | Lethrinus .. | Lactarius .. | Sciaena .. | Dussumieria .. | Dussumieria .. | Sharks, skates and rays. |
| 10 | Sardinella .. | Stromateus .. | Sphyraena .. | Sciaena .. | Chirocentrus .. | Anchoviella. |
| 11 | Cybium .. | Lethrinus .. | Upeneoides .. | Cybium .. | Sharks, skates and rays. | Sardinella. |
| 12 | Lactarius .. | Serranus .. | Stromateus .. | Stromateus .. | Megalaspis .. | Chorinemus. |
| 13 | Sciaena .. | Mackerel .. | Sardinella .. | Upenoides .. | Sciaena .. | *Trichiurus.* |
| 14 | Sphyraena .. | Sciaena .. | Leiognathus .. | Chirocentrus .. | Stromateus .. | Lactarius. |
| 15 | Leiognathus .. | Drepane .. | Cybium .. | Leiognathus .. | Lethrinus .. | Stromateus. |
| 16 | Diagramma .. | Chirocentrus .. | Serranus .. | Megalaspis .. | Upeneoides .. | Pellona. |
| 17 | Drepane .. | Lutjanus .. | Chirocentrus .. | Pristipoma .. | Sphyraena .. | Sphyraena. |
| 18 | Mackerel .. | Cybium .. | Drepane .. | Marckerel .. | Serranus .. | Pristipoma. |
| 19 | Albula .. | Leiognathus .. | Lutjanus .. | Otolithus .. | Histiophorus .. | Lutjanus. |
| 20 | .... | Diagramma .. | Lethrinus .. | Lethrinus .. | Mackerel .. | Serranus. |
| 21 | .... | Sphyraena .. | Diagramma .. | Serranus .. | Lutjanus .. | Diagramma. |
| 22 | .... | Albula .. | Pristipoma .. | Chorinemus .. | Pellona .. | Histiophorus. |
| 23 | .... | .... | Mackerel .. | .... | Drepane. .. | Chirocentrus. |
| 24 | .... | .... | .... | .... | Pristipoma .. | Upeneoides. |
| 25 | .... | .... | .... | .... | Mugil sp. | .... |
| 26 | | | | | | |

TABLE XI.

*Showing the monthly and annual averages of the number of catamarans that went for fishing daily at Cape Comorin during the six year period* 1958–1963.

| *Month.* | *Years.* | | | | | |
|---|---|---|---|---|---|---|
| | 1958. | 1959. | 1960. | 1961. | 1962. | 1963. |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| January .. .. .. .. .. | 155 | 101 | 88 | 64 | 72 | 68 |
| February .. .. .. .. .. | 171 | 127 | 89 | 107 | 76 | 69 |
| March .. .. .. .. .. | 101 | 113 | 101 | 132 | 97 | 107 |
| April .. .. .. .. .. | 92 | 85 | 102 | 117 | 82 | 99 |
| May .. .. .. .. .. | 102 | 91 | 94 | 127 | 91 | 92 |
| June .. .. .. .. .. .. | 147 | 141 | 141 | 124 | 124 | 182 |
| July .. .. .. .. .. .. | 246 | 156 | 120 | 157 | 169 | 194 |
| August .. .. .. .. .. | 273 | 220 | 171 | 228 | 188 | 275 |
| September .. .. .. .. .. | 261 | 278 | 149 | 300 | 169 | 233 |
| October .. .. .. .. .. | 221 | 196 | 174 | 133 | 158 | 214 |
| November .. .. .. .. .. | 96 | 78 | 85 | 76 | 97 | 156 |
| December .. .. .. .. .. | 93 | 117 | 84 | 94 | 102 | 115 |
| Average .. | 163 | 142 | 116 | 138 | 119 | 150 |

TABLE XII.

*Showing the peak seasons of the important fisheries of Cape Comorin during the six year period.*

| *Serial number.* | *Name of fishery.* | 1958. | 1959. | 1960. | 1961. | 1962. | 1963. |
|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| 1 | Trichiurus .. .. .. .. | June to September. | August to October. | July, August and October. | July to October. | July and August. | July to September. |
| 2 | Anchoviella .. .. .. | June to October. | July to October. | June to October. | August to October. | August to October. | June to October. |
| 3 | Lactarius .. .. .. .. | September and October. | September and October. | September and October. | October .. | September and October. | September and October. |
| 4 | Caranx .. .. .. .. | May to October. | June to October. | May to September. | August and September. | June to October (Poor). | June to October (Poor). |
| 5 | Dussumieria .. .. .. | July and September. | June to October. | June to August. | June .. | July .. | June and July. |
| 6 | Serranus .. .. .. .. | March to June. | February to April. | March and April. | February to July. | February to July. | January to July. |
| 7 | Lethrinus .. .. .. .. | February and March. | February to April. | March .. | February .. | December and February to April. | December to July. |
| 8 | Arius .. .. .. .. | January, February, July, August and October. | January, July, September and November. | January, July and September. | March, June, July and November. | June to September. | June to December. |
| 9 | Sharks, skates and rays .. .. | January and July to September. | Poor | July .. | March and June to September. | Poor .. | July to October. |
| 10 | Sardinella .. .. .. .. | March to May and August. | April, May and October to December (Poor). | March to May, October and November. | April, May and October. | May, June, July and September. | November and December. |
| 11 | Lutjanus .. .. .. .. | April .. | April .. | March and April. | February, March and April. | March, April and May. | February to May. |
| 12 | Cybium .. .. .. .. | January, February and October to December. | January to March and October to December. | February and October to December. | January, February and December. | January and October to December. | January, July and October to December. |

# ON THE CHEMICAL QUALITY OF COMMON SALT USED IN THE FISH CURING INDUSTRY IN MADRAS STATE

BY

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**Synopsis**

The chemical quality of the Common salt used in different sections of the fish curing industry in Madras State, namely Government fish curing yards, private fish curing yards and fishery salts produced by the salt manufacturers in the State were tested over a period of seven years from 1957 to 1964 and compared with the Indian Standard Specification for common salt for fish curing I.S. 594–1954 (tentative) and I.S. : 594–1962 (revised). None of the salt samples used in Government and private fish curing yards satisfied the revised standard I.S. : 594–1962 (98 per cent Na Cl) and only 96·89 per cent of the salt samples in Government fish curing yards were up to the tentative standard I.S. : 594–1954 (98 per cent Na Cl). Only one of the 4 salt samples examined from the private fish curing yards satisfied the tentative 1954 standard. Only 5·13 per cent of the market samples, not the revised specification, and only 7·7 per cent of the market samples were within the tentative standards. The scarcity in the market of the salt of required specifications is found to be the chief cause for the use of low-grade salt in fish curing in the State and this will have to be remedied first to improve the quality of salt used in fish curing.

