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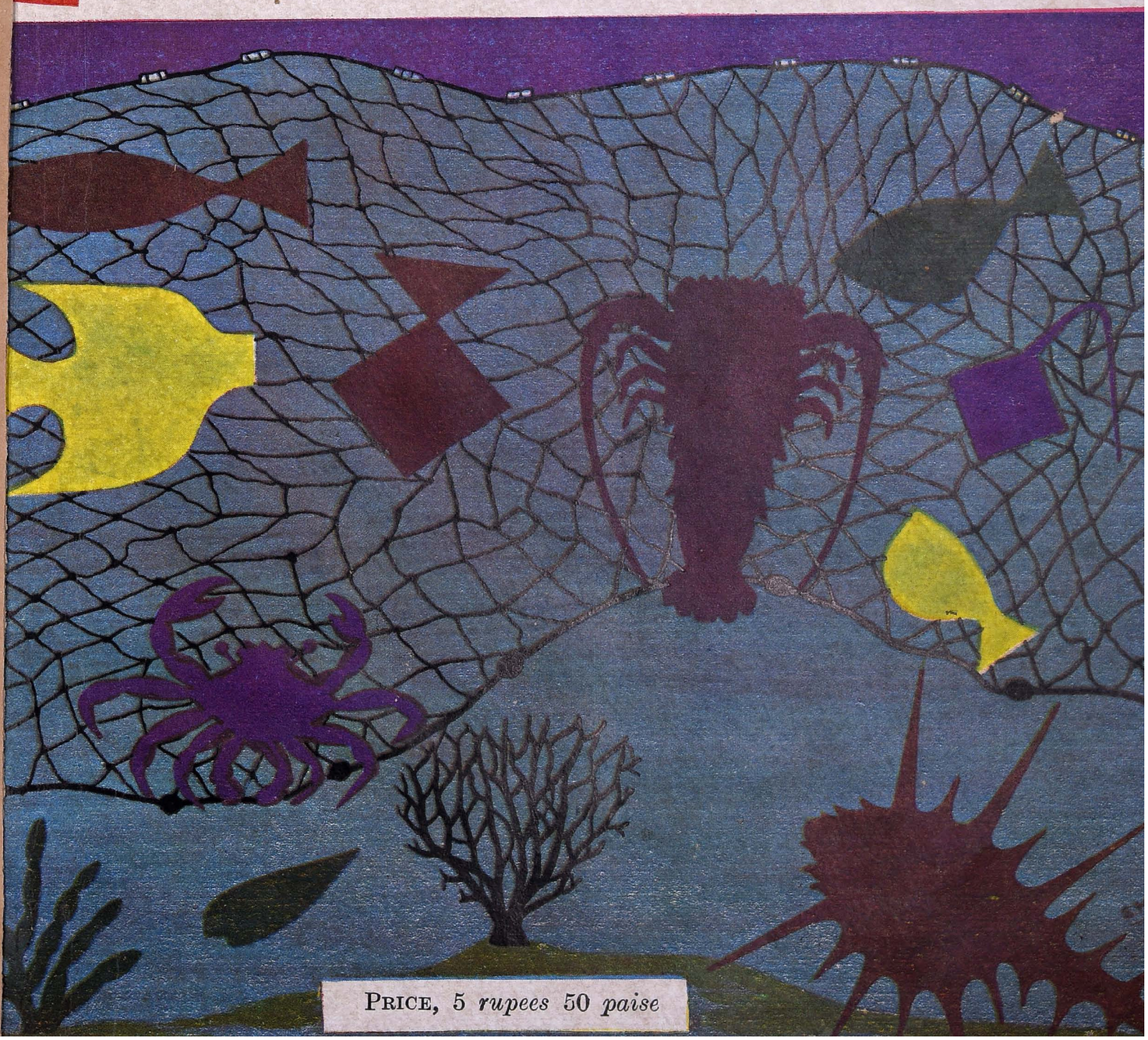

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CONTENTS

BIOLOGY AND FISHERIES OF MYSTUS (OSTEOBAGARUS) AOR (SYKES) IN THE BHAVANISAGAR RESERVOIR

BY

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Any plan of fishery development in the major artificial impoundments of our river systems will have to be centred around a scientific management formulated on biological data of each fish population. The biology of one such population *Barbus dubius* [Ranganathan *et al* (1963)] in the Bhavanisagar reservoir has thrown considerable light on the abundance of this species in reservoirs similar to Bhavanisagar and its disappearance from reservoirs like Mettur Dam. The suitability of utilising this species with success in other impoundments of our State for stocking has also been discussed.

Mystus (*Osteobagarus*) *aor* (Sykes) along with a smaller percentage of *Mystus* (*Osteobagarus*) *seenghala* (Sykes) is a fishery of considerable importance in the rivers and reservoirs of the Cauvery System of Madras State. Going by the local Tamil names குருந்தலை கெளுத்தி and மநந்தலை கெளுத்தி the fish is priced as a table fish of few bones compared to other fishes of the reservoir landings.

TABLE I.

Year-war landings of Mystus *species by the two experimental units at Bhavanisagar.*

Year.	*Total landings.*	*Landings of* Mystus aor	
		Number.	*Weight.*
	KGS.		KGS.
1959–60 ..	18,634	..	..
1960–61 ..	16,969	2,156	4,724·98
1961–62 ..	28,565	2,435	5,161·00
1962–63 ..	17,770	1,700	3,957·75
1963–64 ..	44,770	6,768	11,068·00

TABLE II.

Total estimated landings and the quantity of Mystus *species landed by the licencees in Mettur Reservoir.*

	Total landings.	*Quantity of* Mystus *species landed.*
	KGS.	KGS.
1961	2,33,922	22,632
1962	2,85,057	24,436
1963	4,54,427	35,835

Tables I and II show the year-war landings of these two species by the two experimental units using on an average 1,500 fathoms of Rangoon nets during 1959 to 1963 in Bhavanisagar and the landings at Mettur by the licencees. The catches do not indicate the trend in increase or decrease because the catch efficiency was not uniform and the condition of the nets, etc., varied due to administrative reasons. Of the computed landings of 1,924 metric tons from the regulators of the Cauvery System in Tanjore delta in 1961, 7·8 per cent was that of *Mystus aor* and *Mystus seenghala*.

The biology of this fishery with special reference to reservoir conditions is little known. The account of the extraordinary breeding habits by Sunder Raj (1962), the life history, bionomics and breeding habits by Saigal and Motwani (1962) are all under riverine conditions. The present study of this fish population in Bhavanisagar is for assessing its trend in all our reservoirs where it exists and following a planting practice in other reservoirs of the same type once its biology is known.

MATERIAL AND METHODS

These observations are based on the data collected from the daily landings of the experimental units operated in the Bhavanisagar reservoir since 1959. The data on food, and feeding habits, age and growth, gonadial maturity, breeding habits and condition factor are with reference to this ecological niche. Simultaneously the otoliths and vertebral bones were taken out as detailed below prepared and radial measurements recorded. Opercular bones also exhibited definite age rings in their margins, yet they were not used for the study. The otoliths are lifted from the floor of the skull after exposing and scraping off of the soft brain. The enveloping sacs are removed by manipulation of the forceps and the exposed sagittae are then wiped clean by rubbing gently with fingers. After cleaning with 5 per cent potassium hydroxide, they are slightly grained on a smooth stone with coconut oil. Glycerine and xylol wash improves examination. The vertebrae are obtained by boiling the anterior portion of the vertebral column for 15 minutes washing in running water and drying in sun light the individual vertebra. Sections taken out of a fret work saw and treated for 24 hours respectively with acetone and xylol exhibit clearly age rings for record of measurements.

FOOD AND FEEDING HABITS

Stomach contents of specimens examined in the year 1961 and 1962 are summarised in the table below :—

Months of collection.	*Number examined.*	*Range in length.*	*Percentage feed.*	*Stomach contents.*
(1)	(2)	(3)	(4)	(5)
January	26	480 to 770	empty to ·2	Small fish, rotifers, fresh water oligochaetes.
February	29	420 to 740	·4 to ·9	Chironomid, May fly nymph, fresh water oligochaetes.
March	21	440 to 770	·5 to full.	Chironomid, May fly nymph, fresh water oligochaetes.
April	18	360 to 780	·6 to full.	Chironomid, May fly nymph, fresh water oligochaetes.

Months of collection.	*Number examined.*	*Range in length.*	*Percentage feed.*	*Stomach contents.*
(1)	(2)	(3)	(4)	(5)
May	27	420 to 760	·7 to full.	Chironomid, May fly nymph, fresh water oligochaete.
June	26	380 to 700	·2 to ·8	Rotifers, crustacean eggs, small fish, insect remains.
July	28	300 to 680	·2 to ·8	Rotifers, crustacean eggs, small fish, insect remains and molluscan remains.
August	24	480 to 730	empty to ·6	Rotifers, custacean eggs, small fish and copepods.
September	28	398 to 740	empty to ·4	Copepods, rotifers, small fish.
October	24	460 to 740	·1 to full.	Diatoms, half digested fish Rotifers filamentous algae.
November	28	480 to 720	empty to ·5	Digested fish, worm remains.
December	24	480 to 770	empty to ·3	Digested small fish, worm remains.

The fish is piscivorous. In addition it browses on the mud flats and feeds on May fly nymphs, molluscs, and other benthic fauna including oligochaetes. The presence of Rotifers, diatoms and copepods usually represented in the reservoir plankton in the stomach indicated additional plankton feeding. During the pre spawning and post spawning season the percentage of feed is less. From February onwards, the post spawners resort to active feeding along the margins and in shallower areas on chironomids May fly nymphs and benthic oligochaetes.

THE FISHERY

Mystus aor with *Mystus seenghala* is the second important fishery of Bhavanisagar reservoir, an artificial impoundment, 30 square miles in extent (Ranganathan, *et al* 1963).

Text Fig. 1 is an indication of the monthly landings by the two experimental units of 2 coracles and four fishermen. The Bhavani and the Moyar rivers, the major tributaries of the Cauvery, before impoundment, were inhabited by this species, and thus the reservoir started with a natural impounded stock.

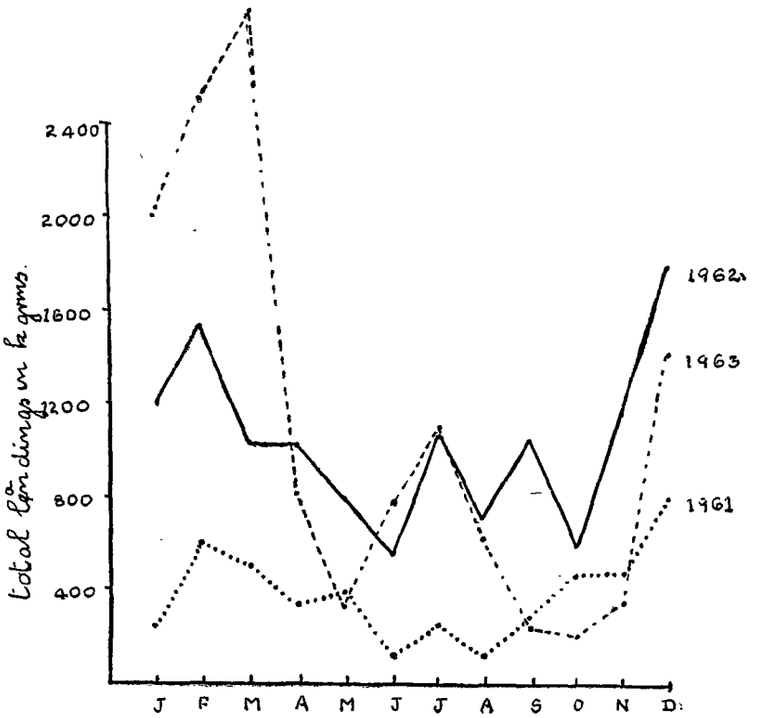


FIG. 1—*Mystus aor*—Monthwar landings of the two experimental units of Bhavanisagar reservoir from 1961–63.

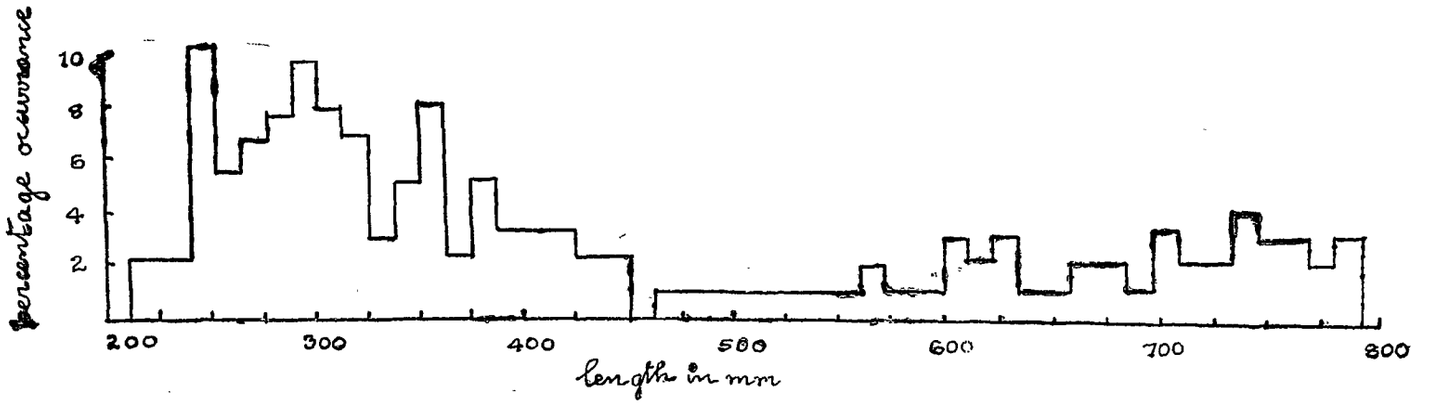


FIG 2—*Mystus aor*—Length frequency histogram of landings in 1962. (Bhavanisagar reservoir).

Text Fig. 2 is the length frequency diagram of the landings in one month in 1962. The evidence of increase in age and additional age groups is a clear proof of the firm establishment of this fishery in the Bhavanisagar reservoir (photo 5). From the experience gathered in Mettur, and through a system of licencing and co-operative marketing as done therein an annual fishery of 75 to 100 tons is anticipated to be fished from Bhavanisagar commercially.

The successful tackles used were "Rangoon nets". They are fabricated locally from synthetic yarn equated to Terelyn code 1 and 2. Each standard net is 35 meshes deep and 100 meshes long, each mesh being 4·5 cms. knot to knot. They are also landed by Uduvalais—bottom set nets 15 meshes deep, 4,000 meshes long, each mesh of 4·5 cms. with tubular cane floats set at intervals of 100 cms. and earthern ball weights. One end of this net is fixed to the water fringe and the other end let free in the reservoir. The fishes are also landed on hook and lines by poachers. Text figure 1 indicates the intensity of the fishery in the different months of the year. Around the breeding season from November onwards to March-April we get an intensified fishery. The increase in catches are due to the upward migration to the top waters till March. From March to May the nets are laid to advantage in shallower fringes where the post spawners move in numbers apparently for active feeding on nymph and benthic fauna. The Moyar side of the reservoir has a richer population of the fish than the Bhavani side. An interesting observation is that, this fishery accounted for 13 to 15 per cent by weight in 1951 in Mettur reservoir as against 10 per cent in 1961. The reason for this decrease in population allowing for limitations in catching method and level in reservoir is discussed elsewhere.

AGE AND GROWTH

The necessity for the study of the year class composition of any fishery over a stretch of many years is evident. Before the formation of the reservoir, the riverine area was prone only to sporadic floods, alternated by low water conditions and exposed to heavy fishing and dynamiting. The maximum age group was then limited to 300 to 420 mm. With the permanent expanse of water and repopulation facility the frequency pattern got extended to the seven-year class of 740 to 770 mm. In view of the limitations imposed by the fishing method, interpretation of the histogram for estimating extent of repopulation or fishing is not attempted. Agreement with Petersen's method is one of the tests of validity for the use of any structure for age and growth determinations. In a population of a species of fish having a single restricted spawning season the individual length of fish of each age group is approximately normally distributed and the modes of length frequency distribution of successive age groups in a sample are separated along the length axis. In *Mystus aor* these conditions are satisfied in that it has a single spawning season (February-April). Figure 2 is a frequency polygon of 600 specimens of *Mystus aor* collected in one month. The different age groups in the polymodel frequency distribution were separated by the use of probability paper. When interpreted the range of length reached by the fishes at the end of each year is—

I year—240 mm.

II year—260 to 330 mm.

III year—340 to 400 mm.

IV year—400 to 530 mm.

V year—520 to 630 mm.

VI year—640 to 700 mm.

VII year—700 to 770 mm.

The fact that tropical fishes also show periodical "checks" (rings) on their discrete hard parts has been demonstrated in a few Indian species [Seshappa and Bhimachar (1951, 1954 and 1955)]. It was found in the course of the investigations that there were distinct zones, viz., rings in the otoliths of the cat fish, *Mystus aor*. It was first assumed that the zones on the otoliths were annual and the age determined from the number of zones was compared with the estimates of growth obtained from the Petersen's method of tracing the length frequency modes. To test the assumption that the zones were annual, a study of the growth at the edge of the otolith according to the season was made. The otoliths of *Mystus aor* are oval in shape with one convex and one flat or slightly concave surface. The oval shape tends to become irregular in the older specimens with calcified concretions protruding on the sides. For estimating the age the convex side was invariably used because the other side is grooved and modified for the passage of the auditory nerve. Before examination the concave side is slightly ground and then kept in a watchglass with enough water to cover for examination under binocular lens. One hundred and fifty specimens were aged like this. The observed mean length of the fishes examined, their range, the number of annual rings in the otoliths and the radius of the otolith from the central point to the age line are shown in the Table 2.

TABLE 2.

Serial number.	*Number of rings.*	*Radius of rings.*	*Range of length in mm.*	*Mean length of fish in mm.*	*Age in year.*
(1)	(2)	(3)	(4)	(5)	(6)
1	2	2·2	260–340	314	II
2	3	2·4	320–390	380	III
3	4	2·75	380–520	488	IV
4	5	3·35	510–630	622	V
5	6	3·7	620–710	699	VI
6	7	3·9	720–770	756	VII

Fishes below 260 mm. were not available in the commercial catches.

Figure 3 is a scatter diagram showing a linear relationship between the length of otoliths in mm. and the total length of the fish in mm. The equation expressing the linear relationships $y = a + bx$ was applied to derive the regression formula where y=the total length of the fish x=length of the otolith and a and b are constants. In the case of *Mystus aor* during the present studies the formula worked out to be $y=22{\cdot}64+124{\cdot}14x$. The back calculated length of fish using this regression equation at the formation of various otolith rings worked out as 278·24 mm., 328 mm., 379 mm., 467 mm., 629 mm., 697 mm. and 757 mm., at the end of the I, II, III, IV, V, VI, and VII year respectively The fair amount of agreement between the length obtained by length frequency studies, by otolith grouping and back calculated length is seen in the Table 3.