**Instructions**

Salt-curing of fish is the most important method of fish preservation in Madras State, accounting for nearly 42 per cent of the total marine fish landing in the State. The scattered distribution of the fishing hamlets all along the coast and their improper communication links with the inland places have compelled the fishermen from time immemorial to preserve a major portion of their daily catches by traditional methods of salt-curing. The salt-cured and dried fish has a good demand in the internal markets as well as in Ceylon and other South-East Asian countries and Africa, not only as a source of protein, but also as a strongly flavoured food used in making less tasty items more palatable. But the quality of the salt-cured fish produced in most instances is far from satisfactory due to many reasons like the use of spoiled fish for curing, the bad quality of salt used, unhygienic methods of handling and curing, improper salting, inadequate drying, etc.

The importance of the use of good quality salt in fish curing was realised by Madras State Government as early as 1874 when they opened the Government salting enclosures (the present day fish curing yards) to discourage the use of salt-earth for fish curing and also for supplying good quality salt at a little above the cost price for *bona fide* fish curing purposes. Since the abolition of salt duty from 1947 there has been considerable decline in the utilisation of fish curing yards by fishermen, as salt is now generally available in the open market at the same rates as in Government yards. Further, since salt manufacture on small scale by individuals is now permitted, low quality salt has become easily available at very cheap rates and consequently many fish curers use salt of very inferior quality and produce cured fish of very bad quality. To meet this situation to some extent and to induce the fish curers to resort to Government fish curing yards the Madras State Government subsidises the supply of salt in their fish curing yards, but the extent of subsidy has not proved sufficiently attractive to detract the fishermen from using low-grade salt available outside the Government fish curing yards. There is also no effective check against the use of low grade salt in fish curing in private premises. V.R. Pillai, et. el. (1956), during the course of their study of the chemical quality of cured fish products of the west coast of India examined 16 samples of salt from the fish curing centres and found their Na Cl content to range from 88·88 per cent to 98·91 per cent and observed that any effort made to have an analytical check on the quality of the salt issued will go a long way in improving the quality of the cured product. Venkataraman and Sreenivasan (1935) and Venkataraman and Vasavan (1956) also made similar observations and stressed the need for using better quality salt. The bacteriology and chemical compositions of the various types of common salt available in the country with special reference to the red halophilic bacteria causing spoilage of salted fish was also studied by Venkataraman and Sreenivasan (1956). Realising the urgent need for the use of good quality salt in fish curing, the Indian Standards Institution laid down tentative specifications for common salt for fish curing in I.S.: 594–1954 and subsequently revised them in I.S. : 594–1962. The extent to which the salt used in the fish curing industry in Madras State during the period 1957 to 1964 actually conferred to these standards is briefly discussed in the present communication.

**Materials and Methods**

Samples of common salt used in the Government and private fish curing yards all over the State and samples of salt offered for supply to the fish curing yards by the various salt manufacturers in the State during the seven year period 1957 to 1964 were examined for their chemical quality as a routine and data compiled. All the salt samples were tested for the various requirements like moisture, Na Cl, Insolubles and solubles like Mg $Cl_2$. Ca $Cl_2$, Mg. $So_4$, and Ca $So_4$ according to the methods prescribed in I.S. : 238–1954.

**Results and discussion**

There are 21 Government fish curing yards in Madras State consuming on an average 8,000 tonnes of common salt annually for fish curing. Though the number of well-recognised private fish curing yards in the State is very limited, a lot of private fish curing takes place in private premises in the various fishing hamlets all along the coast, consuming approximately 7,060 tonnes (estimated) of salt annually. Only solar sea salts are used for fish curing in the State and are purchased by the fish curers from nearly salt manufacturers in Tuticorin (Tirunelveli district), Kanyakumari district, Thanjavur district, South Arcot district and Chingleput district.

Table I shows the summary of the results of analysis of 94 salt samples used for fish curing in the Government fish curing yards all over the State during the seven year period from 1957 to 1964. Table II shows the result of analysis of the four samples of salt used in the private fish curing yards in the State. Table III shows the summary of the results of analysis of 192 salt samples offered for fish-curing by the various salt manufacturers in the State.

It will be seen from Table I, that in the salt samples used in the Government fish curing yards, the moisture ranged from 0·13 per cent to 8·93 per cent, Na Cl from 88·02 per cent to 98·82 per cent and insolubles from 0·13 per cent to 2·76 per cent. In the private fish curing yards, the salt samples had moisture ranging from 1·23 per cent to 6·90 per cent, NaCl ranging from 80·57 per cent to 96·35 per cent and insolubles from 0·70 per cent to 2·47 per cent. The salt samples offered by the salt manufacturers for fish curing had moisture content varying from 0·09 per cent to 19·51 per cent, NaCl varying from 81·2 per cent to 99·58 per cent and insolubles from 0·92 per cent to 7·17 per cent.

The following are the specifications prescribed by the Indian Standards Institution for Common salt for fish curing :—

| | *I.S.* 594–1954 (*Tentative*). | *I.S.* 594–1962 (*Revised*). |
|---|---|---|
| | (1) | (2) |
| (i) Moisture, present by weight, maximum. | 6·0 | 6·0 |
| (ii) Sodium chloride (NaCl) per cent by weight, minimum. | 96·0 | 98·0 |
| (iii) Matter insoluble in water, per cent by weight, maximum. (On dry basis.) | 1·0 | 0·5 |
| (iv) Calcium sulphate (as $CaSo_4$), magnesium chloride (as Mg. $Cl_2$) and Magnesium sulphate (as $MgSo_4$) together per cent by weight, maximum. (On dry basis). | 3·0 | 1·5 |

NOTE.—This represents the matter soluble in water other than NaCl, per cent, by weight maximum.