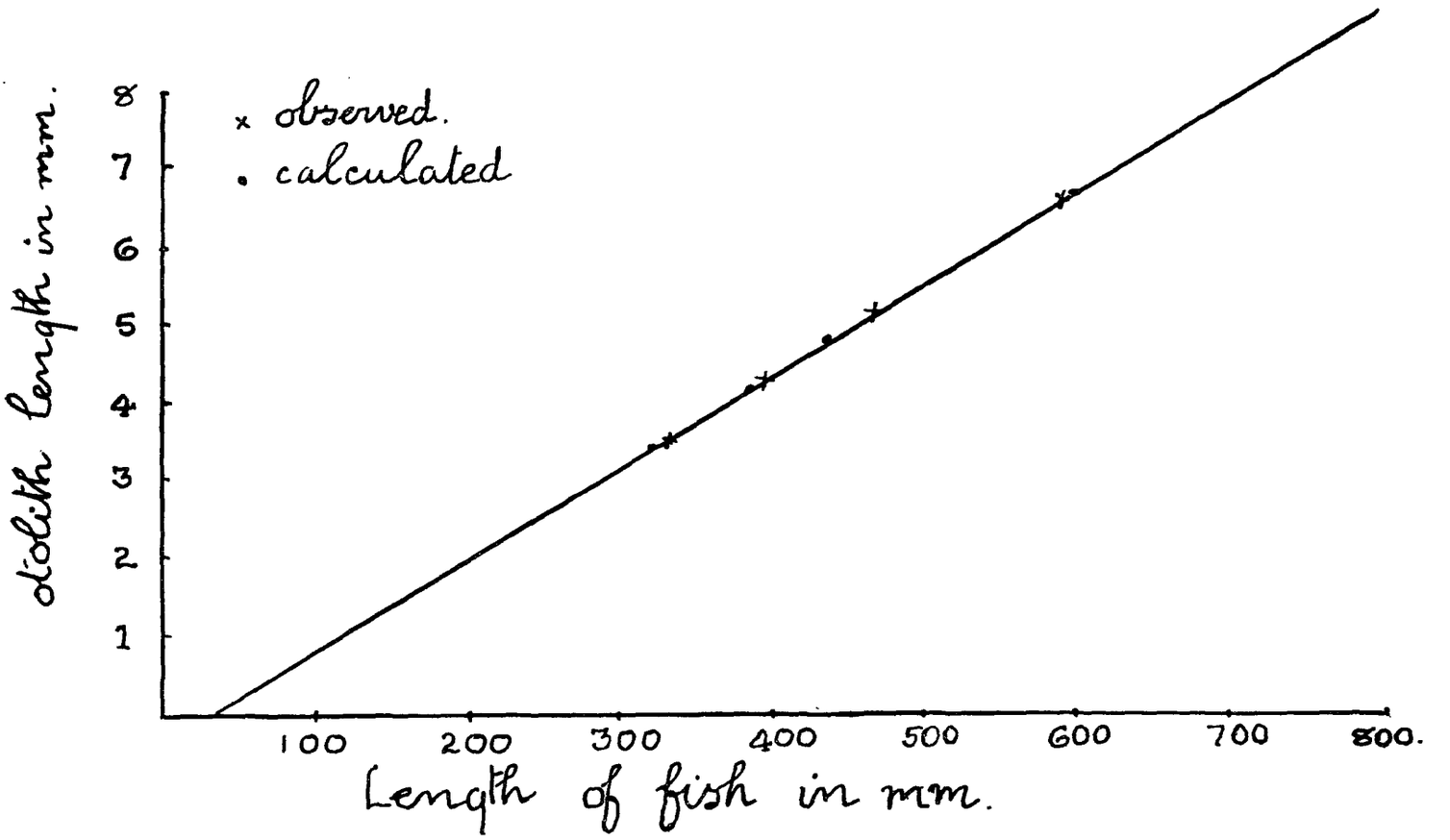


FIG. 3—*Mystus aor*—Scatter diagrams showing linear relationship between length of the otolith in mm. and the total length of the fish in mm.

TABLE 3.

Serial number.	*Age in year.*	*Mean length by length frequency in m.m.*	*Mean length by otoliths in m.m.*	*Back calculated length in m.m.*
(1)	(2)	(3)	(4)	(5)
1	I	240	..	278
2	II	300	314	328
3	III	390	380	379
4	IV	490	488	467
5	V	620	622	618
6	VI	700	699	697
7	VII	740	756	757

Figure 4 illustrates this comparison and the linear relationships very clearly.

Yoship Hiyama and Ryushi Ichikawa (1952) made use of the rings in the vertebrae of fish for estimating the age of fish in addition to scale estimation as an independent factor for comparisons. The vertebrae of *Mystus aor* show definite age rings (Photos 1 to 4) Sections of vertebrae of 150 specimens were prepared and carefully aged. The clean vertebrae were examined against a powerful lens. The radius and the diameter were measured with an ocular micrometer noting simultaneously the number of rings. The straight line relationship of the scatter diagram between the length of the fish on one axis and the radius of the vertebrae on the other met with in the otolith study was also evident here.

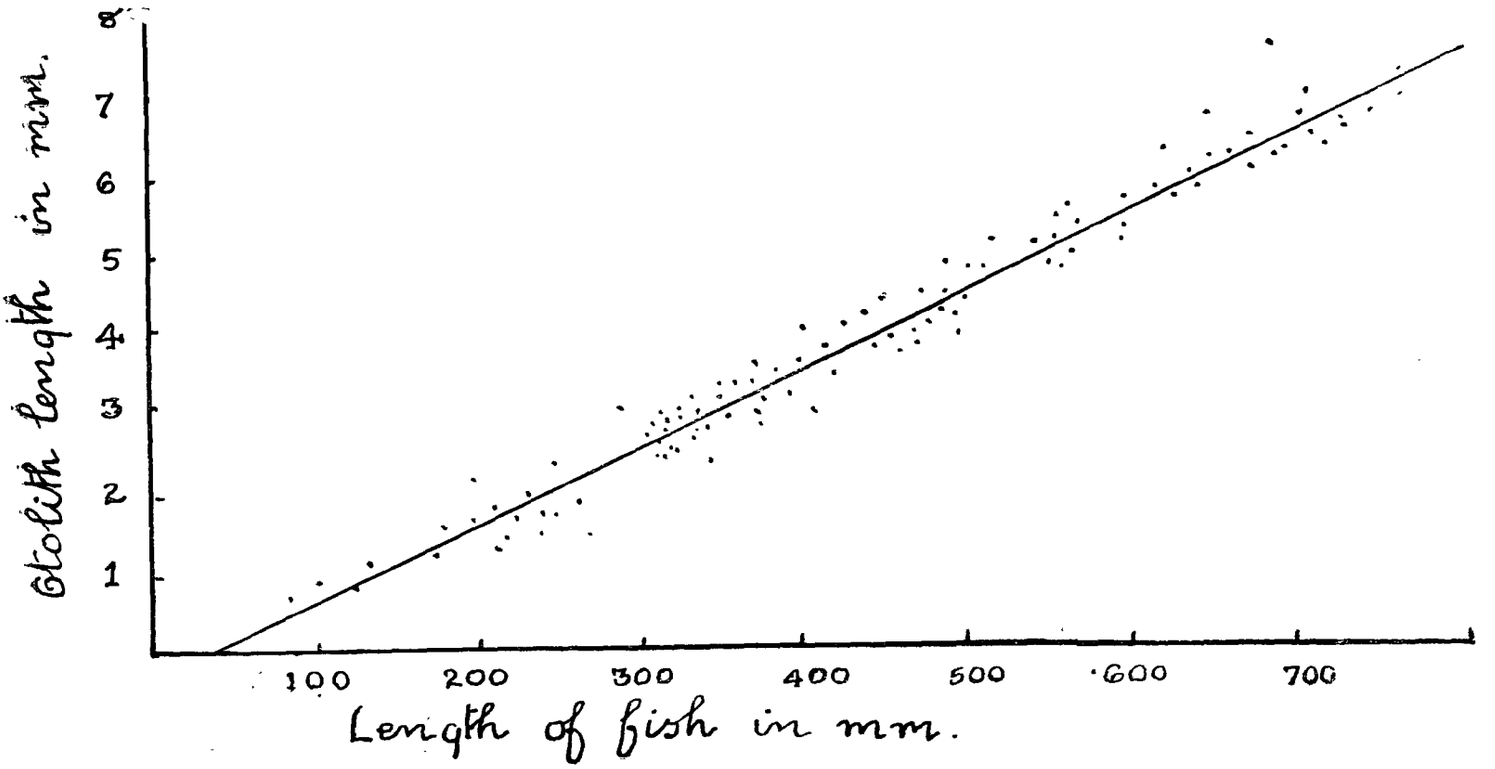


FIG. 4—*Mystus aor*—Comparison of linear relation between otolith and mean grouped length and back calculated length.

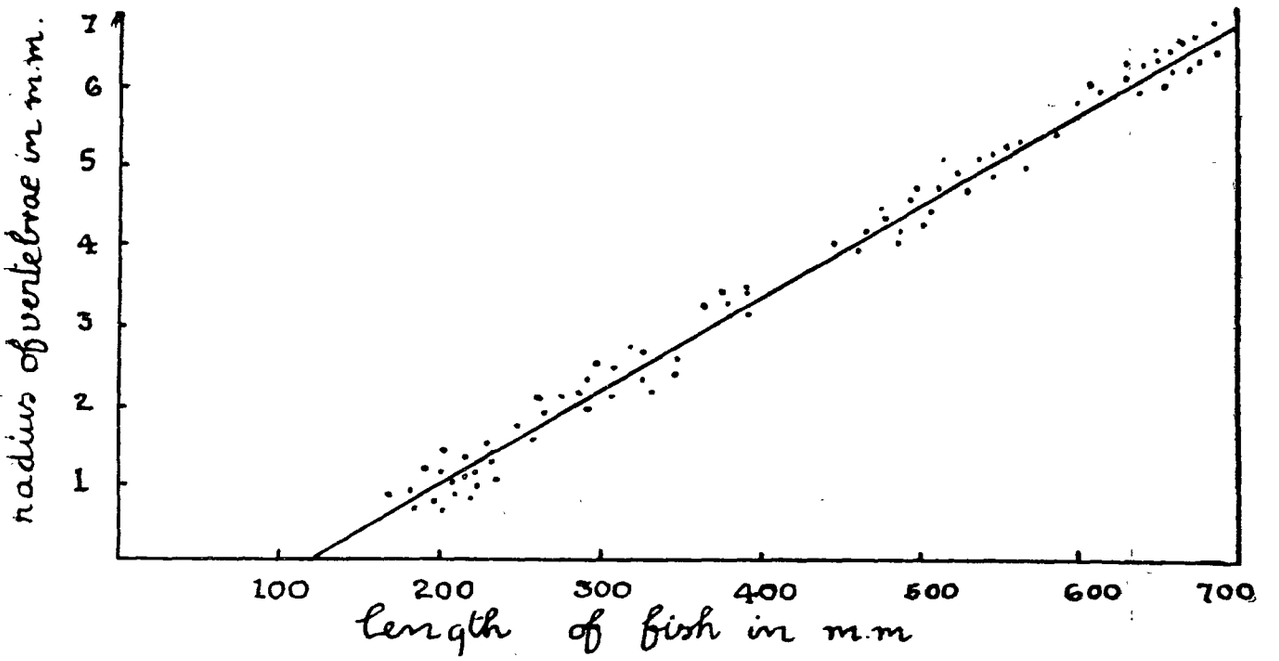


FIG. 5—*Mystus aor*—Scatter diagram showing linear relationship between the radius of vertebrae and the total length of fish.

The observed mean length of the fish in mm. and its relationship to the vertebrae rings are expressed in the table below :—

TABLE 4.

Number of rings.	*Radius of vertebrae in mm.*	*Mean length of fish.*	*Range of length of fish.*
(1)	(2)	(3)	(4)
1	1·1	231	0–250
2	1·1	231	240–330
3	2·5	345	320–380
4	4·0	502	390–520
5	5·5	621	510–630
6	6·0	667	620–690

The regression formula of the equation $y=a+bx$ where x is the radius of the vertebrae, y = length of the fish and a and b are constants, was calculated as $y=123{\cdot}5+90{\cdot}65\,x$ for these studies. The back calculated length of the fish for different year class on this fomula worked out to be I year 214·15 mm.; II year 304·8 mm.; III year 359·19 mm.; IV year 449.84 mm.; V year 567·75 mm.; and VI year 667·4 mm. The close amount of agreement in the estimation of age and length of *Mystus aor* arrived at, by the otolith and vertebral study is seen clearly in the table below and Figure 6.

TABLE 5.

Serial number.	*Mean length by histogram.*	*Mean length by otolith.*	*Mean length by vertebrae.*	*Number of rings.*	*Back calculated length.*
(1)	(2)	(3)	(4)	(5)	(6)
1	240	..	230	1	214
2	300	314	293	2	305
3	390	380	358	3	359
4	490	488	374	4	450
5	620	622	570	5	577
6	700	699	663	6	667
7	745	756	..	7	..

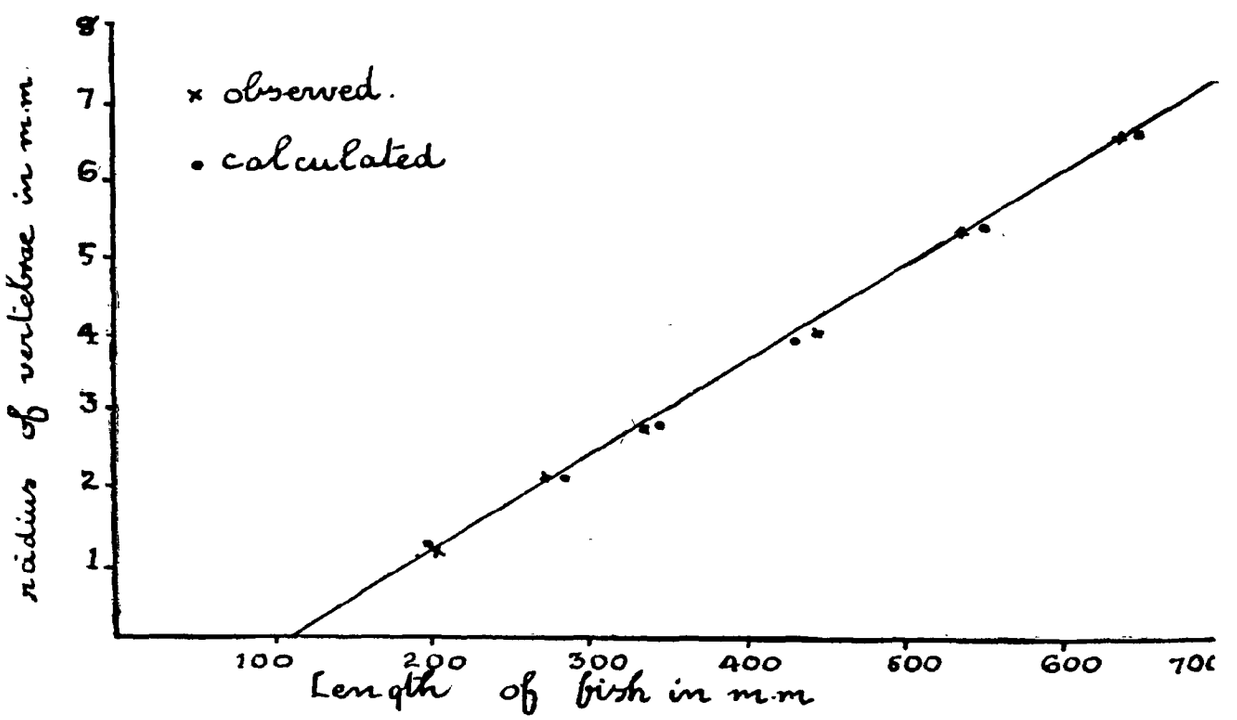


FIG. 6—*Mystus aor*—Comparison of linear relationship between vertebrae radius and back calculated lengths.

Figure 7 illustrates the age and growth of *Mystus aor* in length and its increment at the end of each year.

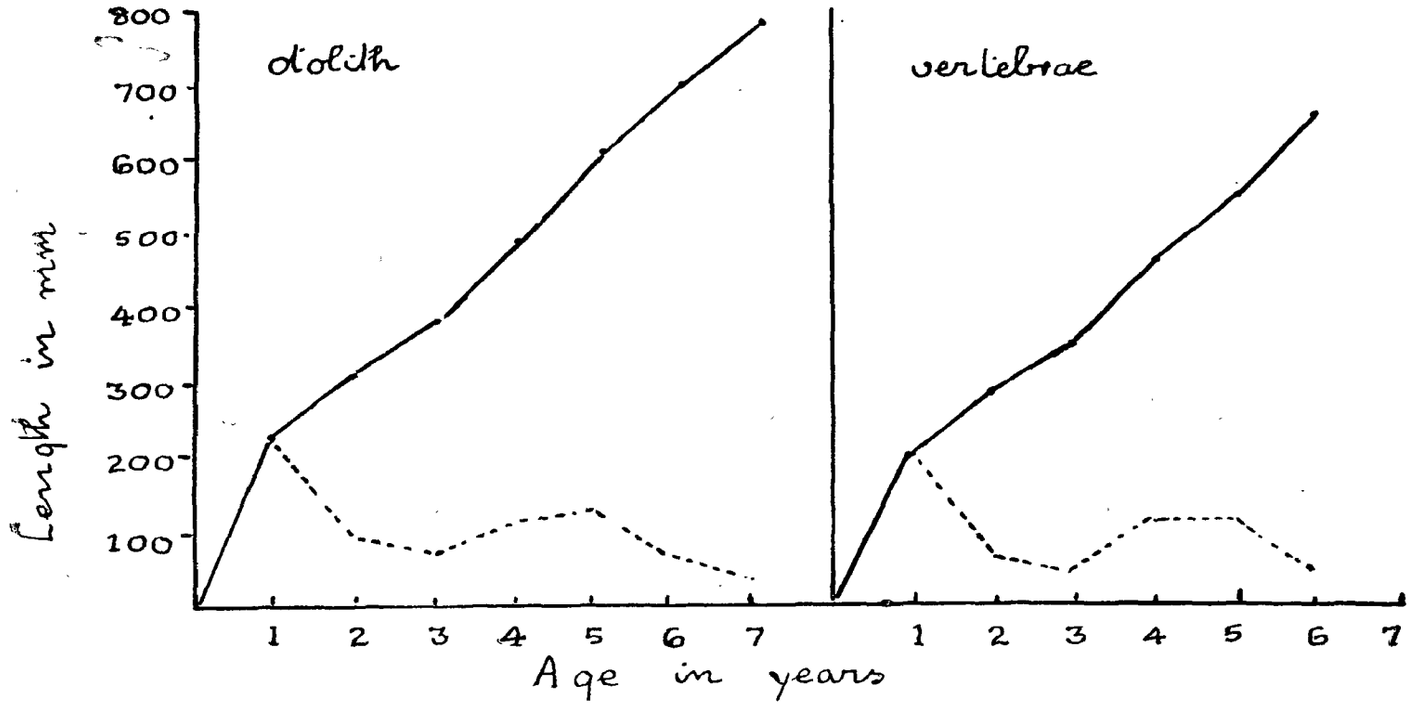


FIG. 7—*Mystus aor*—Relationship between age and growth in length.