The tentative standard shown in column (1) above was prescribed in 1954 and it is stated in the revised standard that as a result of experiments conducted by a number of laboratories in the country for determining the maximum impurities allowable in fish curing salt and the quality of salt available for fish curing purposes, the standard was revised in 1962. The maximum moisture allowed in both the Standards is 6·0 per cent, and it will be seen from Tables, I, II and III that 87·13 per cent of salt samples in Government fish curing yards, nearly 75 per cent of the salt samples in private fish curing yards and 72·91 per cent of the salt samples offered by salt manufacturers for fish-curing conformed to those standards.

Considering the 1954 standard of 95·0 per cent for NaCl, 46·80 per cent of the Government fish curing yard samples, nearly 25 per cent at the private fish curing yard samples and 34·37 per cent of the salt samples offered by salt manufacturers conformed to this standard. However according to the 1962 standard which prescribes a higher NaCl content of 98·0 per cent only 1·06 per cent of the Government yard samples, and 10·41 per cent of the salt samples offered by the salt manufacturers conformed to this standard. None of the private fish curing yard samples came up to this high standard.

Regarding insolubles, 51·64 per cent of the Government fish curing yard samples, nearly 50 per cent of the private fish curing yard samples and 56·41 per cent of the samples in the market satisfied the maximum limit of 1 per cent prescribed in 1954 standard. Only 25·27 per cent of the Government fish curing yard samples, and 46·15 per cent of the samples in the market reached the 1962 standard of 0·5 per cent (maximum) insolubles. None of the samples in the private fish curing yards was up to this specification.

Regarding solubles like $MgCl_2$, $MgSo_4$, $C^aSo_4$, etc., 64·4 per cent of the Government yard samples satisfied the 1954 standard of 3·0 per cent (maximum), but only 2·2 per cent of the Government yard samples could come up to the standard of 1·5 per cent (maximum) prescribed in 1962. In private fish curing yard samples, nearly 25 per cent had solubles below 3 per cent and none satisfied the standard of 0·5 per cent (maximum). 15·35 per cent of the samples in the market satisfied the 1954 standard, whereas only 5·13 per cent of the market samples satisfied the revised standards.

Considering all the requirements as a whole, it can be said that 26·89 per cent of the Government yard samples only satisfied the tentative standards, while none of the samples could come up to the revised standard. Only one of the four private fish curing yard samples examined satisfied the 1956 standard, whereas none of the samples came up to the revised standard. 7·7 per cent of the samples offered by the salt manufacturers satisfied the tentative standard, but only 5·13 per cent of the market samples came up to the 1962 standard.

Though a majority of the salt samples now used in the fish curing industry satisfied the moisture standards, they fell far below the standards required for NaCl, and insolubles. Only 5·13 per cent of the samples offered by the salt manufacturers could satisfy all the requirements. Even according to the comparatively 'lower' standards prescribed in 1954, only 7·7 per cent of the market samples satisfied all the requirements, clearly showing the present poor standards of majority of salt samples in the market. Usually salt is required at the fish curing yards at short notice with very little time for searching the high quality salt satisfying all requirements. Even in the case of Government fish curing yards, where there is a machinery for testing of the salt samples prior to purchase, difficulty is experienced in selecting the salt, as on most of the occasions none of the samples available meets all the requirements. Because of the emergency, sub-standard salt has to be purchased on such occasions. This accounts for only 46·80 per cent of Government yard samples having 96·0 per cent NaCl and 1·06 per cent only having 98·0 per cent NaCl. The conditions are worse in private fish curing. Even out of the 16 salt samples examined by V. K. Pillai, et. al. (1956), none of the samples meets the 1962 standard for all requirements and only one sample satisfies the 1954 standard.

The average NaCl content of the common salt used in the Fish Curing Industry in Madras State is compared below with the average NaCl content of the common salt used in other countries :—

| Serial number and particulars. | Average NaCl. content. |
|---|---|
| (1) | (2) |
| | PER CENT. |
| 1 Common salt used in Government Fish Curing Yards in Madras State. | 94·86 |
| 2 Common salt used in private Fish Curing Yards in Madras State. | 89·90 |
| 3 Common salt offered by salt manufacturers for Fish Curing in Madras State. | 90·88 |
| 4 European solar salt used for fish curing .. | 95·71 (6) |
| 5 Russian solar salt used for fish curing .. .. | 97·74 (6) |
| 6 North and South American solar salt used for fish curing. | 97·30 (6) |
| 7 Solar fishery salt used in Eastern Canada .. | 97·30 (1) |

*N.B.*—(1), (6)—These numbers indicate the references in Annexure from which the figures have been taken.

These comparative figures will show that the chemical quality of the salt used in the fish curing industry in Madras State is very poor when compared with the standards prevailing in other countries. The comparatively better figures in Government fish curing yards also show that steps are being taken by Government to select the best of the salt available in the market, but these figures can reach the standard of 98 per cent NaCl prescribed in I.S. 594–1962, only if more of such good quality salt is produced in the market.

The scarcity in the market of pure common salt conforming to the I.S. 594–1962 standards should therefore be deemed as the foremost reason for the use of low grade salt in the fish curing industry at present. Steps should therefore be taken to see that all the salt manufacturers produce more of high quality salt conforming to the specifications. In view of the paucity in the market for salt of 98 per cent NaCl content, the Madras State Government is now insisting on 1954 standards only (96 per cent NaCl) for the salt used in Government fish curing yards. It is also worthwhile to conduct studies on the preparation of cured fish products by the indigenous processes like dry salting, wet salting and pit curing using salts of different NaCl contents ranging from 96 per cent to 100 per cent and find out the relative merits of each product from the point of chemical quality, consumer preference and keeping quality.

The composition of the salt used in fish curing has been found by Tressler (1930) to be of great importance, not only in affecting the rate of its penetration into the tissues of fish, but also in determining the physical qualities of the product. Though a moisture content of 6·0 per cent has been allowed in the standards. it is preferable to use comparatively dry salt with less moisture content, as high moisture content will lower the effective amount of NaCl in a given weight of salt and unless allowed for, may subsequently cause spoilage in any process where NaCl concentration is the limiting factor affecting preservations. (Shewan, 1951). According to Beatty and Fougere (1957) a good fishery salt must strike quickly and must come out of the fish readily on freshening; it must contain little or no objectionable impurities, particularly compounds of magnesium, iron and copper; it must contain no bacteria capable of living and growing in the presence of salt; and it must be of suitable particle size. Calcium and magnesium impurities generally tend to slow up the striking and the freshening out of the fish before cooking. Shewan (1951 loc.cited) has stated that in higher temperatures of the trophical countries and with thicker flesh of 4 to 5 cms. the penetrations of NaCl may be so retarded by the Ca and Mg impurities that spoilage of the inner flesh may occur producing "putty fish". Though the presence of gypsum up to one per cent, has been found to produce whiter and more attractive cured fish, French and Russian workers have shown that the maximum, concentration of allowable impurities for dry salting was 0·5 per cent Ca iron, 0·6 per cent Mg. iron and one per cent sulphate (Shewan 1951). The average figures for those impurities in Table I show that common salt used in Government fish curing yards were mostly within these limits.

The average "Insolubles" figures for the Government fish curing yard samples, private fish curing yard samples and market samples are respectively, 1·16 per cent. 1·32 per cent and 1·43 per cent as against the tentative standard of 1·0 per cent and revised standard of 0·5 per cent indicating good scope for further reduction of insolubles. Immediate measures for reduction of the insolubles and increase of the NaCl content of all common salt produced in the State will go a long way in improving the quality of common salt used in the fish curing industry in the State.


*Summary.*

The chemical quality of the common salt used in different sections of the fish curing industry in Madras State, namely, Government fish curing yards, private fish curing yards and fishery salts produced by the salt manufacturers in the State was tested over a period of seven years from 1957 to 1964 and compared with the Indian Standard Specification for common salt for fish curing I.S. 594–1954 (Tentative) and I.S. 594–1962 (revised). None of the salt samples used in Government and private fish cuing yards satisfied the revised standard I.S. 594–1962 (98 per cent NaCl) and only 26·89 per cent of the salt samples in Government fish curing yards were up to the tentative standard I.S. 594–1954 (96 per cent NaCl). Only one of the four salt samples examined from the private fish curing yards satisfied the tentative 1954 standard. Only 5·13 per cent of the market samples, met the revised specifications, and only 7·7 per cent of the market samples were within the tentative standards. The scarcity in the market of the salt of required specifications is found to be the chief cause for the use of low-grade salt in fish curing in the State and this will have to be remedied first to improve the quality of salt used in fish curing. The moisture content and the

Ca, Mg and So4, impurities were found to be within the limits allowed in most of the samples, but the chief defects were found to be high insolubles and low NaCl content. The average NaCl contents of the salt samples in Government fish curing yards, private fish curing yards and the fishery salt trade were found to be respectively 94·86 per cent, 89·99 per cent and 90·88 per cent and should be considerably improved. The average figures for "insolubles" in the samples of Government fish curing yards, private fish curing yards and salt manufacturers were 1·16 per cent, 1·32 per cent and 1·43 per cent respectively and should be reduced considerably to reach the revised standard of 0·5 per cent.

*Acknowledgments.*

We are thankful to the Director of Fisheries, Madras, for his kind permission to publish this paper.

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TABLE I.

*Showing the summary of the results of analysis of common salt used in Government fish curing yards in Madras State during the years* 1957–64.

| Serial number and particulars. | | | On dry basis. | | | | |
|---|---|---|---|---|---|---|---|
| | Moisture. | $NaCl_2$ | Insolubles | MgC12 | CaC12 | MgSo4 | CaSo4 |
| (1) | (2 | (3) | (4) | (5) | (6) | (7) | (8) |
| | PER CENT. | PER CENT. | PER CENT. | PER CENT. | PER CENT. | PER CENT. | PER CENT. |
| 1 Number of samples examined .. .. .. | 94 | 94 | 91 | 90 | 65 | 60 | 91 |
| 2 Range observed— | | | | | | | |
| Maximum .. .. .. .. .. .. .. .. | 0·13 | 88·02 | 0·13 | 0·05 | 0·01 | 0·04 | 0·37 |
| Minimum .. .. .. .. .. .. .. .. | 2·93 | 98·82 | 2·76 | 2·18 | 0·98 | 1·81 | 3·02 |
| 3 Average .. .. .. .. .. .. .. .. | 4·26 | 94·86 | 1·16 | 0·61 | 0·32 | 0·47 | 1·58 |
| 4 Number of samples conforming to I.S. : 594—1954 .. | 82 | 44 | 47 | 58 | | | |
| 5 Per centage of samples conforming to I.S. 594—1954 .. | 87·13 | 46·80 | 51·64 | 64·4 | | | |
| 6 Number of samples conforming to I.S. : 594—1962 .. | 82 | 1 | 23 | 2 | | | |
| 7 Percentage of samples conforming to I.S. : 594—1962 .. | 87·13 | 1·06 | 25·27 | 2·2 | | | |
| 8 Percentage of samples conforming to I.S. 584—1954 for all requirements. | 26·80 | | | | | | |
| 9 Percentage of samples conforming to I.S. 594—1962 for all requirements. | *Nil.* | | | | | | |

TABLE II.

*Showing the results of analysis of common salt samples taken from the private fish curing yards.*

| Serial number and date. | Particulars. | | On dry basic. | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Moisture. | Insolubles. | NaCl. | MgCl. 2 | CaCl. 2 | Mg.Sa. 4 | CaSo4 |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| | | PER CENT. | PER CENT. | PER CENT. | PER CENT. | PER CENT. | PER CENT. | PER CENT |
| 1 2nd December 1960. | Tuticorin Fish Curing Yard .. | 1·57 | 2·47 | 88·53 | 0·43 | .. | 0·14 | 3·17 |
| 2 2nd December 1960. | Do. | 6·20 | 9·70 | 80·57 | 3·32 | .. | 0·78 | 1·52 |
| 3 18th September 1962. | Aliyar Fish Curing Yard, Rameswaram. | 1·23 | 0·99 | 96·35 | 0·11 | .. | 0·12 | 1·30 |
| 4 18th September 1962 | Do. | 4·04 | 1·11 | 94·53 | 0·15 | .. | 0·40 | 2·77 |
| | | 3·26 | 1·32 | 89·99 | 1·00 | .. | 0·36 | 2·19 |

TABLE III.