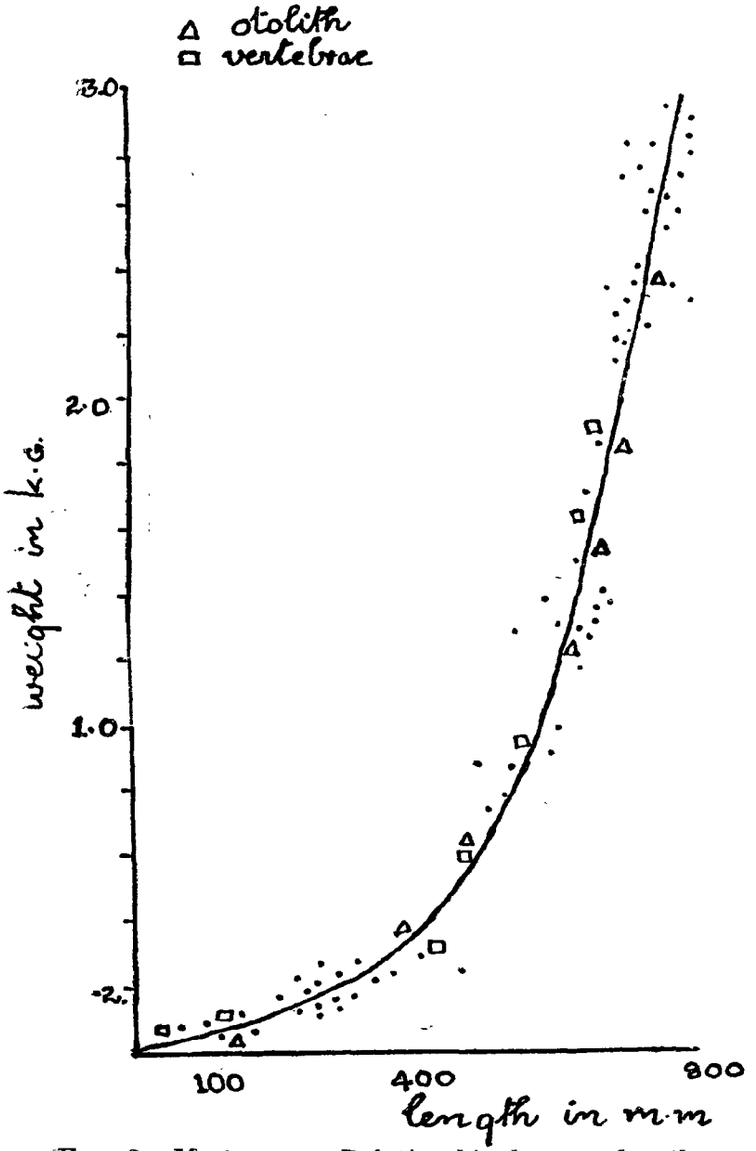


FIG. 8—*Mystus aor*—Relationship between length and weight.

It is seen that the general increase in length of the I and II year decreases in the III year and then it increases up to the fifth year. There is a gradual decrease afterwards.

LENGTH-WEIGHT RELATIONSHIP

Le Cren (1947) has reviewed in detail the methods employed in estimating the length-weight relationship of fishes with a clear exposition of the superiority of the equation $W=Cl^n$. A scatter diagram of weight on length (Figure 8) suggested that this relationship in the case of *Mystus aor* confirmed to this general formula where W=weight of the fish, L=length of the fish and 'c' and 'n' are constants.

The data gathered from the entire years landings from Bhavanisagar Reservoir of *Mystus aor* ranging from 240 to 780 mm. were divided into five groups. The average weight and length of each group was taken up for calculation. In the present work in the case of *Mystus aor* the constants worked out to be c=6·579 and n=3·492 and the logarithmic equation

$$\text{Log } w = -6{\cdot}579 + 3{\cdot}492 \text{ log } L.$$

Figure 8 is a scatter diagram of the absolute value of length and weight and Figure 9 is linear being the regression of log weight on log length.

Figure 10 exhibits the relationship between mean length of fish and mean weight.

Table 7 shows the growth in weight of *Mystus aor* at the end of each year and its increment. It shows that the growth in weight gradually increases up to the fifth year after which there is a decrease.

TABLE 7.

Number.	*Age in years.*	*Mean weight in grams.*	*Increase of weight in grams.*
1	I	100	..
2	II	213	113
3	III	329	116
4	IV	644	325
5	V	1,392	748
6	VI	2,006	614
7	VII	2,380	374

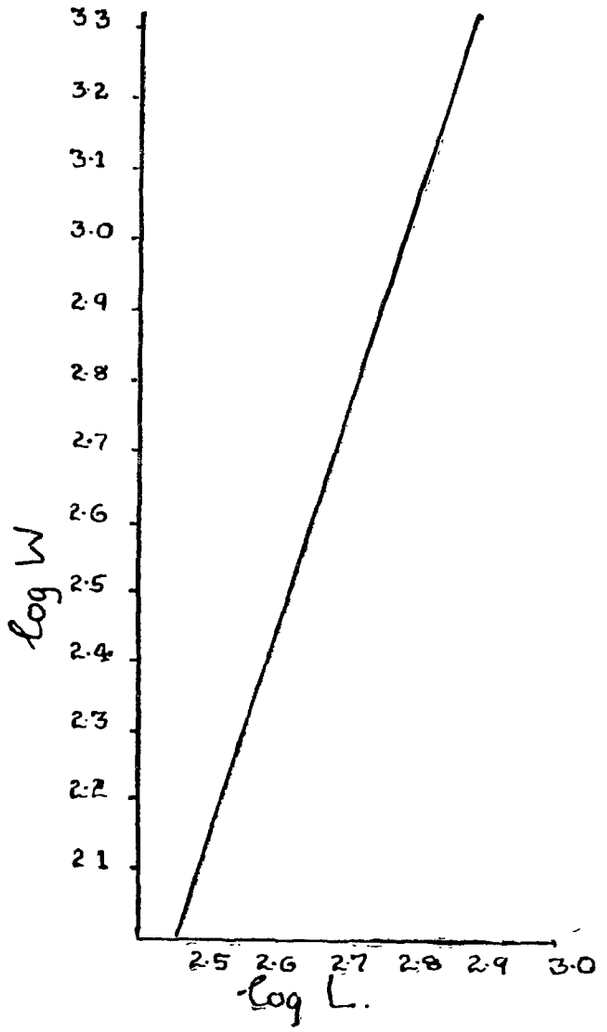


FIG. 9—*Mystus aor*—Linear straight line of log length by log weight.

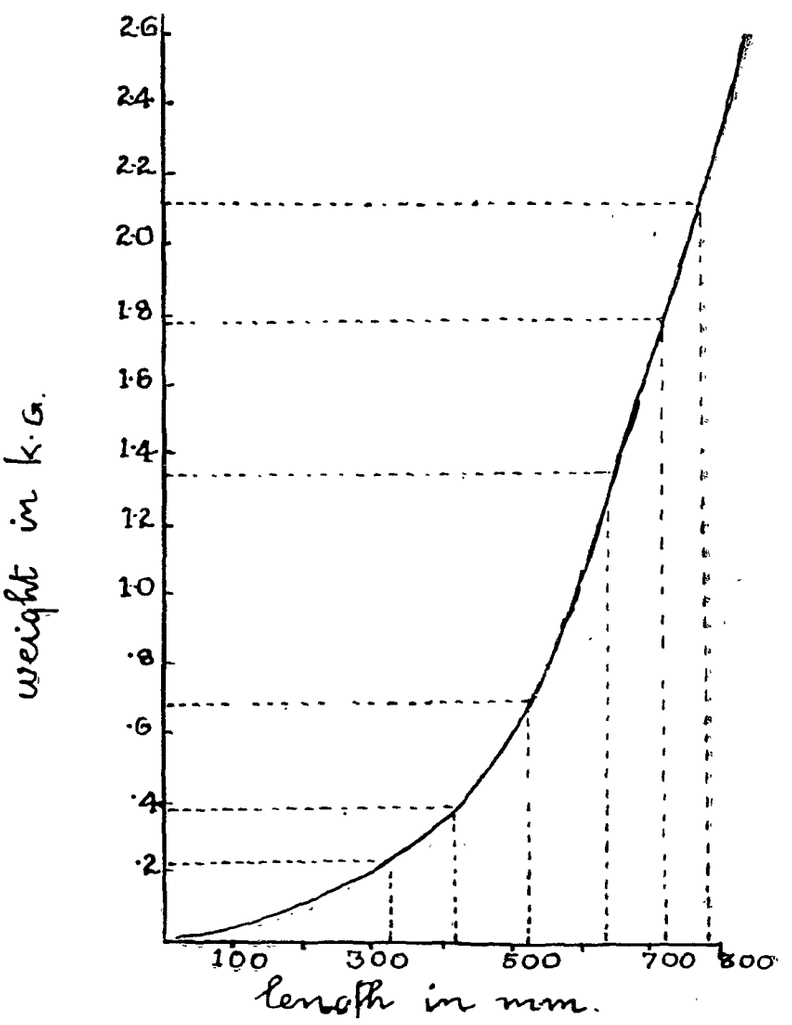


FIG. 10—*Mystus aor*—Relationship between mean length and mean weight.

RELATIVE CONDITION

A complete discussion on the relative condition with reference to season, sex and maturity will be taken up at a later stage. The general formula $K = W \times \frac{10^5}{L3}$ was applied.

Number.	*Length in mm.*	*Weight in grms.*	$K = W \times \frac{10^5}{L3}$
1	314	213	0·6882
2	380	329	0·995
3	488	644	0·5543
4	622	1,392	0-5784
5	699	2,006	0·5872
6	756	2,382	0·5509

In this initial study there was no marked difference between the female and male Kn factor. The relative condition is below 1 in all the fishes. This is naturally to be expected because of the linear shape. It shows that the relative condition decreases up to fourth year and onwards there is an increase. It is yet to be confirmed whether this inflection in the IV year is an indication of attainment of sexual maturity.

MATURATION—FECUNDITY AND SPAWNING

The sexes are separate. There is no special mention of the morphological characters distinguishing the male and female either by Sundar Raj (1962) or Saigal and Motwani Satyanesan's (1962) account of the presence of papilla in the males of *Mystus aor* does not carry conviction of a clear differenciation. Pantulu (1961) sexes out male *Mystus gulio* by the well defined protruberance with a free tapering end and the females by the separate urinogenital opening. Tom Moen (1949) has successfully sexed the channel cat fish *Ictalurus punctatus* (Rafinesque) with the aid of a probe, where in the female cat fish, the urinary and genital ducts have separate external openings while in males these ducts have only one opening. The use of a probe to separate sexes in *both Mystus aor* and *Mystus seenghala* especially during the breeding months was successful. In addition all the male specimens examined had a pair of flap (Fig. 1) like structure behind the anal orifice. Each flap was 2 to 2·2 mm. by 4 to 4·5 mm. depending on the size and age of the adult. In the commercial catches of Bhavanisagar fishes above 350 mm. in male and 450 mm. in females above were mature. The II stage is reached in the female by November and by January to February they reach IV stage. As maturity advances the yellow fat reserves in the coelom get absorbed. By February the mature females and males start on upward migration towards the top waters of Moyar in Bhavanisagar and Pannavadi in Mettur. The confluence between the riverine and the lacustrine area is now full of migrating breeders.

Compared to carps the fecundity of the fish is poor and evidently so because of the highly evolved parental care.

The following are the estimated number of ovarian eggs from 10 different females of *Mystus aor* in March 1962 :—

Serial number.	*Total length.*	*Total weight.*	*Weight of gonad.*	*Volume of gonad.*	*Estimated eggs.*
(1)	(2)	(3)	(4)	(5)	(6)
				(*in c.c.*)	
1	775	2,800	17·5	17·5	26,250
2	785	2,900	19·2	18·5	27,840
3	770	3,100	25·0	21·1	34,380
4	770	2,925	25·0	22·2	33,100
5	750	2,725	20·0	18·4	22,000
6	773	3,275	28·0	24·0	38,400
7	780	3,200	22·5	19·0	23,480
8	680	2,267	16·8	17·0	26,420
9	640	2,040	17·0	17·2	28,240
10	620	1,584	16·6	17·3	21,490

The ripe ova are orange yellow in colour. The diameter of the unfertilized egg varies from 1·76 m.m. to 2·1 m.m.

Sundar Raj (1962) and Saigal and Motwani (1962) have discussed in length the breeding habits of the fish under riverine conditions. According to both the breeding seasons extend from April to August. The breeding seasons in Bhavanisagar is from end of February to April-May, before the onset of the south-west floods. Under lacustrine conditions the fishes after attaining gonadial maturity start on a short upward migration towards the top waters. It is at once apparent that the presence of a fall sharply dividing the lacustrine area from the riverine area will be a barrier and will adversely affect the re-population trend. The favourite spawning grounds in Bhavanisagar is the Moyar side for a distance of 3 to 4 furlongs from the commencement of the reservoir area where a gentle and slow riverine flow is felt.

The area consists of exposed mud flats all around and the sluggish muddy river in the centre, with a gentle flow of 300 to 400 cusecs. After a short play the nests are constructed, they, being saucer shaped pits ranging in size from 38 cm. to 60 cm. and with the central pit 18 cm. by 10 to 12 cm. wide. In spite of the heavy silt around, the nests are clear and on running the hand over, the surface is felt as though of fine mud plastered. The nests are usually constructed overhanging cliff, or tree stump or a stone or decaying tree trunk and are in waist to chest deep water. The 600 to 700 metre length of spawning ground is actually littered with a number of these nests and it will be impossible to cross the river in this stretch without stampeding the nests.

The following data furnished by the Assistant Director of Fisheries (Hydrology) gives an indication of the physico-chemical features :—

Date of collection.	18th March 1961.	8th April 1961.	12th February 1962.	12th March 1962.	30th April. 1963.
Time	9·00	9·30	90·0	9·00	9·35
Temp. °C.	26·2	25·2	27·0	26·2	26·1
Colour	C'less.	C'less.	C'less.	C'less.	C'less.
Odour	No.	No.	No.	No.	No
Turbidity	30	30	30	30	30
Weather ..	Bright sunshine and cool breeze.				
Free Co_2	Nil.	Nil.	Nil.	Nil.	Nil.
Carbonate	3·0	3·0	3·0	3·0	1·5
Bicarbonate ..	4·7	5·1	92·4	51·8	51·8
p^H	8·1	8·1	8·3	7·7	7·4
Dissolved oxygen Mg/1.	62	7·0	7·4	6·3	6·0
Saturation (per cent).	71·94	80·09	..	..	73·03
Po_4	Nil.	Nil.	Nil.	Nil.	Nil.
Silicate	2·0	2·5	7·6	4·4	2·0
Nitrate	Nil.	Nil.	Nil.	Nil.	Nil.
Chloride	9·0	9·0	12·0	27·0	8·

In spite of the flowing condition the quantity of dissolved oxygen is little compared to the usual record in the spawning grounds of major carps in tropical waters. All stages in the development of the fish have been collected from these nests including the early fertilised eggs, not reported to have been come across by Sundar Raj (1962) in the Bhavani river. As observed by all previous workers the male guards the brood. The females, after the play, are lethargic and are caught on their return migration by hand or in the Rangoon nets in the lacustrine area. The female post-spawners are easily identified by the red surface as a result of the play in the shallow areas and can be distinguished by the absence of the milky secretion of the males. Male specimens from the nest have been collected at various stages. As the time of care increases the inflammation of the ventral surface and the milky secretion are more prominent. The stage of embryo in the brood can be judged with some practice on an examination of the ventral surface of the guarding males. The males even when scared or when disturbed from the nest have a tendency to return to the nests to continue the watch. The brood is guarded for nearly 35 to 45 days when the juveniles reach 4·5 to 6 cms. Till that stage the juveniles move inside the pit in one group browsing the milky secretions of the ventral surface of the male. The presence of the brood from the hatchling stage in the pit can be felt when they come to browse our finger tips when inserted inside these nests, an observation recorded earlier. The young ones 4 cm. old when examined for stomach contents had copepods and a few phytoplankton.

There is no justification in the inference of Sundar Raj (1962) that the fertilised eggs are housed in the papilla like process as in the case of *M. gulio*. Early fertilised eggs from cleavage stage have been seen in the nests. One nest examined on 20th March 1963 had 12,462 fertilised eggs. As many as 4,700, 8 mm. stage hatchlings and 4,268, 2·8 cm. fry have been collected from each individual nest. The developmental stages of *Mystus aor* confirm to the description given by Saigal and Motwani (1962). The fertilised egg is 2·1 to 2·2 mm. in diameter, the zona radiata is adhesive and the perivitilline space occupies little space. The newly liberated hatchling is 4·2 to 4·5 mm. When they reach 8·00 to 8·5 mm. stage the yolk gets absorbed with a clear oral opening. One remarkable feature likely overlooked by previous workers is the presence of a four-lobed cluster of external gills projecting out from the last gill arch, one on each side (Figure 11). The circulation of the blood in the external gills is clear under the microscope. It has earlier been recorded that oxygen saturation is low, and with the silt laden water, these accessory external gills seem to be an adaptation. The development of external gills in fish embryos have been recorded in all elasmobranchs, Polypterous and Amia (1957) and by Bhimachar (1957) in *Lepidocephalichthys thermalis*.

Figures 12 and 13 are illustations of the hatchling and fry of *Mystus aor* collected from the nests in the spawning ground of Bhavanisagar.

Discussion.

1. *Mystus aor* and *Mystus seenghala* are fishes of considerable commercial value. The biology of this fishery in artificial impoundments of rivers where they existed before as in Bhavanisagar and Mettur Dam is discussed in full.

2. The lacustrine condition is ideal for growth. They feed on copepods, rotifers, small fishes, insects, chironomids and fresh water oligochaetes.

3. Otolith and vertebrae are very useful indicators for assessing the age of this fish which is an annual breeder. The readings of the polymodel curve obtained by histogram studies of length frequency from the departmental catches were found to agree with the mean length obtained by vertebral and otolith age grouping. The range in length reached by the fish in the first year is 240 mm., second year 260–330, third year 340–400, fourth year 400–530, fifth year 520–630, sixth year 620–700 and seventh year 710–770 mm.

4. The mean weight reached by the fish each year is 100, 213, 229, 644, 1,392, 2,006 and 2,380 grams respectively. There is a gradual rate of increase in length in the first and second years, decrease in third year and then there is an increase up to fifth year after which there is a decrease. As regards weight there is an increase up to fifth year after which there is a decrease.

5. The relative condition is round about ·55 to ·68. The Kn factor decreases up to fourth year and onwards there is an increase.

6. The fishes are best caught in Rangoon net of mesh 4 to 4·5 cm. and also by Uduvalais. The catches are heavy during the pre-spawning season when they migrate upwards the top waters and post-spawning season in March, April when they start heavy feeding.

7. The breeding season is from February when they start upward migration and the nests are laid in the area just above the lacustrine area where the silt laden river flows lazily. The spawners are lethargic and this congregating stretch is the scene of heavy poaching. A conservation programme of patrolling this area from fishing and even from disturbance is necessary.

8. The record of landings at Bhavanisagar shows there is no adverse effect on the carps. *Mystus aor* will be a successful and repopulating fishery only in impoundments where there are no barriers, and at all fluctutations of level provided the river and lacustrine portion is continuous. The reason for the success of the fishery in Bhavanisagar, is due to the Moyar ideally suited for migration and construction of nest. In Mettur Dam, however, in normal years of level there are no chances of the pits being constructed up to Pannavadi at full reservoir level and the chances of nest when the reservior level is 45′ to 60′ during March to April is limited. There is absolutely no chance of *Mystus aor* breeders tackling the Hogainakal falls in the summer when the falls is high. The fish is recommended for stocking based on Bhavanisagar reservior studies for systems like Vaigai where during March to May, the river and the lacustrine conditions are continuous.

9. The presence of external gills in the hatchling of 8 to 9 mm. is a case of adaptation noted for the first time in this genus.

Acknowledgment.

The authors wish to express their thanks to late Sri Raghbir Singh, I.A.S., Director of Fisheries, for assistance

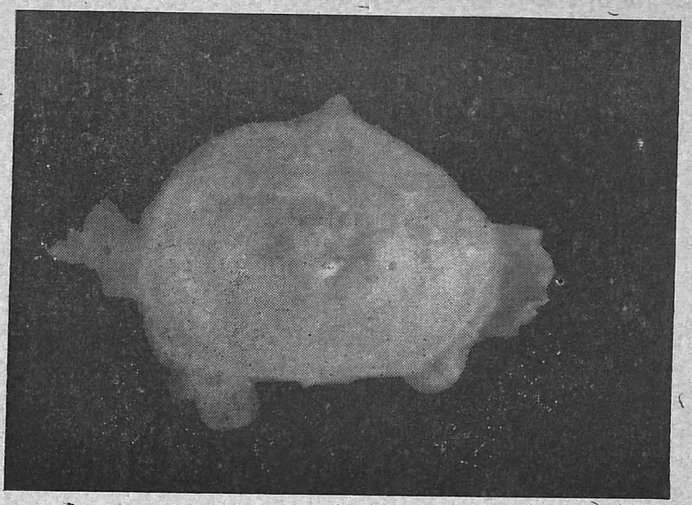


PHOTO 1.
VERTEBRA SECTION OF MYSTUS AOR SHOWIN ; TWO AGE RINGS.

PHOTO 2.
VERTEBRA SECTION OF MYSTUS AOR SHOWING THREE AGE RINGS.

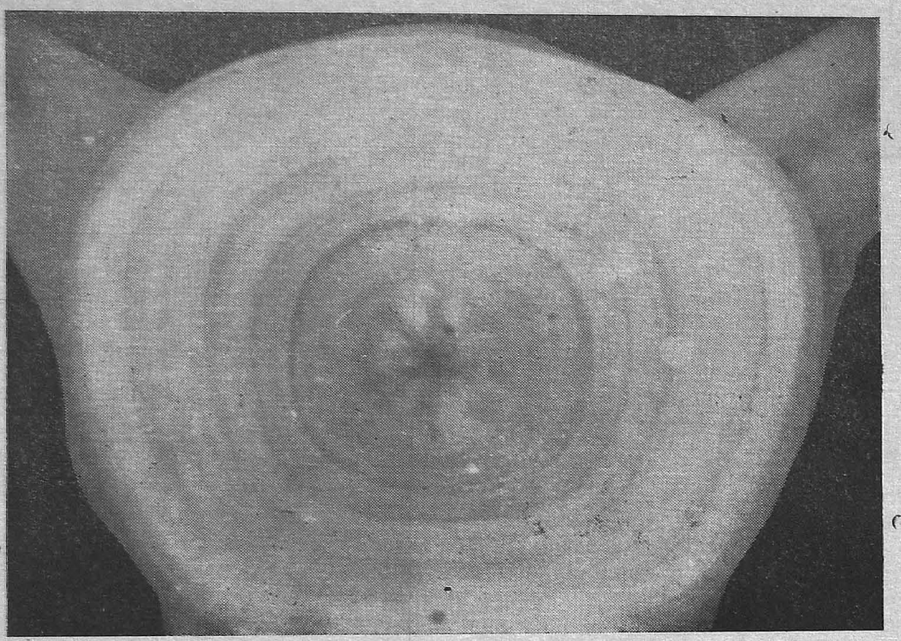


PHOTO 3.
VERTEBRA SECTION OF MYSTUS AOR SHOWING SIX AGE RINGS.

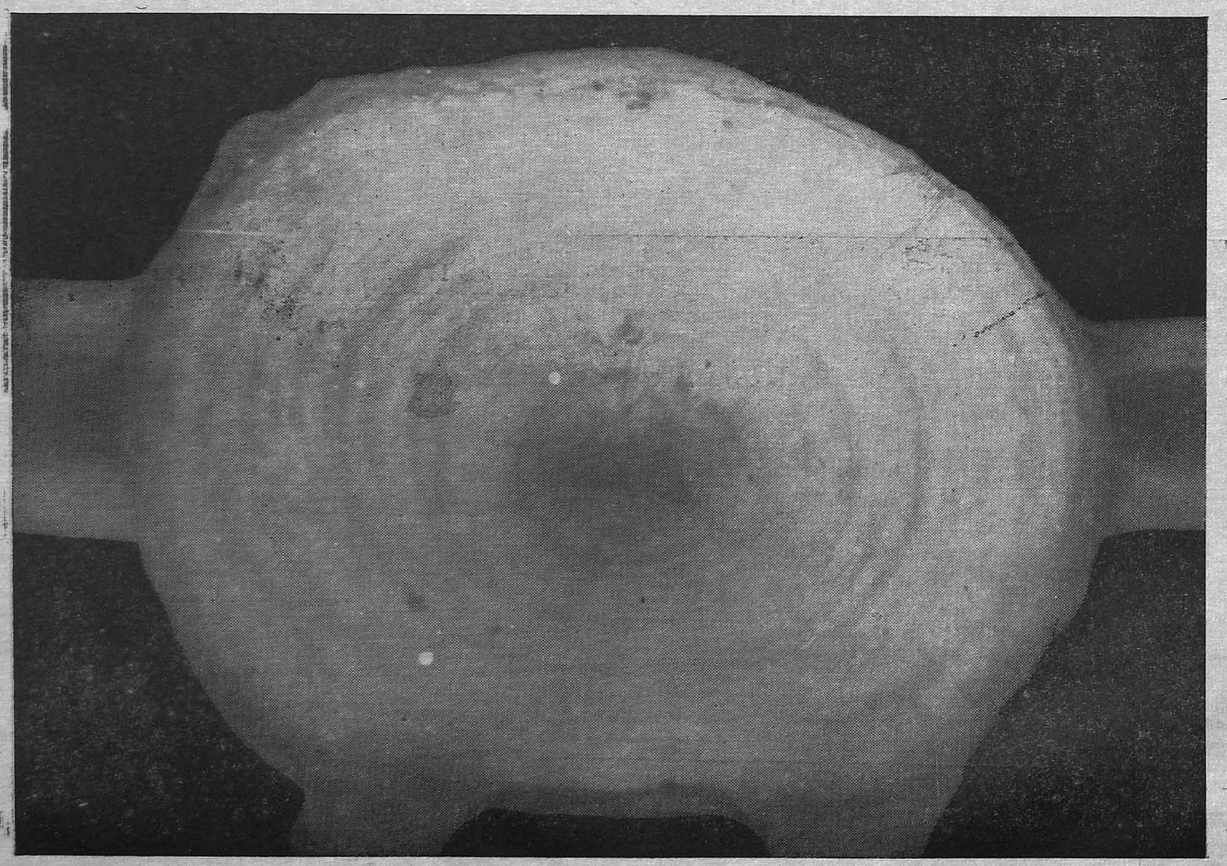


PHOTO 4.
VERTEBRA SECTION OF MYSTUS AOR SHOWING SEVEN AGE RINGS.

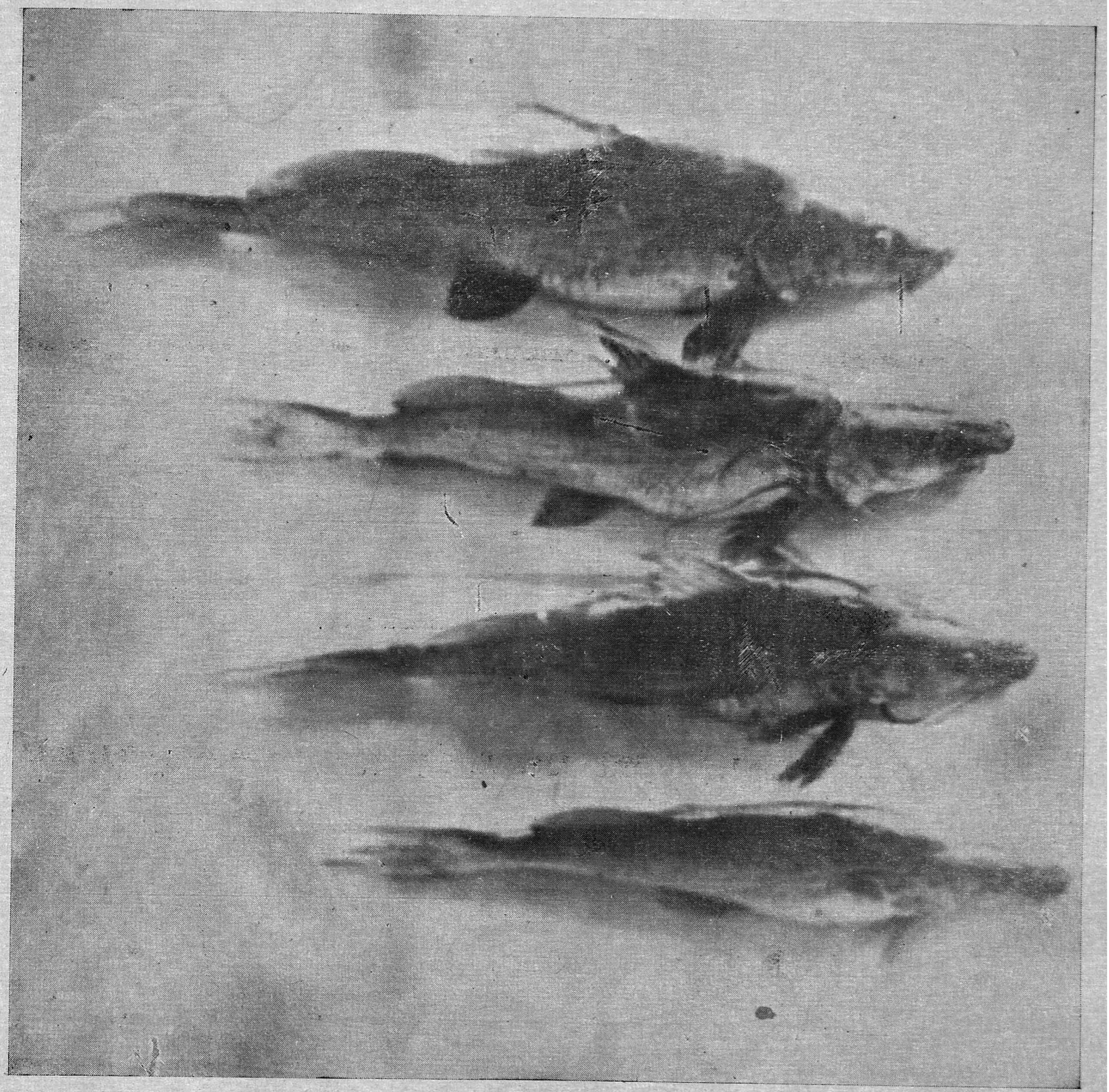
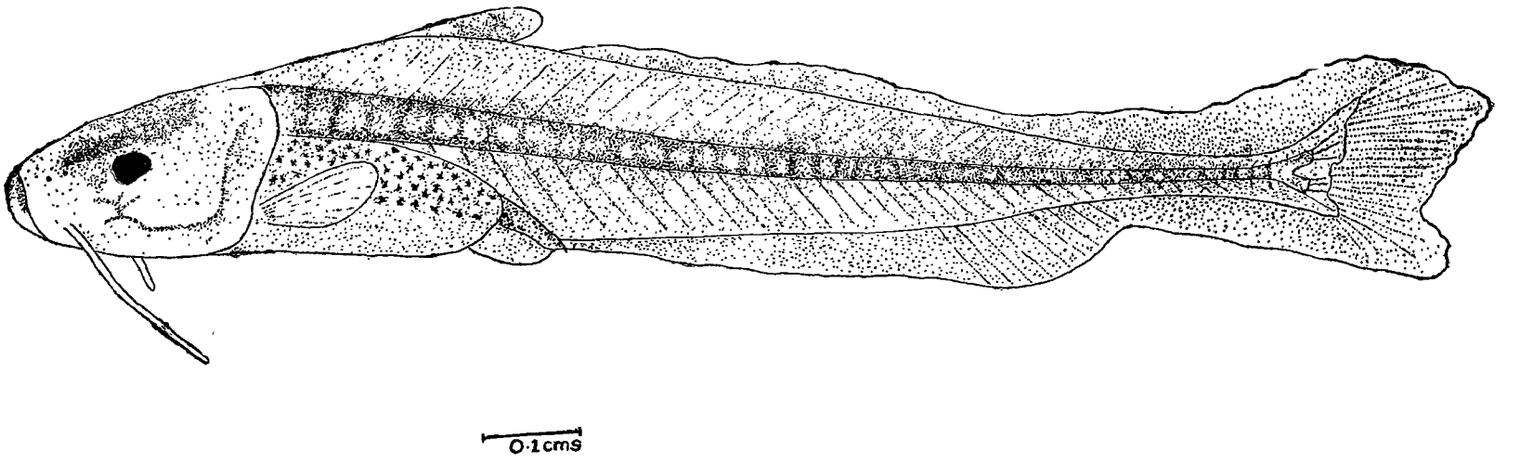


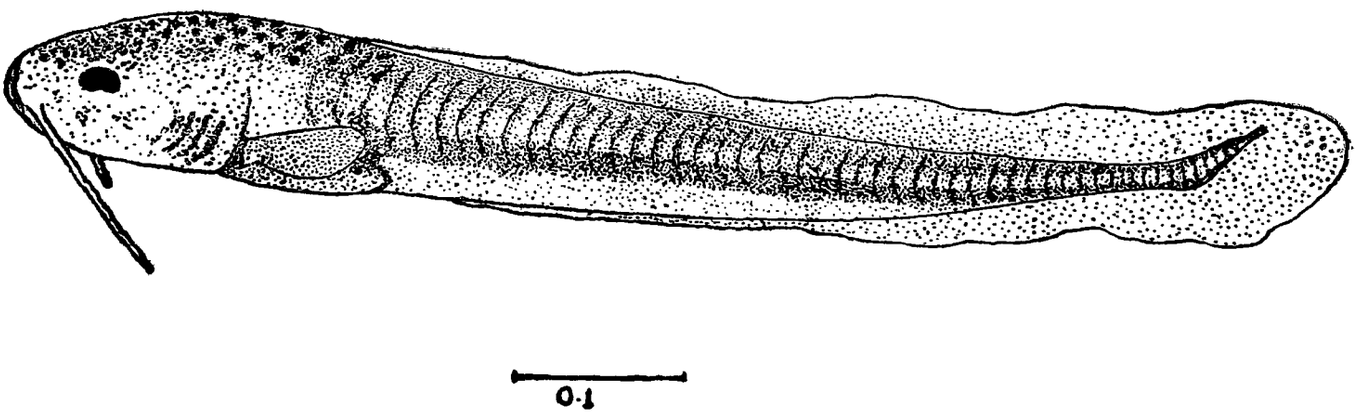
PHOTO 5.
DIFFERENT AGE GROUPS OF MYSTUS AOR CAUGHT IN THE RANGOON NETS IN BHAVANISAGAR RESERVOIR.

Fig. 13



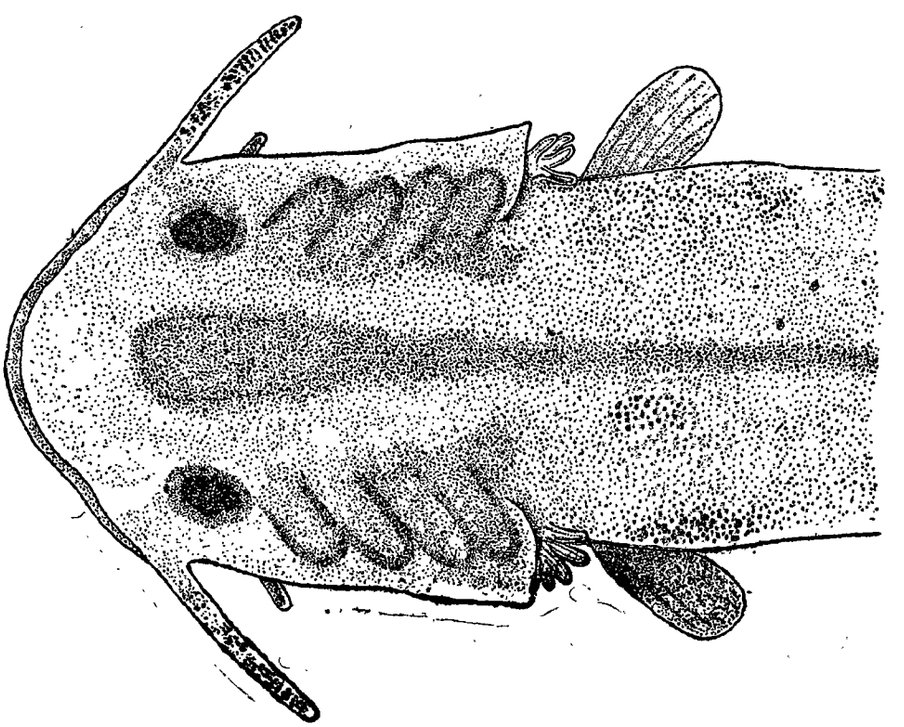
MYSTUS AOR FRY 1·4 cms. LONG.

Fig. 12



MYSTUS AOR HATCHLING 0.8 cms. LONG.

Fig. 11



HEAD REGION OF MYSTUS AOR SHOWING EXTERNAL GILLS.

rendered during the work, to Sri N. V. Choodamani and P. I. Chacko, Deputy Directors of Fisheries, for suggestions during the course of the work and Sri A. Srinivasan, Assistant Director of Fisheries (Hydrology) for the hydrological data of the spawning bed and Sri E. R. Venkatasamy, Inspector of Fisheries, for diving and collecting the spawn of cat-fish in the Moyar side.

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ON THE OCCURRENCE OF A NEW SPECIES OF ICHTHYOPHTHIRIUS (CILIATA) IN THE FRY STAGE MURREL, OPHIOCEPHALUS MARULIUS (HAM)

BY

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While studying the large scale mortality of the "red stage" murrel fry, white spots of varying sizes were observed on the skin and fins of all the fish reared in cement cisterns. The spots were identified as tiny eruptions enclosing an enchelid (order Holotricha) ciliate parasite of the genus *Ichthyophthirius sp. Nov.* (Figs. 3A and B).

Ichthyophthirius multifilis Fouquet, the only species known up till now according to Buschkiel (reported by M. Sachlan, 1952), was discovered in Europe in 1869 [M. Sachlan (1952)]. Dr. A. L. Buschkiel, a Dutch Hydrobiologist, after a thorough study on *Ichthyophthirius*, both in Europe and East Indies, mentions an epidemic in fish ponds in the isle of Java, causing extensive losses [Van Duijn Jnr. (1956)]. The first report of this disease in India is by Y. R. Tripathi in 1955 on the young *Xhiphophorus hellerii*.

In *Ichthyophthirius multifilis Fouquet* the specific name 'multifilis' indicates its *prolificness* due to multiple fission forming 500 to 1,200 individuals within a cyst. [Sachlan (1952)]. Observations by the authors, on hundreds of this ciliate now described, during day and night, revealed that they divided only by simple direct fission. No cyst was formed. On account of this reproductive behaviour and the lateral position of the cytostome, not terminal, as in *Ichthyophthirius multifilis Fouquet*, it is felt, that it well deserves a distinct specific status.

MORPHOLOGY AND BIOLOGY

The tiny eruptions enclosing the parasites are made of one or more layers of the host epithelium augmented by the epidermis due to the irritation caused by the parasite. These eruptions are 0·3 to 0·7 mm. in diameter while the parasites al ne vary from 0·25 to 0·5 mm. in diameter. In some cases two lesions were found fused to form one. The smallest of the eruptions just protruding out of the cutis are 0·1 mm. in diameter. Compared to other areas, those on the eye are very big 1·25 to 2 mm. in diameter, the morbid growth of the epithelial wall itself measuring 0·50 to 0·75 mm. But for the extreme morbid growth in the eye region, parasites of sizes 1·0 mm. [Van Duijn Jnr. 1956] and 2·5 mm. diameter [M. Sachlan, 1952] did not occur.