*Showing the summary of the results of analysis of common salt samples offered for fish curing by the manufacturers in Madras State during the years* 1957–64.

| Serial number and particulars. | Moisture | On dry basis. | | | | | |
|---|---|---|---|---|---|---|---|
| | | NaCl. | Insolubles | $MgCl_2$ | $CaCl_2$ | $MgSo_4$ | $CaSo_4$ |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| | PER CENT. | PER CENT. | PER CENT. | PER CENT. | PER CENT. | PER CENT. | PER CENT. |
| 1 Number of samples examined .. .. .. .. | 192 | 192 | 39 | 35 | 28 | 38 | 39 |
| 2 Range observed— | | | | | | | |
| Minimum .. .. .. .. .. .. .. .. | 0·00 | 81·2 | 0·02 | 0·04 | 0·014 | 0·03 | 0·0 |
| Maximum .. .. .. .. .. .. .. .. | 19·51 | 99·58 | 7·17 | 6·04 | 0·74 | 2·47 | 9·21 |
| 3 Average .. .. .. .. .. .. .. .. | 4·20 | 90·88 | 1·43 | 1·76 | 0·10 | 0·72 | 1·86 |
| 4 Number of samples conforming to I.S. : 594—1954 .. | 140 | 66 | 22 | 6 | | | |
| 5 Percentage of samples conforming to I.S. : 594—1954 .. | 72·91 | 34·37 | 56·41 | 15·38 | | | |
| 6 Number of samples conforming to I.S. : 594—1962 .. | 140 | 20 | 18 | 2 | | | |
| 7 Percentage of samples conforming to I.S. : 594—1962 .. | 72·91 | 10·41 | 46·15 | 5·13 | | | |
| 8 Percentage of samples conforming to I.S. : 594—1954 for all requirements. | (7·7 | | | | | | |
| 9 Percentage of samples conforming to I.S. : 594—1962 for all requirements. | 5·13 | | | | | | |

# THE FOULING ORGANISMS OF THE PEARL OYSTER FARM, KRUSADAI ISLAND, GULF OF MANNAR

BY

R. ANANTHANARAYANAN.

The pearl oyster farm of the Krusadai Biological Station is erected in a land locked area of the Kundugal channel situated in the head region of Gulf of Mannar. The sea is not always rough and the hydrobiological conditions are also favourable for the existence of the oysters (Chacko 1950 1954 and 1952 Devanesam and Chidambaram.

In the pearl oyster farm of Krusadai Marine Biological Station wooden rafts, wooden cubicles and fabricated iron cages are used. These cages and cubicles are suspended over the rails planted in the channel in a depth of about six metres. Preliminary accounts of the organisms fouling the cages and cubicles have been made by Chacko, Kuriyan (1950) Kuriyan and Mahadevan.

In the site, observations were made from August 1962 to May 1963. The different kinds of organisms and their seasonal features are noted as given below :—

*Coelenterates*

Among the coelenterates the most common occurence as follows :—

Lytocarpus.—Abundant in April.

Mambranipora.— Do.

Obelia colonies.— Do.

Sertularia.—August.

Paranemonia.—March and April.

*Polyzoans.*—Nellia occulata, Bugula sps. Sedentary organisms like this found to attach on the wooden rafts as well as on the wire net.

Nellia occulata.—March and August.

Bugula.—April to August.

*Turbellaria.*—Turbellarians are frequently been blamed for the destruction of oysters. All are carnivorous. However it is probable that the turbellarians enter the oyster shell, only when it has sickened or died. In such a state the oyster is unable to work the adductor muscles to close the shell valves together. Then the turbellarians finishes off the victim, but anyway it is not to be blamed for the primary weakness. Planarians are the special visitors for the pearl oyster cages in the month of March and August.

*Annelida.*—Following were the annelidan members found in the cages. Lepidonotus Carinatulus, Dasychone Cingulata, Sebellastrate indica, Spirorbis, Oligochaeta and members of Syllidae. Dasychone cingulata (Sars).—March to August and December Sebellastrate indica—August.

pidonotus Carinatulus (Grube)—March and December.

*Arthropoda*

Mostly crustaceans—Balanus tintinnabulam (Linnaeus) usually found to attach on the wooden parts of the raft, because they prefer the flat sustratum. Lepas was also represented but when compared to Balanus they are lesser in number. Hippolysmata vittata (Stimpson) were the attractive visitors to the cages. Balanus tintinabulam (Linnaeus)—April to December. Hippolysmatta vittata (stimpson)—August to March. Alpheids—December.

*Decapods*

Some of the crabs were also found trapped inside the cages. They were Charybdis annulata (Fabricius) Thalamitta prymna, Thalamitta admitta (Nerbst) Polyonyx sps. Tylocracinus styx (Herbst) crabs were found throughout the year.

Besides that, numerous isopods and thousands of amphipods (Corophium) were also found sticking to the wire net, They occur almost through out the year.

*Mollusca.*—Members of the nudibranchs were the distinguished spectators in the pearl oyster cages. They were as follows :—

(1) Eolidina mannarensis.—March.

(2) Pleuroleura (Bergh) Striata.—March.

(3) Discodoris rubra.—April.

(4) Eulis (Cuthona) inornata.—March.

(5) Eolidina (Spurilla) neapalitana.—March.

(6) Eubranchus productus.—December.

*Bivalvia*

Modiolus sps. in thousands.—November.

Isognoman sps.—March.

Ostrea cuculata.—December.

*Echinodermata*

*Asteroidea.*—Pentaceras herdmani. Only once juvenile sps. of Pentacera sps. was found inside the cage.

*Echinoidea.*—Sea urchins are also rare. Only once juvenile sps. of salmacis virgulata (Agassiz) was collected inside the cage.

*Crinoidea.*—Sea lily. Two numbers were found inside the cage whose specific name could not be determined. They were collected during the month of April and August.

*Holothuroidea.*—Though the holothurians (edible sea cucumber) were commonly occuring inside the cages in the coast of Japan it was completely absent in the oyster cages at Krusadai.

*Tunicata.*—Some of the tunicata found to attach on the wooden rafts were white transparent, simple ascidians whose specific name could not be determined. The compound ascidians Diandracarpa of the genus branen-helmi (Michulson) found to attach on the upper side of the valves of the oysters. They almost choke the oysters. Hence periodical cleaning is necessary.