The mature parasite just emerging out of the host is nearly spherical, but it changes its shape (amoeboid) to a great extent especially in an unsuitable medium (e.g.) a 2 ppm. solution of methylene blue. It becomes slightly elongated when it gets anchored to a substratum.

The body is covered with cilia of uniform size (Fig. 1). The metachronous beat of the cilia presents a picture of a wave passing along the margin successively. While in the host inside the lesion, it performs lively rotating movement

but for which one would be led to presume that the lesion is a cyst formed by the parasite. The mature parasite while free in water progresses by successive rotating movement. Sometimes instantaneous alteration of form is brought about by the rapid contraction of the myonemes.

The circular mouth is lateral in position almost in between the anterior and posterior ends of the cell, thus differing from *Ichthyophthirius multifilis Fouquet* where the position is terminal. The cytopharynx is recognized by the presence of elongated rods. Dark bodies are seen in the cell which are probably the ingested cells of host.

The adult is mononucleate possessing only a horse-shoe shaped macronucules, a feature common to the genus. During division the micronucleus makes its appearance as a brown spot on the macronucleus somewhat excentric in position.

Multiplication is by simple direct fission (Fig. 2A). Van Duijn Jnr. (1956) reports that simple division occurs in *Ichthyophthirius multifilis Fouquet* only when the oxygen content of the medium is remarkably reduced. However mention is not made of the concentration of oxygen at which simple direct fission is resorted to. Oxygen content during the present study never went down below 6·0 mg/L. Nevertheless in no case cyst formation occurred.

The maicronucleus divides first and the two halves become spherical. The micronucleii are discerned as brown spots on the macronucleii. During the process a darkly pigmented granular zone develops around the nucleii (Fig. 2C). Each cytoplasmic half twists over the other in opposite directions along the plane of division which deepens the constriction of the cuticle. In the last phase only a narrow bridge exists in between, which extends to more than 400 microns because of the pull exerted by the dividing halves from the opposite directions (Fig. 2B). In some cases, instead of this twisting and pulling, only the cilia of the two halves beat in opposite directions right from the plane of division which seems to exert the necessary force required for constricting the cuticle. This process lasts for more than thirty minutes. The optimum temperature for division is 74° F. which prevailed in the nights during the study and the range is 72 to 78°F. The ultimate number of individuals formed is not more than eight. During the first one or two divisions equal halves are formed and later on slightly unequal halves are produced.

These individuals are then after a host, and have been found to attach themselves to debris coming on the way. In aquarium jars the young parasites have been found to anchor themselves to the fins of the young fish when they remain static. Quite often the fish is found to react to this infection by flapping the particular portion uneasily as if disturbed. When it succeeds to attach itself, aided by the host slime, it bores its way into the skin where it is said to feed on the dead epithelial cells [Van Duijn Jnr. (1956)].

When it grows in size the tiny bladder enclosing the parasite erupts out as a white spot on the surface of the skin. On 24th December 1963 a murrel fry having six white spots was kept in a 4 ppm. methylene blue solution to avoid reinfection. On 26th December 1963, the fish had thirty-three spots and the number did not increase since then. It appears therefore after three or four days the fish contracted the infection, almost all lesions erupt out. The exact time between the appearance of the spots and the leaving of the parasite is not constant. On 26th December 1963, a lesion appeared on the right eye of a fry which already had thirty-two eruptions. On 28th December 1963, the parasite from the eye had left the host but others remained. On 23rd December 1963, a fry of 45 mm. size had only one spot on the dorsal aspect of the head. On 27th December 1963, besides the spot on the head, two on the left flank of the body, two on the right pectoral fin and one on the left pectoral fin were found. On 28th December 1963 all have left but one newly appeared at the junction of the dorsal fin with the body. So it is found that most of the parasites leave after 3 to 7 days of the appearance of the spots when the temperature is between 72° F to 78° F. But they may take longer time to leave when conditions are unfavourable.

COMBINED INFECTION WITH GYRODACTYLUS

All the fish of size 25 mm. and below already infected with *Ichthyophthirius*, contracted a secondary infection with *Gyrodactylus*. They were found swarming in large numbers *all over the body* more specially on the fins. According to M. Sachlan such a multiple infection of *Ichthyophthirius* together with *skin flukes* is common in Europe but seldom found in Indonesia.

SYMPTOMS OF INFECTION

Advanced infection brings about loss of equilibrium and exophthalmia ; the fish lies on its side or back and performs unhealthy movement. It whirls around aimlessly when disturbed and prefers taking shelter among weeds. The pectoral and dorsal fins droop down. The respiratory movement of the operculum is reduced to about half that of a healthy fish of the same size. The movement fluctuates from 57 to 68 times per minute whereas that of an uninfected fish is 115 times per minute. Quite frequently the fish rises to the top and gulps air, sometimes twists within five minutes and occasionally a gas bubble is sent out through the mouth. The fins and body shiver violently while dying.

TREATMENT

Van Duijn Jnr. (1956) and H.S. Davis (1946) are of opinion that since this parasite is surrounded by the living host tissue where it cannot be penetrated by chemicals it is very difficult to combat the infection ; but however the knowledge of its life-cycle has been useful to evolve measures to destroy the parasites leaving the host for multiplication. Van Duijn Jnr. who has tried quinine salts, mepacrine ydrochloride, mercurochrome and medical quality methylene blue, claims that methylene blue is the most effective in killing the parasite free in water. He used methylene blue as a permanent bath of 1 : 500,000 and at temperature between 70°F to 80°F found the disease disappearing in five days. Experiments conducted in enamel bowls on infected fish with methylene blue and observations on the behaviour of the parasite to a drop of methylene bluein microscopic slides confirm Van Duijn's

claim. However, experiments conducted in open cement cisterns did not give favourable results with methylene blue.

Methylene blue.—Ichthyophthirius reacted to methylene blue of 2 ppm. concentraction by altering its shape frequently by the formation of amoeboid processes. Sometimes into a small bud of about one-eighth the size of the body the rest of the cytoplasm streamed in. This process was followed by an elongation of the body and fast aimless movement different from the slow circular movement of the mature parasite free in water. Occasionally from one end of the elongated cell a spherical bud was put forth which pinched off while the mother half rotated vigorously around its own axis (Fig. 4A). According to Van Duijn Jnr. (1956) budding is a means to get rid of the portions penetrated by methylene blue. At last the cuticle ruptured and the cytoplasm exuded out (Fig. 4B). The macronucleus either disintegrated or elongated much while the ends broke off.

An infected young murrel of 45 mm. size having six white spots was introduced on 24th December 1963 in an enamel bowl containing 4 ppm. methylene blue solution. On 26th December 1963, thirty-three white spots were counted and on 27th December 1963 only fourteen spots remained. No reinfection was noted.

TABLE I.

Showing percentage of mortality during Methylene blue treatment in three cement cisterns.

Date.	Stock.			Number died.			Percentage of mortality.			Food.		
	Cistern 1.	Cistern 2.	Cistern 3.	C1.	C2.	C3.	C1.	C2.	C3.	C1.	C2.	C3.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
17th January 1964 ..	250	250	250	16	23	43	6·4	9·2	17·2	Fish pellets.	100 numbers of 11 mm. size Tilapia, 200 numbers of 21 mm. size Tilapia, 200 numbers of 28 mm. size Chela.	Plankton rich in copepods.
18th January 1964 ..	234	227	207	25	36	39	10·1	16	18·8	Do.	Nothing was added afresh.	Do.
No feeding was done on 19th January 1964.												
20th January 1964 ..	209	181	168	120	115	97	57·4	63·5	58	Do.	50 numbers of 11 mm. size Tilapia.	Do.
21st January 1964 ..	89	66	71	13	19	15	14·6	28·7	21	Do.	Nothing was added afresh.	Do.
22nd January 1964 ..	76	47	56	9	15	25	11·8	31·9	41	Do.	Do.	Do.
Total mortality for 250		183	213	219.								
Percentage of mortality for 250.						73·2	85·2	87·6.				

However, Table 1 shows that methylene blue of 4 ppm. loses its effect when treated in open cement cisterns (4′ × 3′ × 2′) and the young fish succumbed in large numbers. Following the second day of administration the colour of methylene blue began to fade. Van Duijn Jnr. (1956) opines that methylene blue may lose its quality by oxidation and by absorption by decaying organic matter. The high mortality which occurred in the three cisterns may be explained by one or other of these factors. All three cisterns were planted with *Elodea* and *Hydrilla* for shade, the dead leaves of which might have added to the putrifying organic matter. In cistern two and three, the presence of excreta of the forage and the dead plankton respectively might have been responsible.

HOMOTROPINE HYDROBROMIDE AND COPPER SULPHATE.

H. S. Davis (1946) reports that according to Ellis (1937) salts of heavy metals like copper combine with the mucous of the skin and gills forming an insoluble compound which brings about asphyxiation. It was observed in the present study that the transparent mucous became white in contact with copper sulphate. H. S. Davis (1946) used sodium chloride to remove the slime before treatment with copper sulphate. We have tried homotropine hydrobromide in different concentrations for varying periods and found that, besides being not toxic for a day or two up to 50 ppm. concentration, the slimy mucous from the skin of the fish was completely removed within 6 to 10 hours. After this preliminary treatment the infected fish were transferred to a 1 to 2,000 solution of copper sulphate. It is found that the time that could be allowed for a fish of 24 mm. size and below in copper sulphate without injurious effect is only 90 seconds and that for 45 mm. size and below 180 seconds. By the removal of the slime all the spots were exposed to the direct action of copper sulphate ; the eruptions were found ruptured and the parasites killed ; whereas methylene blue killed the parasite by disintegrating the cell, copper sulphate killed by fixing it. After this treatment the fish were kept in running or oxygenated water.

When the fish were kept for 5 to 6 minutes in copper sulphate solution they suffered mortality at a high rate. Four hundred fry stage murrels of 25 mm. size, when kept

in 1 to 2,000 copper sulphate solution for six minutes, came to the surface gulping air without an exception. Though they were transferred to flowing oxygenated water, the whole lot died out within three days.

Host-parasite relationship.—*Ichthyophthirius* readily takes to a wide range of hosts. H. S. Davis (1946) reports that trouts of all ages are infected when *Ichthyophthirius* becomes established in trout hatcheries. But mostly it is not injurious because the parasite develops slowly at low temperatures and is unable to complete its life-cycle where there is rapid flow of water. Severe epidemics are common in Western Europe (Van Duijn). In Indonesia *Puntius javanicus* (Blkr), *Helostoma temmincki* C.V. and *Osphronemus goramy Lac* were commonly attacked (M. Sachlan) Y. R. Tripathi (1955) found, *Labeo bata* (8 c.m.) and *Cirrhina mrigala* (8 c.m. and8·5 c.m.) susceptible to infection by *Ichthyophthirius*. We have artificially infected *Labeo fimbriatus* (6·5 c.m.) and *Barbus hexagonolepis* (6 c.m.) and since the fifth day their condition became highly insabularious. *Labeo fimbriatus* (15 c.m. to 25 c.m.) were not affected. *Lepidocephalichthys thermalis* and *Chela malabaricus* were readily susceptible and succumbed largely. *Tilapia mossambica* (3 c.m. and 5 c.m.) were not infected. Infection of fish belonging to family Ophiocephalidae is recorded for the first time. Young murrels of three different size groups kept in aquarium jar for the same period reveal that the fry stage is the most susceptible for *Ichthyophthirius* as well as for a multiple infection with *Gyrodactylus* (Figure 5). Table II depicts the intensity of infection among the three size groups.

TABLE II.

Showing the intensity of infection among different size groups of murrel.

Size groups.	*Total length.*	*Weight.*	*White spots.*	*Gyrodactylus.*
(1)	(2)	(3)	(4)	(5)
		GM.		
Size I	25 mm.	0·112	331	1000s
	25 mm.	0·112	420	1000s
Size II	32 mm.	0·227	102	Nil.
Size III	55 mm.	0·290	33	Nil.

Fingerling murrels (7·5 c.m. to 9·5 c.m.) were never infected even under artificial conditions.

SUMMARY

1. A new species of *Ichthyophthirius* a ciliate parasite on the fry stage murrel *Ophiocephalus marulius* is recorded for the first time.

2. Mode of reproduction is by simple direct fission. Position of cytostome is lateral. In these two points it differs from *Ichthyophirius multiafilis Fouquet*, the only species so far described.

3. Combined infection with Gyrodactylus occurs in murrels below 25 mm. size.

4. The new species is named *Ichthyophthirius-simplifilis* because of the simple fission in breeding.

5. Observations on the behaviour of this parasite to methylene blue confirms the claim of Van Duijn Jnr.(1956) that it is the most effective measure to combat this parasite in the laboratory. But experiments conducted in open cement cisterns did not give favourable results.

6. Fifty ppm. homotropine hydrobromide solution removes the slime from the skin thus exposing the lesions for the direct action of copper sulphate and preventing the formation of compounds with mucous which brings about asphyxiation.

7. Intensity of infection is greater in fry stage murrels than in fingerlings.

8. *Labeo fimbriatus* (6·5 c.m.) *Barbus hexagonolepis* (6·0 c.m.) *Lepidocephalichthys thermalis* and *Chela malabaricus* were artificially infected.

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Fig. 1

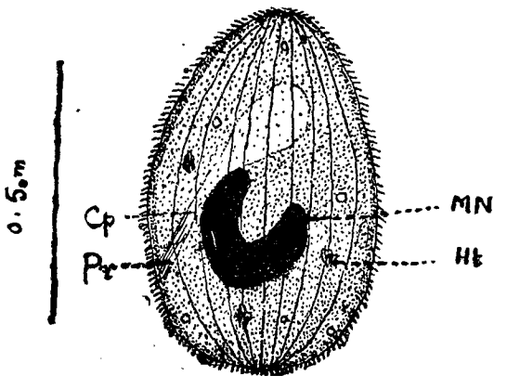


Fig. 2-a

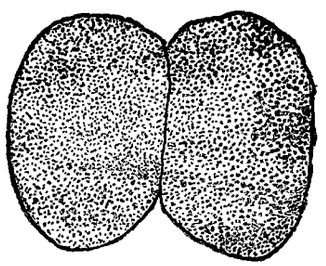


Fig. 2-b

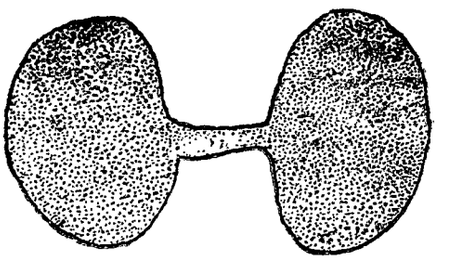


Fig. 2-c

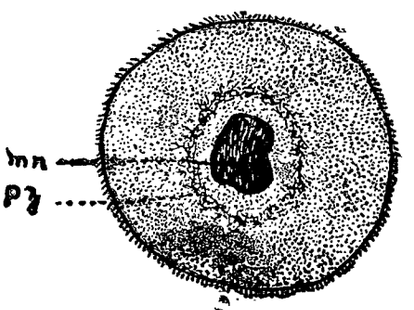


Fig. 1.—MATURE ICHTHYOPHTHIRIUS Sp.

Fig. 2-a.—SIMPLE DIVISION OF ICHTHYOPHTHIRIUS Sp.

Fig. 2-b.—ELONGATION OF THE CYTOPLASMIC BRIDGE.

Fig. 2-c.—SHOWING THE MICRONUCLEUS ON THE MACRONUCLEUS AND THE PIGMENTED ZONE AROUND THE NUCLEII.

KEY TO LETTERING.

Cp.—CYTOPHARYNX.

He.—HOST EPITHELIUM.

Ht.—INJESTED HOST TISSUE.

I.—ICHTHYOPHTHIRIUS IN TISSUE ERUPTION.

MA.—MACRONUCLEUS.

Mn.—MICRONUCLEUS.

Op.—OPERCULUM.

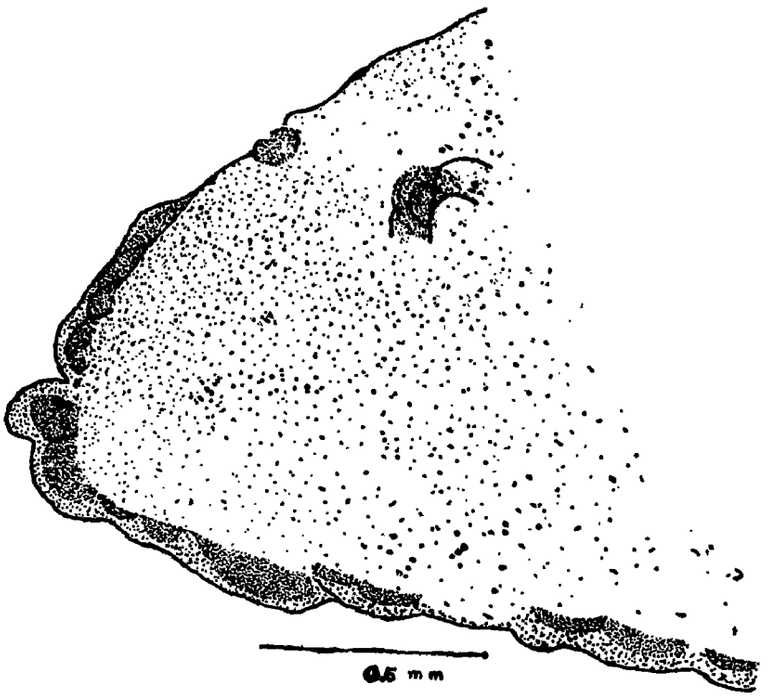
Pf.—PECTORAL FIN.

Pr.—PHARYNGEAL RODS.

Pz.—PIGMENTED ZONE.

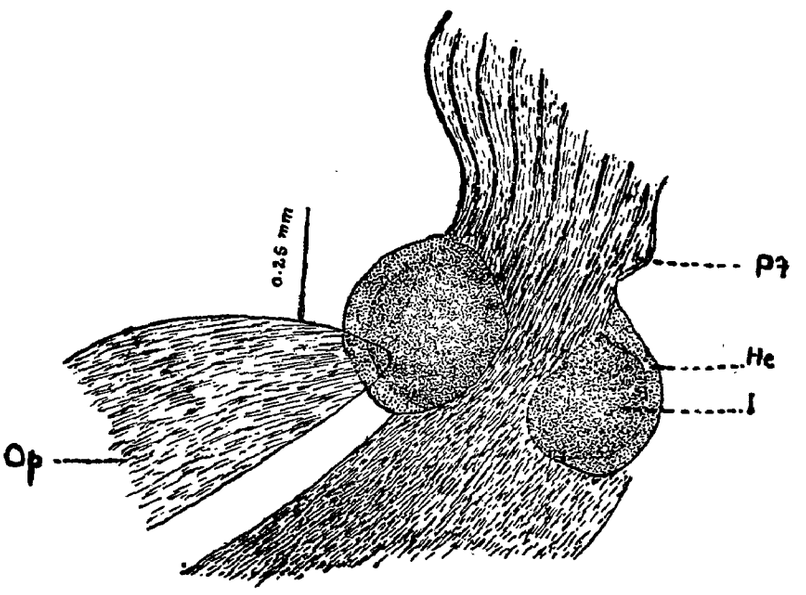
427-16—3A

Fig. 3-a



SHOWING ERUPTIONS ON THE HEAD AND EYE.

Fig. 3-b



ERUPTIONS AT THE ORIGIN OF THE PECTORAL FIN.

Fig. 4-a

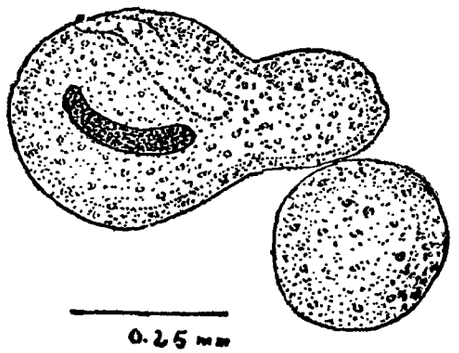


Fig. 4-b

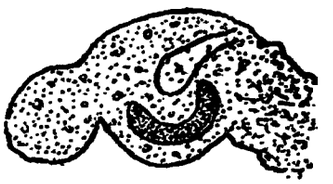


Fig. 5-a

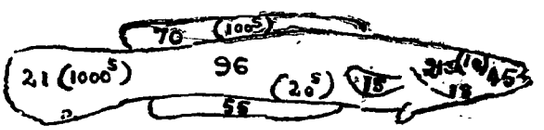


Fig. 5-b

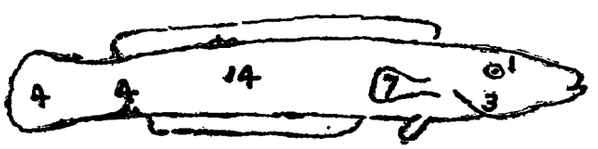
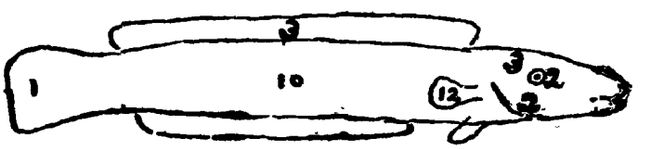


Fig. 5-c



F g. 4-a.—BUDDING IN METHYLENE BLUE.

Fig. 4-b.—DISINTEGRATION IN METHYLENE BLUE.

Fig 5-a, b, c.—SHOWING THE RELATIONSHIP BETWEEN THE SIZE OF THE FISH AND THE INTENSITY OF INFECTION.

	Total length of the Fish.	*Weight of the Fish.*	*Number of Ichthyophthirius.*	*Number of Gyrodactylus.*
(1)	(2)	(3)	(4)	(5)
a.	24 mm.	0·012 gm.	331	1,000s.
b.	45 mm.	0·19 gm.	33	Nil.
c.	55 mm.	0·29 gm.	33	Nil.

(Bracketed numbers indicate Gyrodactylus Unbracketed numbers indicate Ichthyophthirius.)

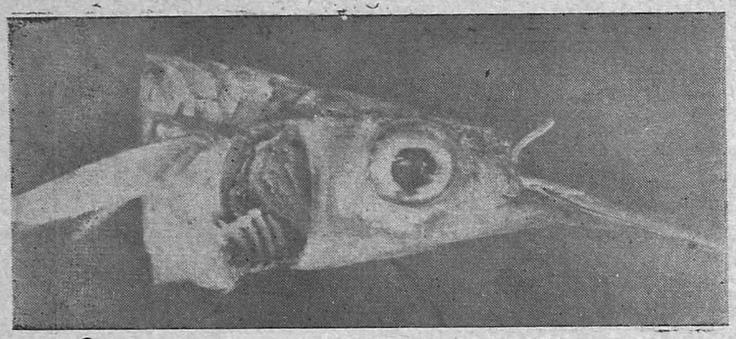


Photo 1—Female *Irona far* in the gills of *Hemirphanpus far* (Day) showing the anterior half of its body immersed within the gill tissue.

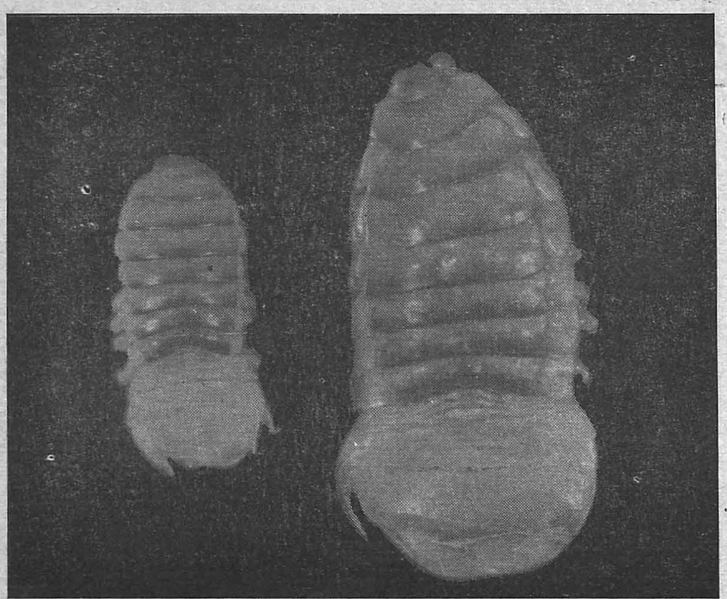


Photo 2—A pair of *Irona far* showing relative size, colour of telson, etc. In the female, the membraneous telson is broader than thorax.

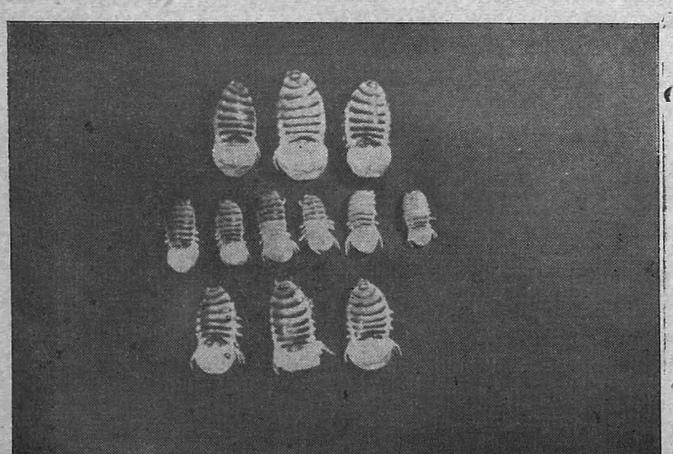


Photo 3—Photograph of six female and six male specimens of *I. far*. The middle row shows differently striated males.

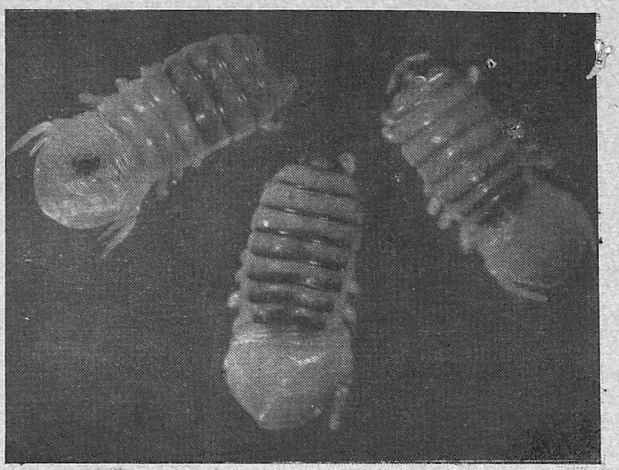


Photo 4—Three differently stripped males of *I. far*, one showing striations in the anterior thoracic segments only, the second in all, and the third in the few posterior segments only. Uropods longer than telson here.

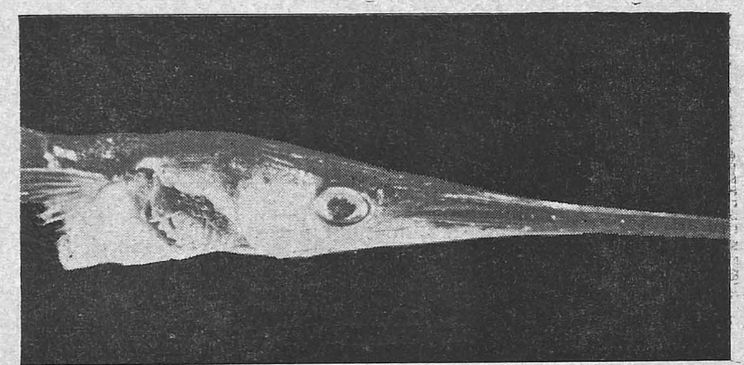


Photo 5—The parasite *I. gigantea n. sp.* with the host *Tylosurus lieurus* (Bleeker). It left half of the body is immersed in the gill tissue.

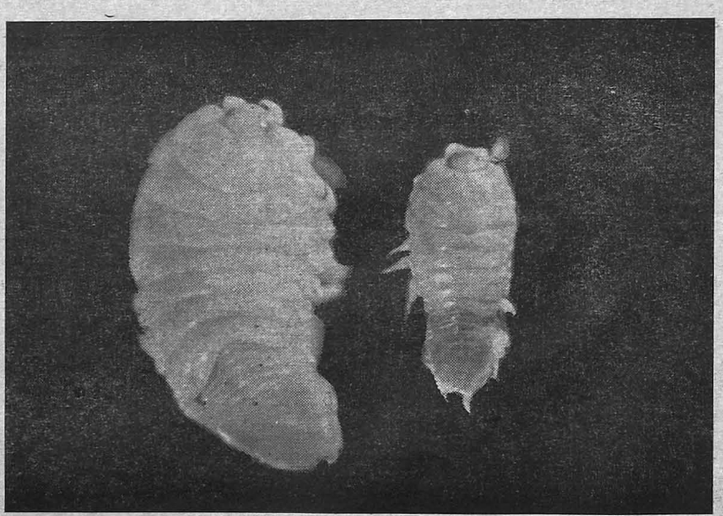


Photo 6—A pair of *Irona robusta* showing colouration, symmetary and relative size. The male is symmetrical with uropodes extending beyond the telson.

ON A RE-DESCRIPTION OF TWO SPECIES OF IRONA, IRONA FAR AND I. ROBUSTA (NAIR 1650)

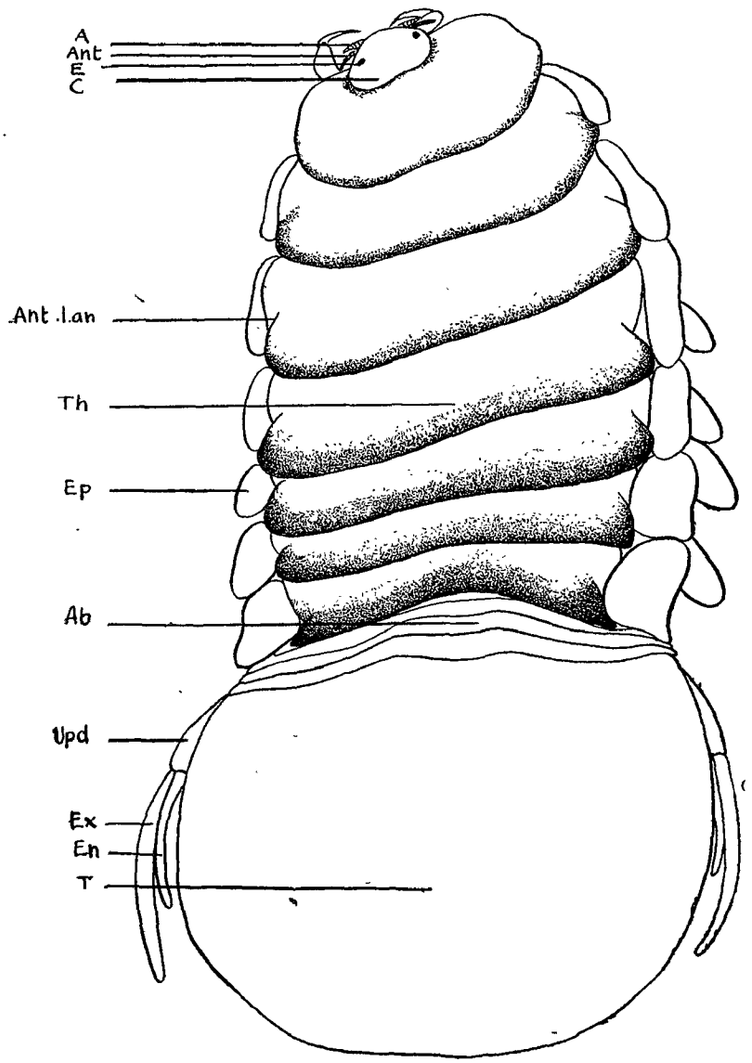
BY

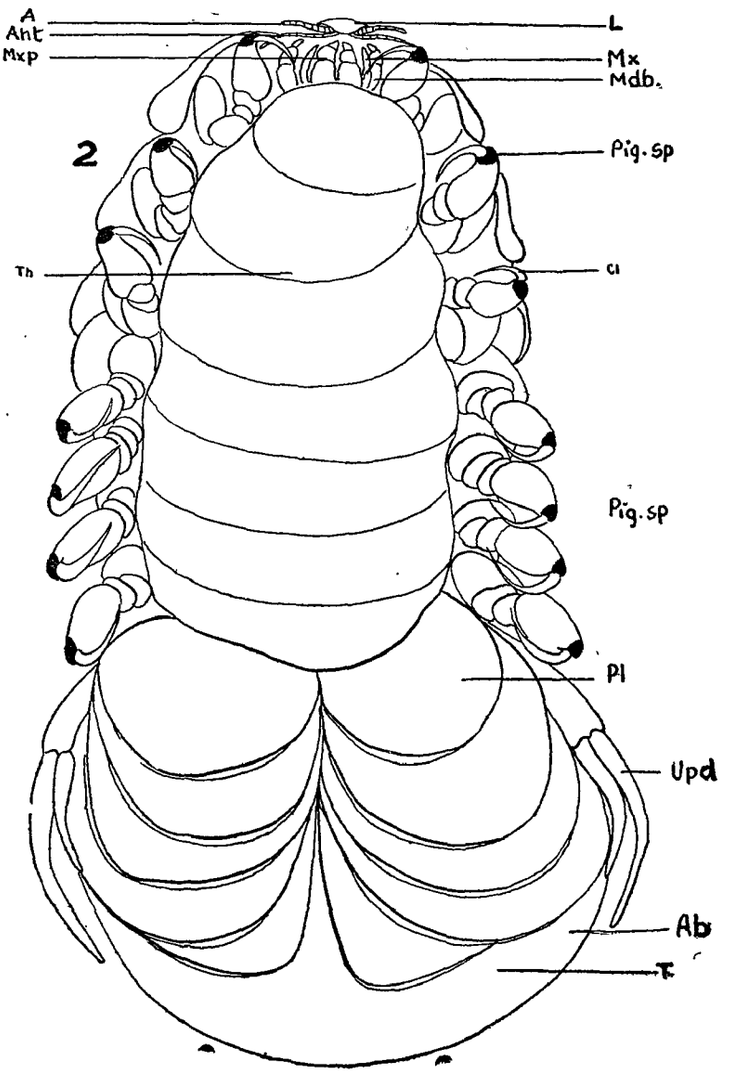
SRIMATHI J. G. ABRAHAM, M.SC., ASSISTANT DIRECTOR OF FISHERIES (MARINE BIOLOGY), MADRAS

INTRODUCTION

While engaged in collection and study of cymothoan parasites of fishes from Madras Coast between November 1947 and January 1950 these parasites were collected in large numbers from Madras fishes and studied. The work was done in the University Zoological Research Laboratory, Madras, while serving as Research Assistant.

Unfortunately while the paper was about to be published in 1950 a paper on these parasites was published by S. G. Nair (1950) in the Madras University Journal. As his description was found to be erroneous in many details of importance and as the description of males and their appendages was very meagre, a re-description of these species has been found necessary.





This paper is based on observations on 102 specimens of *I. far* and 90 specimens of *I. robusta*. Appendages of atleast a dozen specimens of females and males from each species have been dissected and studied.

A key to all the known species of *Irona* is also furnished in addition to an exhaustive account of these parasites.

The distribution of *Irona* species seems universal. *I. melanosticta* has been recorded from Sandwich Islands [Sch. and Meinert (1884)] Japan [Thielemann (1910)], S. Africa [Bernard (1914)] and S. Australia [Hale (1926)] and is said to infest *Tylosurus chorum* and *Hyporhamphus intermedius*. *I.rendardi* (Bleeker) is said to occur in South Australia and infests *Tylosurus ferox*, *T. macleayana* and other *T. species*. *I. nana* [Sch. and Meinert (1884)] occurs in America in *Hemiramphus* species. *I. foveol* [Hansen (1897)] also occurs in America but the host is unknown. *I. nanoides* [Stebbing (1905)] occurs in Ceylon waters.

The hosts of I. *valia, foveolata* and *nanoides* are not mentioned by the authors. *I. far* and *I. robusta* infest the

branchial chamber of *Hemiramphus far* and *Tylosurus lieurus* and are recorded from Madras coast.

1 IRONA FAR

One hundred and two parasites (Photo 1-4) were collected from nearly 125 specimens of *Hemiramphus far* caught on the Madras coast during July, August and September 1948 of which 27 were males. The females (Photo 1) are much larger than the males and always found in the branchial cavity of the host. Usually the anterior region of this parasite is immersed and hidden in the tissues of the gills of the host while the posterior region with telson and uropods only are exposed external to the gill flap. The males (Photo 2-4) are found attached to the soft skin of the body, very often near the base of caudal or dorsal fins. One or two of these males were collected from the branchial cavity also. When disturbed these parasites often leave the host and crawl to the other fishes drawn in the net. This habit has been observed by Dr. Linton in *Irona nana*. Males and young females of these parasites were found to live up to 25 days under laboratory conditions outside the host fish.

The females (Figures 1 and 2)—*Size and colour.*—The size varies from 18×7 mms. to 26×11 mms. A female of average size 22×9 mms. has been described below :—

	L. B.
Head	1·5×2 mms.
Thorax	14×9 mms.
Abdomen excluding telson.	1·75×9 mms.
Telson	6×10 mms.

Colour.—Yellow with segmental black stripes. Epimera and telson—white. Bases and tips of dactyli dark brown.

The characteristic feature of this parasite (Figure 1) is its colouration. It has a dark yellowish dorsal ground colour with prominent dark brown or black transverse bands across the posterior margins of the segments. The first thoracic segment unlike the others shows this pigmental stripe at its anterior concave margin also. Those of the last three thoracic segments are wider, darker and hence more conspicuous than the anterior stripes. The abdominal stripes are very delicate and less conspicuous. The epimera are either white or yellowish while the well developed broad telson is always white. In some forms very minute pigmented cells lie scattered over the dorsal surface of the body specially in the cephalon and segments of the antennal pairs. The tips of all the dactili are dark brown in colour. The bases of the dactili externally at their junction with the propodi, show circular or triangular dark brown areas (Figure 2). To my knowledge such pigmented areas or dots have not been described in any other cymothoan.

General appearance.—The body is more or less, oval and broad, moderately convex very much twisted either to the right or to the left and is about 2½ times as long as wide. The *cephalon* is very small about 1/14th of the length roughly triangular and is deeply set in the anterior margin of the first thoracic segment. It is broader than long and its broad front is curved and folded ventralwards over the bases of the antennal pairs. The eyes are small, circular about 0·75 mms. in diameter and are located in the mid-lateral margins of the cephalon.

In very large specimens the eyes seem to be covered up by the thin integument but in most they appear to function.