*Pisces*

The following two varieties of fishes were the common visitors to the oyster cage :—

1. Tetradon sps.
2. Petroskirtis leinardi.

*Sea weeds*

Some of the seaweeds were also found inside the cages almost throughout the year. The conspicuous genera of algae represented inside the cage were as follows:—

*Chlorophyceal*

1. Gracillaria.
2. Ulva lactuca..
3. Entersporpha sps.

*Pheophyceara*

1. Padina sps.
2. Sargassam sp.

*Rhodophyceae*

1. Ceramium sps.

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# STUDIES ON THE EXTRACTION AND PROPERTIES OF AGAR-AGAR FROM THE SEA-WEED GRACILLARIA SP. IN MADRAS STATE

BY

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## I. Introduction.

Agar-Agar is the complex polysaccharide occuring in large amounts along with cellulose in the cell walls of the seaweeds like *Gracillaria spp. Gelidium micropterum, Sarconema sp.* and *Hypnea sp*, and is in much demand in many industries. In the Food industry it is used in the preparation of jellies, desserts, salads, ice cream, jams, vegetable paste, and aerated waters and in the preservation and canning of meat and fish. In textiles, it is used as sizing medium for fabrics and as a thickener in drying and printing of textiles. In leather trade it is used as a sizing medium and in the fnished process of leather making. It is used in the manufacture of cosmetics, creams, soaps, shoe polish, hand lotions, quality adhesives, photographic films plywood, petroleum emulsion, plastic material for making dental imprints, marine storage, batteries, etc. graphite in an agar gel is used as a lubricant in the hot-drawing of tungsten wire for electric lamps. Agar also finduse as Activator in Nicotine sprays and in sizing of paper and electroplating of lead. In medicine, it is used as a laxative and as glycerine substitute as an ointment base and wound dressing. Above all the uses of agar in bacteriological work as a medium for the growth and culture of bacteria and in analytical and colloidal research are well known.

The most common agarophytes occuring in the coasttal districts of Ramanathapuram Tirunelveli and Thanjavur in Madras State are *Gracillaria spp* and *Gelidium micropeterum,* which have been found to be valuable raw materials for the production of Agar-Agar by Bose et. al. (1943), Karunakar et. al. (1948), Chakraborty (1945), Thivy (1951), Mohanty (1956), and Chacko and Malu Pillai (1958) who employed different processes for the extraction of the agar. Thivy (1958) also worked out Cottage industry method of manufacturi[ng]

Bacteriological agar from *Gracillaria edulis* (Gmel), Silva. Kappanna and Visweswara Rao (1963), studied the effect of different treatments of Gracillaria and Gelidium on the quality of the agar produced and standardized the conditions for the production of good quality agar. A series of experiments were also made by the present authors at the Fisheries Technological Station, Tuticorin, with a view to standardise the process of extraction of agar from the sea-weed *Gracillaria sp.* and to prepare a process flow chart for the commercial utilisation of the large quantities of the seaweed occuring in the State to manufacture Agar-agar on a pilot plant scale. The details and results of these experiments form the basis of this paper.

## II. Meterials and Methods

The sea-weeds *Gracillaria sp.* required for these experiments were collected from Pamban and Krusadai Islands, in Ramanathapuram district in Madras State. The weeds were sun dried and bleached according to the method described by Thivy (1961), before they were used for the experiments. The gel strength, setting temperature and melting temperature were determined with 1·5 per cent agar solutions as recommended by Wood (1946). Moisture, ash, acid insolubles, Nitrogen, Calcium and sulphates were determined according to the official methods of analysis of the A.O.A.C. (1955).

## III. Details of Experiments

The methods adopted by the earlier Indian workers mentioned above for the extraction of agar formed the basis of the present series of experiments and various modifications were made in these methods in the different experiments with a view to find out the possibilities of increasing the yield of the agar and improving the quality of the product. The details of the various experiments conducted and the results obtained are described below :—

*Experiment No.* 1.—This is based on the Central Marine Fisheries Research Station Cottage Industry Method of Thivy (1958 loc. cited), 250 grams of the clean, dry sun-bleached seaweed were washed in water and abrased in a mechanical stone grinder. 1,000 revolutions were made and the sea-weed was rinsed in 4·5 litres of water and filtered through filter cloth. The seaweed was again abrased in the stone grinder, making another 500 revolutions. Then soaked the seaweed in 12 litres of water, filtered, ground to paste and the paste again soaked in 12 litres of water for 24 hours. The paste was dried, the dried paste weighing 163 grams i.e., 65 per cent of the weight of the dried sea-sweed. The dry pulp was added to 7·5 litres of boiling water and boiling continued for 45 minutes. Filtered hot and the filtrate cooled to form a gel, the supernatent gel removed from the sediment, melted in a water-bath and recooled to form a gel, cut into strips and dried on plastic wire mesh screens in the sun. No freezing or thawing was done. The residue left in the first extraction was used for the second extraction as described by Thivy.

*Experiment No.* 2.—This is a modification of the method followed in Experiment No. 1, in that the gel formed in the first and second extractions were purified by freezing and thawing the product.

*Experiment No.* 3.—This is a repetition of Experiment No. 2.

*Experiment No.* 4.—One kilogram of the clean, dry, bleached sea-weed was washed in hot water and ground to pulp in a mechanical wet grinder. The ground pulp was then added to 30 litres of boiling fresh water in an open vat and the boiling continued for another 45 minutes . Filter the boiling liquid through a filter cloth while still hot, collecting the filtrate in trays. Allowed the filtrate to cool to a gel, frozen in a deep freezer for 40 hours, thawed and dried in air-oven. The residue after the extraction was again utilized for second extraction and was added to 15 litres of boiling fresh water and the process repeated as above. The yield in the second extraction was noted and the properties of the product studied separately.

*Experiment No.*5—500 grams of the clean dry, bleached sea-weed were soaked in water for four hours, washed, ground to paste in a mechanical wet grinder and added to 24 litres of boiling fresh water. At this stage, 40 c.c. of N. $H_2 So_4$ was added to the boiling solution to bring down the pH of the medium to 6·0 and the boiling continued for 45 minutes. Filtered the boiling solution while still hot through a filter cloth, collecting the filtrate in trays. Allowed the filtrate to cool to a firm gel, frozen in a deep freezer, thawed, and dried in air-oven.