The *thorax* constitutes the major length of the body and forms two-thirds the total length of the specimen. The broadest region is that of fourth and fifth segments. The antero-lateral angles of the first thoracic segments are short, curve round the posterior margin of the cephalon and extend forwards up to the posterior margin of the eyes. This segment is longer than the three succeeding segments and has a concave posterior margin. The second, third and fourth segments are slightly shorter than the first but longer than the last three segments. The posterior margin of the last thoracic segment is deeply concave, and covers the anterior abdominal segments partially. The *epimera* (Figure 1) of all the thoracic segments but the first are very distinct. Those of the second and third are much narrower while those of the last four are oval, larger and broader. Those of second to fifth segments do not reach the posterior margins of the segments while those of sixth and seventh nearly reach. In a few specimens these epimeral plates just touch each other or gently overlap each other posteriorly. They are not directed outwards and dorsalwards as in *I. nanoides* and *I. foveolata* but are flat, oval and do not rise above the level of the body surface.

The antero-lateral angles of third to seventh segments are distinctly marked off by oblique lines while those of the first and second segments are not clear. The peraeopods are shorter in proportion to the size of the body than in males, and increase in length very gradually. In some the last three peraeopods of one side are closely set and seem to be shorter than the anterior pairs. This is only because of the twisted nature of the body. Measurements show that these are really slightly longer than the anterior pairs. There are no carina at the basis of the posterior peraeopods.

The *abdomen* is not narrower than the thorax and is continuous with it. The exposed abdominal region excluding the telson is either as long as or slightly longer than the last thoracic segment. The first segment is completely hidden by the last thoracic segment while the second is partially hidden laterally. The third, fourth and fifth segments are very distinct of which the last is slightly longer than the preceding ones.

The telson is nearly 1½ times broader than long, as broad as the fifth pleaon segment anteriorly while it is broader and rounded posteriorly. The well developed uropods are shorter than the telson shield.

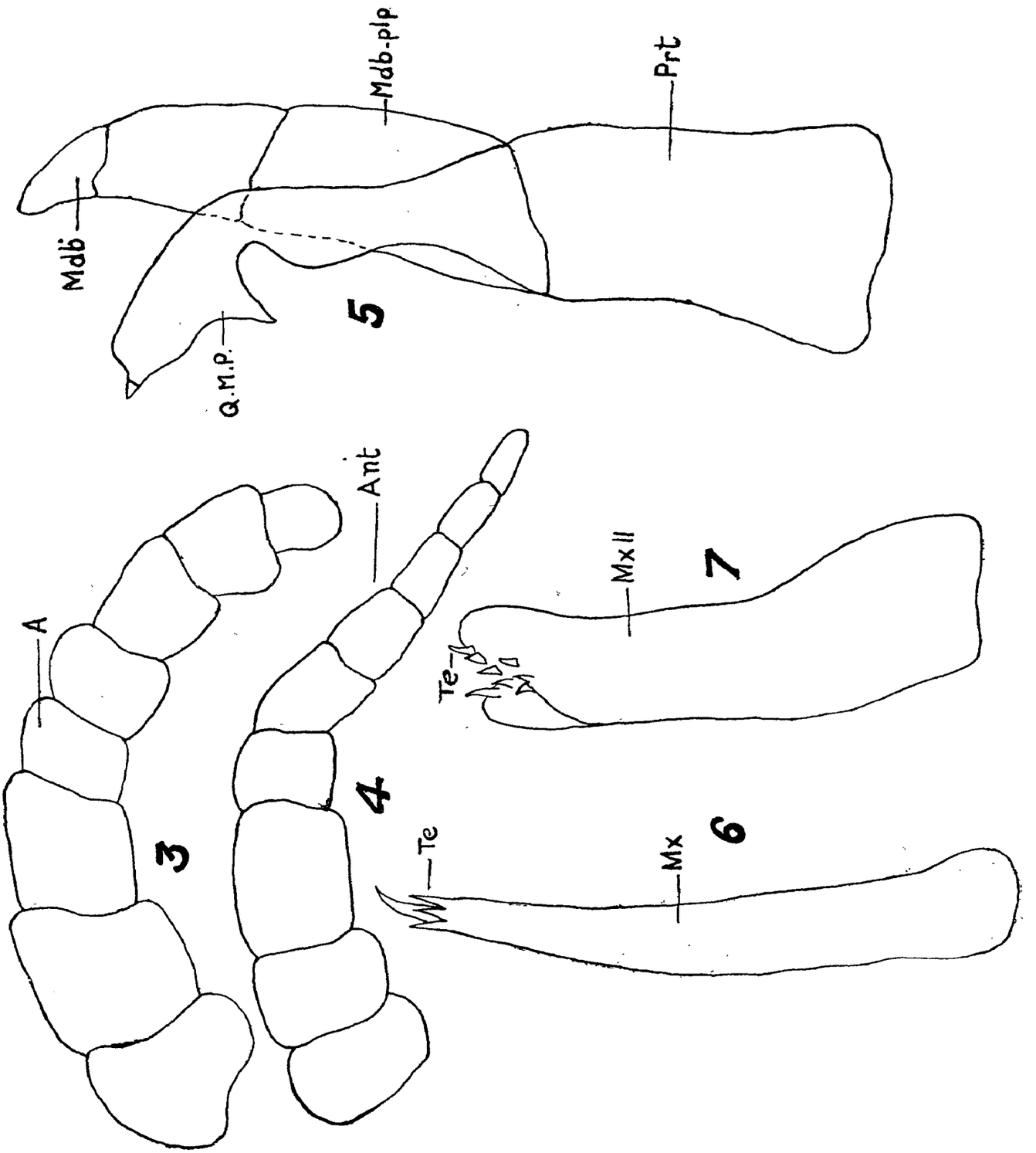
Appendages.—The *antennules* (Figure 3) are uniramous, more robust than the Antennae and widely separate at their bases. Each is eight-jointed of which the proximal three are very short while the distal five gradually taper towards the tip. The distal segment is blunt tipped.

The *antennae* (Figure 4) are very slender, filamentous, nine jointed and slightly shorter than the antennules though they look longer in situ. The proximal four segments are stouter than the distal 5 segments which are much more delicate and taper to a fine tip. The distal segment ends in a pointed tip. The distal segments of this appendage are very often found to lie curved over the cephalon dorsally.

The *labrum* is a thin white semi-lunar flap with a regular rounded posterior margin (not bilobed as in *I. nanoides*).

The *mandible* (Figure 5) consists of a well developed Protopodite and a three-jointed *mandibular* palp.

The stout base of protopodite narrows considerably, extends forwards and inwards and expands into a quasi-molar process as in I.nanoides which shows a concave bilobed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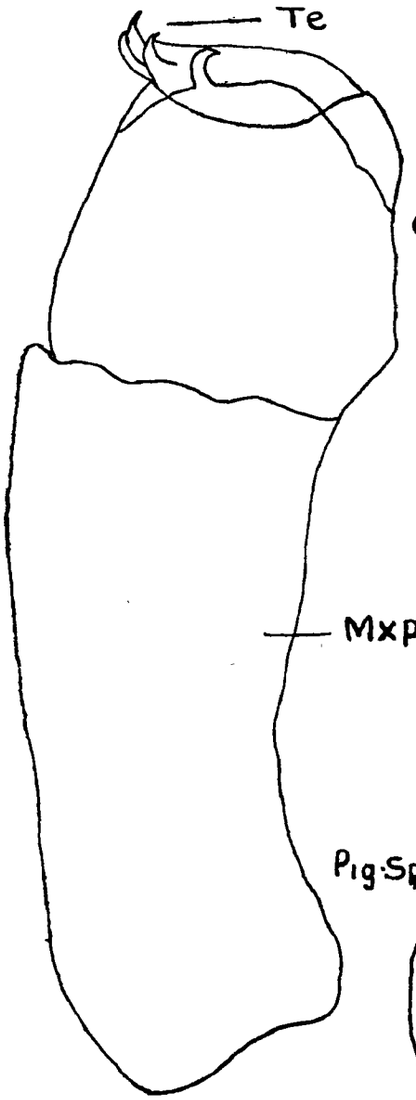

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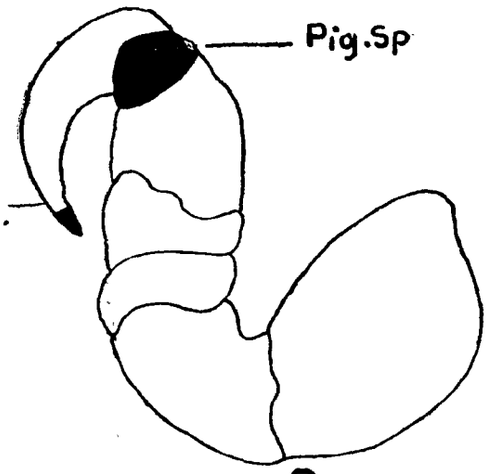

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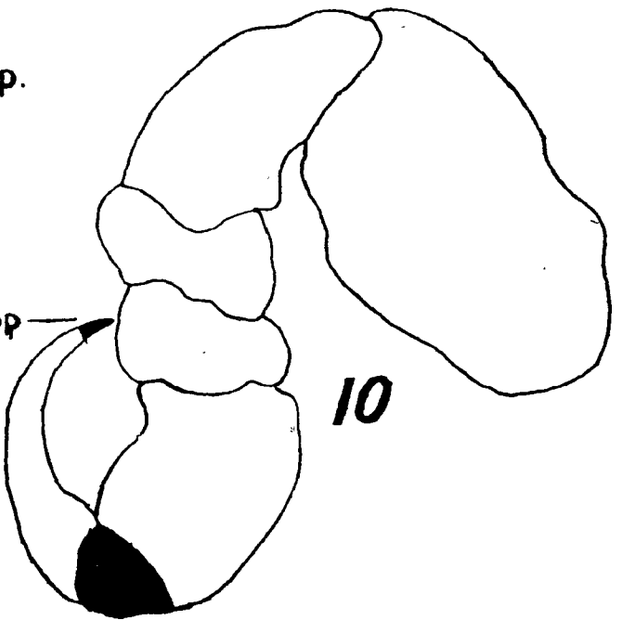

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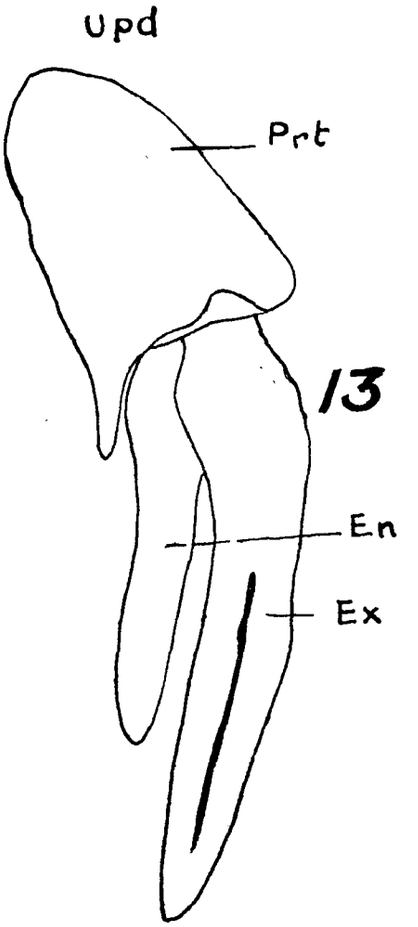

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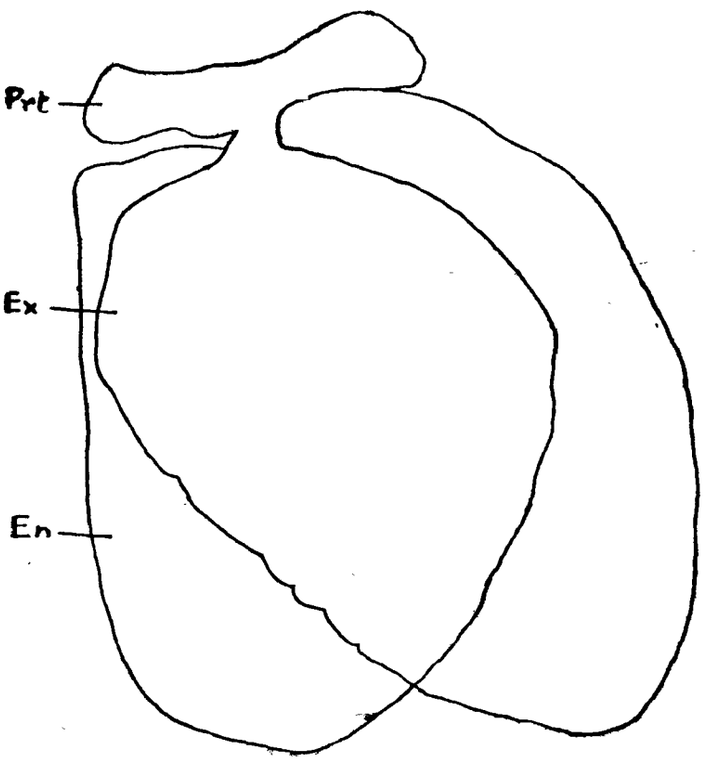

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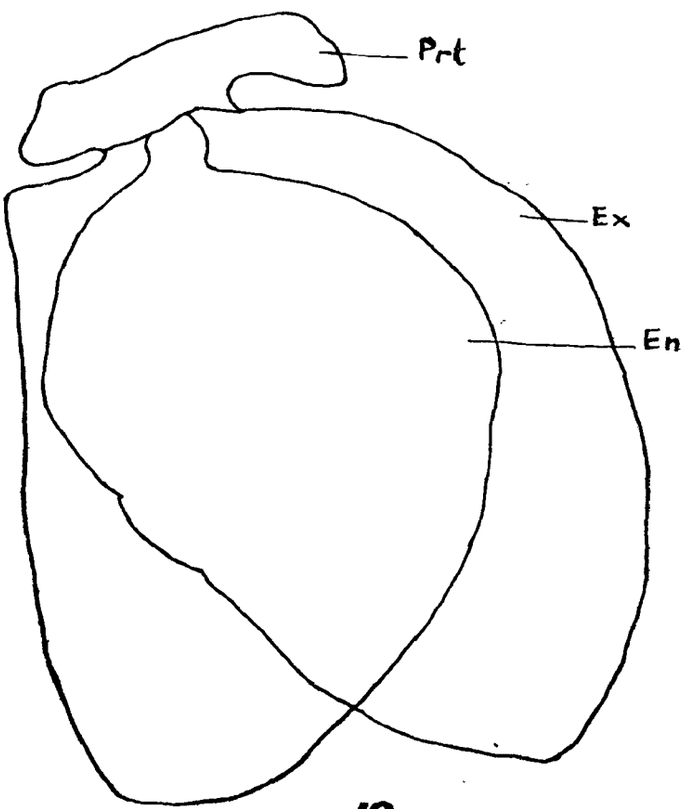


12

toothed inner margin. Anteriorly it carries a brown tooth while there is a longer white tooth at its posterior end. In most cases, the narrow-base or neck of the quasi-molar process is almost entirely over-lapped by the palp. These processes lie just beneath the labrum. In *I.nanoides* the quasi-molar is much shorter than the palp. Hence it is very slightly shorter than the palp. The palp is about 0·95 mm. long and its segments taper gradually towards the tip. In *nanoides* the distal segments of the palp shows a curved spine and is setose. Here it is plain. The distal segment is short, roughly triangular and devoid of spines or setae. The palps curve round the edges of the cephalon in close contact with the eyes, their distal segments lying over the bases of the antennae.

The *I.maxilla* (Figure 6) is a simple more or less cylindrical appendage with a broad base and a narrow tip furnished with four sharp brown spines. It is about 1·2 mms. long and 0·25 mms. at its base. Of the four spines the outermost one is the longest and the other three are shorter and located at its base. These spines are very greatly curved at their tips.

The *II.maxilla* (Figure 7) are more prominent flat structures and cover the I. maxillae. Each is about 1 mm. long with a broader proximal end and a narrower distal one, which carries two unequal lobes of which the outer is about twice broader and slightly longer than the inner narrow shorter lobe. At the junction between the two lobes and at their free ends, there are about six to eight white transparent teeth. The number and size of teeth vary in this appendage. The teeth vary from 0·035 mm. to 0·05 mm. in length.

The *maxilliped* (Figure 8) as usual is three-jointed and measures about 2 mms. The basal joint is very long, broad and nearly twice the length of the second segment which is however as broad as the former and tapers towards the end to which is movably articulated the small short terminal joint which carries at its summit three outwardly and anteriorly directed white curved teeth. In a few forms an additional tooth is found at its base or junction with the second segment.

I. Peraeopod (Figure 9) is the shortest of all the seven pairs. The dactylus is directed towards the mouth and its pigmented tip reaches the base of the carpus. The basis is the stoutest of all the segments.

VII. peraeopod (Figure 10) is the longest of all the peraeopods. The basis is about 0·3 mm. thicker than that of the first pair. The claw is long and about 2 mms. in length and reaches the base of the carpus here also.

The pleopods are biramous foliacious structures capable of respiratory exchange. The protopodite is two jointed and very stout whereas the rami are very broad, oval, well developed and devoid of marginal fringe of setules. All are similar except in size.

I. pleopods (Figure 11) is the largest of all the five pairs. The exopodite is very broad, oval and arises from the outer region of the protopodite and covers the endopodite almost completely. Its free margin is more pointed than that of the endopodite. The latter arises from the inner half of the protopodite and is much smaller, and exposed only at its inner distal margins. The inner margin is more or less straight and the tip is blunt and rounded. No sexual characters persist in the *II pleopod* (Figure 12) as is met with in certain females of the group. There is no marginal setae. There are no coupling hooks in the margins of the protopodite.

The *uropods* (Figure 13) lie closely apposed to the sides of the well developed telson. Here unlike in males these are shorter than the telson well developed and about 5·1 mms. long. The protopodite is quite stumpy, longer than broad and carries a long pointed spinous process at its inner distal margin, internal to the point of origin of the endopodite. The exopodite is flat and flexuous elongated and narrow and about one and a half times longer than the endopodite. The latter is flat, shorter and narrower than the former but ends in a more or less sharp tip.

The Male (photos 2—4)—*Size and colour.*—The males vary in length from 13 to 18 mms. and are about half or two-thirds the size of females. A male 16 mms. long shows:—

	L	× B
Head	1·2 mms.	2 mms.
Thorax	9 mms.	5 mms.
Abdomen	6 mms.	4·5 mms.
Telson with uropods ..	5·2 mms.	wide.

Colour.—Brown with all or few of the anterior or posterior segments showing pigmented striations (Photos 3 and 4).

The epimera telson and uropods are white in all males.