*Experiment No.* 6.—Experiment 2 was repeated and a second extraction was also made, boiling the residue of the first extraction in 20 litres of dilute $H_2 So_4$ at a pH of 6·0 and repeating the subsequent processes as before. The yield of the second extraction was noted and the properties of the product studied separately.

*Experiment No.* 7.—Method is the same as in experiments 5 and 6 but the ground pulp was soaked in fresh water for 24 hours and then dried before extraction.

*Experiment No.* 8 *and* 9.—Procedure is the same as in experiment 7, but the ground pulp after soaking for 24 hours, was straight away used for extraction without drying.

*Experiment No.* 10.—1·5 kg. of the clean, dry, bleached seaweed was well powdered in a Raymond Laboratory Mill worked by ½ horse power motor and the powder was well washed with water and then ground to paste in a mechanical wet grinder. The ground pulp was added to 60 litres of boiling fresh water along with 180 ml. of N. $H_2 So_4$ and the boiling continued for four hours. Filtered hot through filter cloth, the filtrate cooled to form gel, cut into strips, frozen, thawed and dried in a hot current of air at 50°C in a tunnel drier.

*Experiment No.* 11.—The procedure is the same as in experiment 10, but the powdered sea-weed after washing, was straightaway extracted, without grinding to paste.

## IV. Results and discussions]

The results of the eleven experiments are detailed in Annexure I which shows the yield of agar in each experiment and the gel strength, setting temperature, melting point, moisture, ash, acid insolubles, nitrogen, calcium and sulphate contents of the agar samples obtained in each experiment. The properties and composition of commercial samples of Japanese and Difco agar are also shown in this Annexure for comparison.

In the first three experiments in which the Central Marine Fisheries Research Station Cottage Industry method was followed, the yield of agar ranged from 20 per cent to 33·5 per cent only as compared with the yield of 46 per cent reported by Thivy (1961. loc. cited). The gel strength of the agar obtained was also as low as 60 g ; but it could be improved and the ash, acid insolubles, mineral constituents and nitrogen content of the agar could be considerably reduced by freezing and thawing the product as can be seen from the experiments 2 and 3. This is in conformity with the observations of Kappanna and Visweswara Rao (1963 loc. cited). In experiment 4, where the repeated soaking of the weeds and the ground paste for several hours in water was avoided, the gel strength of the product was found to improve, as reported by Wood (1946. loc. cited). In experiments 5 and 6, where the extraction was done at a pH of 6·0 by the addition of $H_2 So_4$ to the boiling solution, the yield was found to improve much and the product had a comparatively high gel strength. Soaking of the ground pulp in water for 24 hours, before extracting at a pH of 6·0 as done in experiments 7, 8 and 9 decreased the yield considerably and so it was decided to avoid soaking. Maximum yields of agar of 33·33 per cent and 37 per cent with gel strengths of 141 g. and 156 g. respectively were obtained in experiments 10 and 11, where the clean, dry, bleached sea-weed was first disintegrated into fine powder in a laboratory mill and the extraction done at pH of 60 by the addition of sulphuric acid, as reported by Kappanna and Visweswara Rao (1963 loc. cited). The agar produced in the last two experiments compared favourably with the commercial samples of agar now being sold in the market both in appearance and in composition and properties as can be seen from the figures in Annexure I. Repetition of Experiment No. 11 a number of times gave consistantly good yield of agar of high gel strength and so the process adopted in this experiment may be taken as the standard one.

Based on the experiments described above, the process flow chart shown in Annexure II may be adopted for the commercial utilisation of the seaweed *Gracillaria sp.* occurring in the coastal districts of Ramanathapuram, Thanjavur and Tirunelveli in Madras State for production of Agar-agar on a pilot plant scale.

The required raw materials namely *Gracillaria sp.* may be collected during their maximum growth from June to December, every year by employing labour. The collected weeds should be washed well in sea-water and dried in the sun on mats for 3 days, sprinkling sea-water over the weeds daily morning. The dried weeds should be washed well in fresh water several times and again sun-dried on mats, sprinkling fresh water daily morning. The washing in fresh water and drying should be continued until the weeds are completely bleached. The resultant clean, dry, bleached sea-weed should be stored in a well-ventilated room and used as and when required in small lots for further processing operations. Thivy (1961, loc. cited) has estimated that in the Pāmban area of Ramanathapuram district in Madras State, about 40·6 tonnes of fresh *Gracillaria spp.* can be harvested annually to yield about 5·1 tonnes of dry sea-weeds. It may be possible to harvest further quantities of this agarophyte from other coastal villages between Point Calimere and Cape Comorin to procure the required raw material of 10 tonnes/annum to feed a pilot Agar Plant of capacity 30kg. (raw material) daily.

This pilot plant may require equipments like one disintegrator for finely powdering the dried and bleached seaweeds, one steam jacketted open pan type S.S. evaporater one steam jacketted S.S. filtration unit, one steam boiler to supply steam for the evaporater and filtration units, a number of S.S. Setting trays for allowing the agar gel to form Plastic or Nylon wire mesh screens to dry the agar strips, one ice plant or big freezing cabinets for freezing the agar gel, one temperature controlled cabinet drier for drying the frozen and thawed agar at 50°C in hot air and one micro-pulveriser for powdering the agar. All these equipments are available in our country and may cost about Rs. 1 lakh in all. The expenditure on these items may be reduced if the pilot plant for agar is put up in a place like Tuticorin where the State Government has already put up a 5 tonne ice plant and a Fish Canning Factory with a Steam Boiler, so that these costly equipments could be suitably made use of for the Agar plant also. Another essential requisite for the location of this plant will be the availability of copious supply of fresh water for the bleaching operations of the seaweed and for further washing and extraction operations. About 1,000 gallons of fresh soft water may be required daily to handle 30 kg. of the dried sea-weed.

This pilot plant will be able to produce about 10 kg. of agar per day or about 3 tonnes of agar/annum, which will be approximately our country's requirements at present. The agar requirements of our country are at present mostly met by imports from Japan, U.S.A. and other countries and their prevailing market rates vary from Rs. 40 to Rs. 220 kg. depending on the quality of the product. The setting up of an agar plant in Madras State may help to save foreign exchange to the tune of Rs. 2 lakhs besides finding a good use for the sea-weed resources of the State. It has been computed that based on the process flow chart detailed above, the cost of production of agar-Agar will come to less than Rs. 20 per kg. only and so the establishment of a pilot plant for manufacture of agar will also be a profitable venture.

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## ANNEXURE I.

*Showing the yield and properties of Agar obtained in the various experiments.*

| *Experiment number and Method used for extraction.* | *Proportion of seaweed water used.* | *Yield.* | *Gel. strength (gms.)* | *Setting temp. (C°)* | *Melting temp. (°C)* | *Moisture* | *Ash.* | *Acid Insolubles.* | *N2* | *Ca* | *So4* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
| | | PER CENT. | | | | PER CENT. | PER CENT. | PER CENT. | PER CENT. | PER CENT. | PER CENT. |
| | | | | | | | | (on dry basis). | | | |
| 1 C.M.F.R.S. Method (Thivy 1958, loc. cited) .. | 1:30 | 28 | 60 | 40 | 81 | 17·4 | 11·17 | 3·5 | 0·3100 | 1·99 | 2·4000 |
| 2 C.M.F.R.S. Method as in Experiment 1 but the Gel purified by freezing and thawing. | 1:40<br>1:40 | 15<br>5 | 70<br>100 | 39<br>.. | 80<br>.. | 17·00<br>14·10 | 6·2<br>5·2 | 1·37<br>1·10 | 0·060<br>.. | 1·30<br>.. | 2·98<br>.. |
| 3 Do. | 1:40<br>1·40 | 28<br>5·5 | 65<br>63 | 40<br>.. | 79<br>.. | 17·12<br>13·00 | 6·7<br>7·69 | 2·6<br>3·4 | 0·194<br>.. | 1·38<br>.. | 2·97<br>.. |
| 4 Seaweed after washing, ground to pulp in wet grinder and added to boiling water and boiled for 45 minutes Filtered, cooled to Gel frozen, thawed and dried in air-oven. | 1:30<br>1:15 | 15<br>11 | 121<br>65 | 42<br>.. | 81<br>.. | 17·4<br>17·4 | 10·92<br>11·73 | 3·92<br>2·34 | 0·288<br>.. | 1·977<br>.. | 1·73<br>.. |
| 5 Soaked in water for 4 hours, ground to paste in wet grinder, added to boiling water, Sulphuric Acid added to bring pH to 6·0 and boiling continued for 45 minutes, filtered, cooled to gel. frozen, thawed and dried. | 1:48 | 25·5 | 115 | 42 | 81 | 16·18 | 10·74 | 2·63 | 0·298 | 1·82 | 1·78 |
| 6 Same as Experiment 5 but second extraction also done. | 1:48<br>1:40 | 23<br>14 | 102<br>70 | 41<br>.. | 81<br>.. | 18·58<br>16·25 | 14·45<br>19·01 | 5·84<br>7·501 | ..<br>.. | 1·59<br>.. | 1·74<br>.. |
| 7 Same as Experiments 5 and 6 but the ground pulp soaked for 24 hours and dried before extraction. | 1:40 | 16 | 169 | 39 | 79 | 13·48 | 13·58 | 2·89 | 0·09 | 1·405 | 3·4 |
| 8 Same as Experiment 7 but no drying of the pulp before extraction. | 1:40 | 21 | 128 | 39 | 81 | 21·9 | 14·96 | 1·18 | 0·119 | 1·51 | 3·41 |
| 9 Same as Experiment 8 but second extraction done. | 1:48<br>1;40 | 16<br>8 | 129<br>126 | ..<br>.. | ..<br>.. | 17·3<br>16·19 | 5·9<br>3·4 | 0·193<br>0·161 | 0·32<br>.. | 2·009<br>.. | 3·567]<br>.. |
| 10 Seaweed powdered finally in a laboratory mill before extraction and ground to paste in a wet grinder before extraction as per experiment No. 8. | 1:45 | 33·33 | 141 | 40 | 79 | 20·6 | 6·504 | 1·767 | 0·305 | 1·89 | 2·335 |
| 11 Seaweed well powdered in laboratory mill and straight away extracted as per Experiment No. 8. | 1:60 | 37 | 156 | 42 | 79 | 19·72 | 7·718 | 1·858 | 0·298 | 1·727 | 3·654 |
| 12 Commercial Agar Samples— | | | | | | | | | | | |
| (i) Japan Agar (used for Bacteriological work). | .. | .. | 245 | 38 | 85 | 19·96 | 3·378 | 0·420 | 0·15 | 1·36 | 3·897 |
| (ii) Bapco agar (Japanese) Kappanna and Visweswara Rao (1963, loc. cited). | .. | .. | 75 | 38 | 86 | 17·13 | 2·28 | .. | 0·16 | 0·56 | 1·50 |
| (iii) Difco agar, (Kappanna and Visweswara Rao (1963, loc. cited), | .. | .. | 55 | 38 | 89 | 18·91 | 3·02 | .. | 0·16 | 0·30 | 2·02 |

## ANNEXURE II.

*Process Flow Chart for Production of Agar-Agar* (10 *kg*).

Red Sea-weed (*Gracillaria spp.*) Wet wt. 250 kg.

↓

Wash Well in Sea-water and Sun-dry for 3 days, sprinkling sea-water daily morning.

↓

Washed several times in fresh water and sun-dry on mats with repeated sprinkling of fresh water until bleached completely and dried (30 kg.)

↓

Pulverise into fine powder in Disintegrator.

↓

Rinse the sea-weed powder in fresh-water.

↓

Extract the powder in boiling fresh-water (1,200 litres) in an open S.S. Evaporater for 4 hours, at pH 6·0 by addition of about 3 litres of N. $H_2So_4$.

↓

Filter the Hot extract in S.S. Steam Jacketed Filter.

↓

Allow the Filtrate to set to gel in S.S. Trays.

↓

Cut the gel into Strips.

↓

Freeze the gel in a freezer or ice plant for 24 hours.

↓

Allow the Frozen Gel to thaw.

↓

Dry in a current of Hot Air at 50°C in a Drier.

↓

Powder the Dried Agar in a Mechanical Pulveriser.

↓

Pack in Polythene Bags or Tins. (Agar-Agar) 10 kg.

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