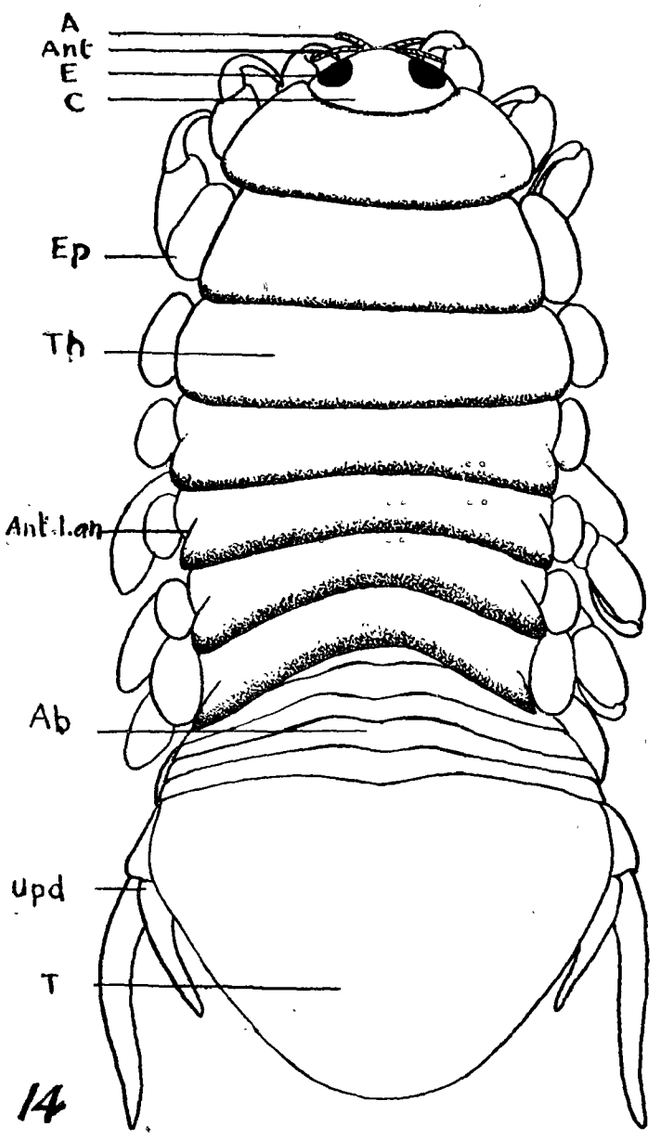
The claws show the pigmented tips and the pigmented areas in their bases (Figure 15) as in females. The pigment cells lie scattered in the cephalon and antennal pairs.

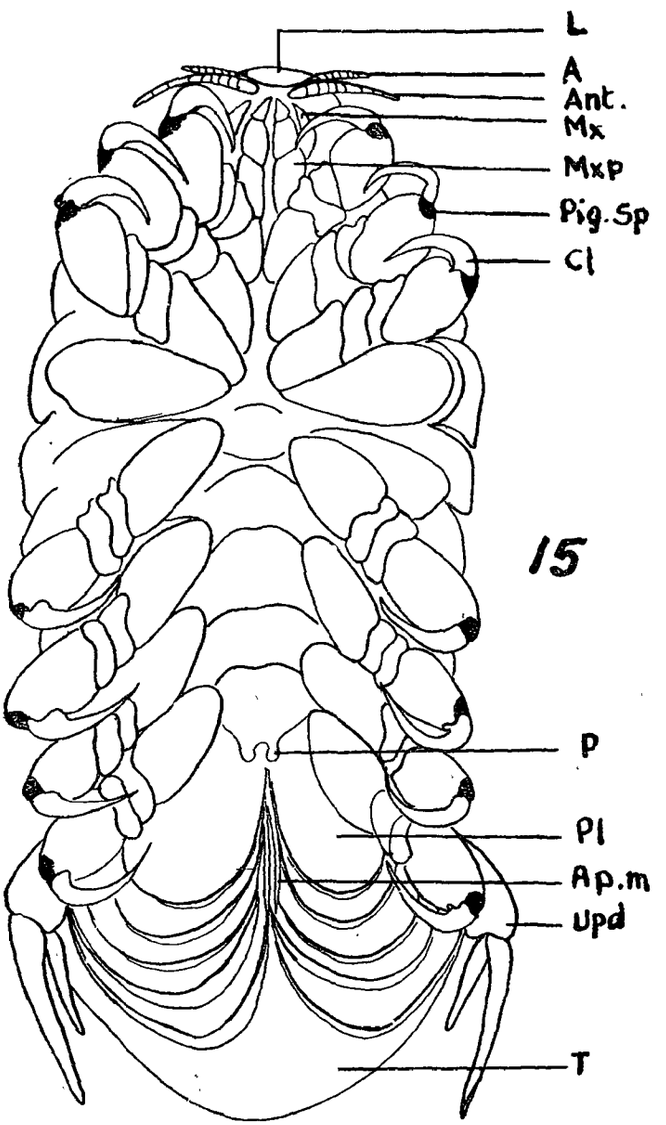
General appearance.—The body is more symmetrical than in females and is nearly thrice as long as broad. The broadest region of the body is at the third thoracic segment. The cephalon is small roughly triangular and its front edge is folded over the antennae. The eyes are more prominent than in female being about 0·5 mm. in diameter. The thorax forms the major length of the body, its first segment being broader than the cephalon and the anterolateral angles are short, blunt and extend up to the posterior margin of the eyes. It is slightly shorter than the succeeding two segments. The second is longer than the first but shorter and narrower than the third. The third is the broadest and longest of all the thoracic segments. The last four segments gradually decrease in size. The posterior margins of the fourth and fifth are slightly concave while that of the last segment is very concave into which the slightly broader abdominal segments are tucked in. Though the epimera of all the segments but the first are distinct as in female, here they differ to some extent. Those of the second and third segments are elongated and broader than those of the following four segments. Of the posterior four pairs, those of the last pair are broader and larger than the others. The posterior margin of the epimera of the sixth segment lies over the anterior margin of the following epimera. The anterior four pairs do not overlap each other in males. None of the epimera reach the posterior margins of the respective segments. Those of the sixth and seventh almost reach.

The antero-lateral angles of the last three segments are very clearly marked (Figure 14) while those of the fourth segment are slightly indicated. Those of second and third are not indicated at all. The peraeopods are

onger in proportion to the size of the body than in females. The *abdomen* is slightly broader than the thorax and is very slightly immersed in the thorax. The first segment is almost hidden while the other four segments are distinct. Unlike in female the lateral regions of the

The *antennae* (Figure 17) are shorter and more slender than the antennules and are nine-jointed. The proximal three segments are massive, the fourth is longer than the former but thicker than the rest and the terminal five joints are slender and elongated.





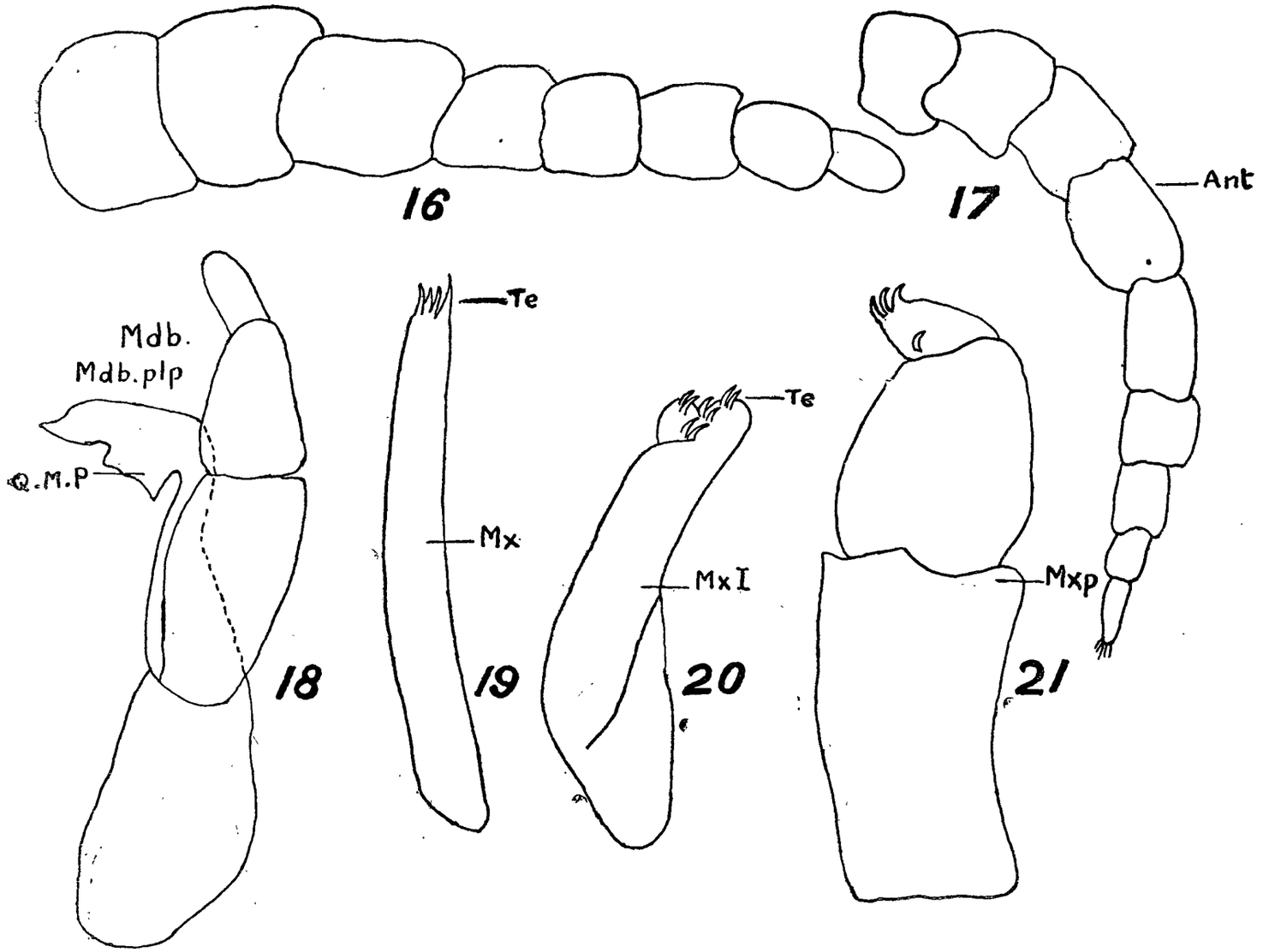
second segment is not hidden. The segments very slightly increase in length in the fifth segment as is observed in the female. The telson is well developed, broad, white and membranous with its posterior margin gently rounded. Unlike in female, the uropods are longer than the telson.

The ventral view of the male presents two important sexual features. The articular membrane existing between the last thoracic segment and the first abdominal shows in the mid-ventral line, two white club-shaped structures with rounded or slightly narrower tips. These are the penis (Figure 15). Each penis is about 0·4 mm. long 0·2 mm. broad at its point of origin from the body wall, and about 0·1 mm. at its tip. The endopodites of the second pair of pleopods carry at their bases slender elongated style like appendix masculina about 1·75 mms. long and 0·2 mm. thick at the base.

Appendages.—The antennules (Figure 16) are similar in structure to that of female. It is nearly the same length as in female and eight-jointed.

The terminal joint is pointed and setose, the setules varying from 0·04 mm. to 0·05 mm. in length.

The *mandible* (Figure 18) except in its smaller size agrees in general structure with that of female. The terminal segment of the palp is cylindrical with rounded tip and not triangular as in female. The anterior tooth of the quasi-molar process is not coloured here and the process has a narrow neck and broader base. The *I. maxilla* (Figure 19) is slightly shorter than that of the male but similar in structure. *II. maxilla* (Figure 20) very similar to that of the female. Here the number of teeth in the two lobes is constant. There are two sets of two teeth each in the outer lobe and two similar sets in the inner lobe. The *maxilliped* (Figure 21) is very similar to that in female, the relative length of the segments vary slightly. Here the basal joint is the longest and nearly one and a half times as long as the second. The distal segment is the shortest conical and carries three apical and one sub-apical outwardly directed curved teeth. In one out of the nearly ten



males studied, the distal segment showed about 9 teeth throughout its length. The teeth are about 0·06 mm. long and longer than those of the *I. maxillae.*

The *I. peraeopod* (Figure 22) is the shortest of all with its basis being the stoutest and longest of all the joints. The Merus and carpus are the shortest. As in female the dactylus is curved and reaches up to the base of the carpus. The pigmented tip of the dactylus and pigmented area at the base, are present.

The *7th peraeopod* (Figure 23) is the longest of all the thoracic appendages and no carina developed at the basis. The inner and outer margin of the distal end of the basis is produced into 2 short processes. This is not observed in the female. The dactylus and pigmented area are similar to those in female.

All the pleopods except the second pair are more or less similar in structure. A *typical pleopod* (Figure 24) consists of a short and broad protopodite. The exopodite is very large, springs fro n almost the whole breadth of the former, narrows gently posteriorly and covers the major part of the endopodite. The latter springs from the inner half of the protopodite, and is narrowed at its origin. Its inner margin is straight while its exposed free end is rounded unlike that of the exopodite. The exopodite and endopodite are nearly the same length. The *II. pleopod* (Figure 25). The short protopodite and exopodite are similar to those of other pairs. The endopodite is much smaller and shorter than the exopodite and almost completely hidden by it. Springing from the anterior inner margin of each of the endopodite is a styliform appendix masculina. This is about 1·75 mms. long, just reaches the posterior margin of the endopodite. It is nearly 0·2 mm. thick at its base and very much narrow at the tip. These are the appendix maculina and are supposed to aid in copulation. The *uropods* (Figure 26) are white in colour, well developed and longer than the telson in males. The stumpy protopodite shows two short processes on its inner and outer margins. That of the inner margin is very slightly longer than the outer.

My observations based on 102 specimens of *I. far* show the following differences :—

Female—1. *Colour.*—Live specimens show a yellow background with dark brown or black transverse striations. Epimera yellow or white telson uniformally white. Colour s not white with edges tinged yellow as described by Nair 1950).

2. *Coloured spots.*—Characteristic is the presence of dark brown or black triangular areas externally at the bases of the dactili at their junction with the propodi (Figure 2). The tips of dactili are dark brown. These have not been mentioned by Nair (1950).

3. *II. antenna.*—Nine-jointed and slightly shorter than the antennae and *not* eight jointed.*

4. *Mandibles.*—With three-jointed palp and a well developed protopodite which extends forwards and inwards and expands into a quasi-molar process as in *I. nanoides* which show a concave bilobed toothed inner margin. The spine at the anterior tip is coloured brown. The terminal joint of the palp is triangular and pointed at the tip.

The quasi-molar is not the distal segment of a two segmented ramus of the mandible as described by Nair (1950).

5. *II. maxilla* is unequally bilobed with 6-8 transparant spines usually eight spines in four sets of two each and not three and two in each lobe.

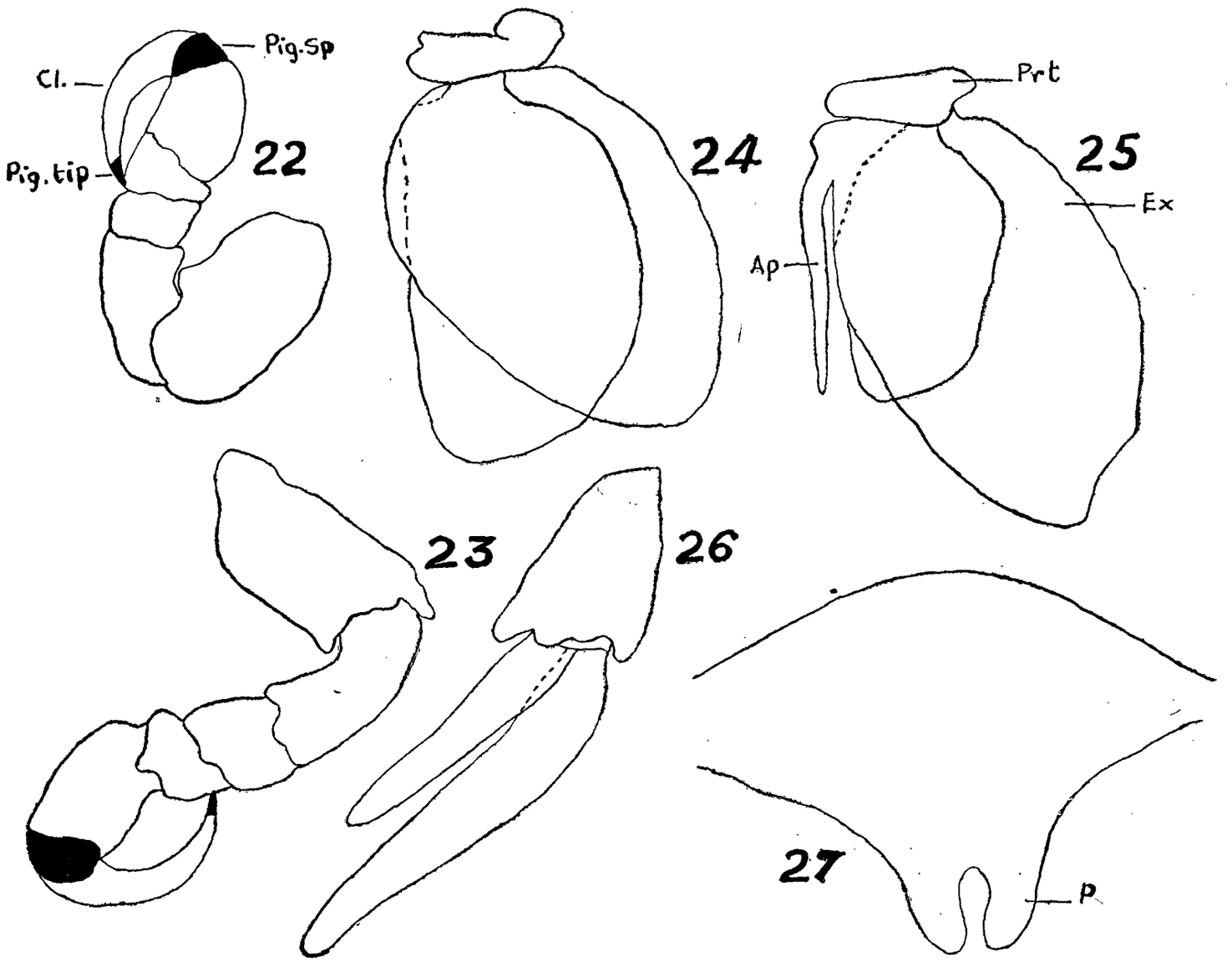
6. *Maxilliped* consists of three outwardly and anteriorly directed white curved spines. In a few forms there is an additional spine at the base at its junction with the second segment. This additional spine has not been described by Nair (1950).

7. *Anterolateral angles.*—Anterolateral angles of all the thoracic segments except first are marked by oblique grooves. No mention about anterolateral angles is made in Nair's description.

8. *Pleopods.*—Description of pleopods by Nair is meagre and incomplete.

9. *Telson* is well developed and broadly rounded and *not semi-circular* as described by Nair (1950).

1. *Male—Colour.*—Live male parasites show brown background with all, or few of the anterior or posterior segments showing the pigmented striations (the segments



* According to Schioedte et Meinert (1884) who established the Genus Irona, second antennae should bear 9–10 segments (p. 381) Nair's (1950) observation that II antenna is eight-jointed would render his generic diagnosis open to question.

not showing the striations being white in colour. This white colour is observed to be soon after moulting of that portion of thorax takes place).

The epimera, telson and uropods are white in all males. Colour is not same as that of female are much paler as described by Nair (1950).

2. *Pigmented areas.*—Claws of all the peræopods show dark brown tips and the pigmented areas at the bases of dactili as in females. This has not been mentioned by Nair.

3. *II antenna*—are shorter and more slender than *I*, antenna, nine jointed, the terminal joint being pointed and setose—not described beyond saying that appendage resemble those of females.

4. *Mandible* with a three jointed palp the terminal joint being cylindrical with a rounded tip and not triangular as in females. The anterior spine of the quasimolar is not coloured as in female. This is not described by Nair.

5. *I maxilla* as in female.

6. *II maxilla* the number of spines in the two lobes is constant being always eight. There are two sets of two each in each of the two rami of the II maxilla.

7. *Maxilliped*—Usually with four outwardly and forwardly curved spines at the distal segment. However, the number of spines may vary up to nine in some specimens.

The cephalic appendages of males have not been described.

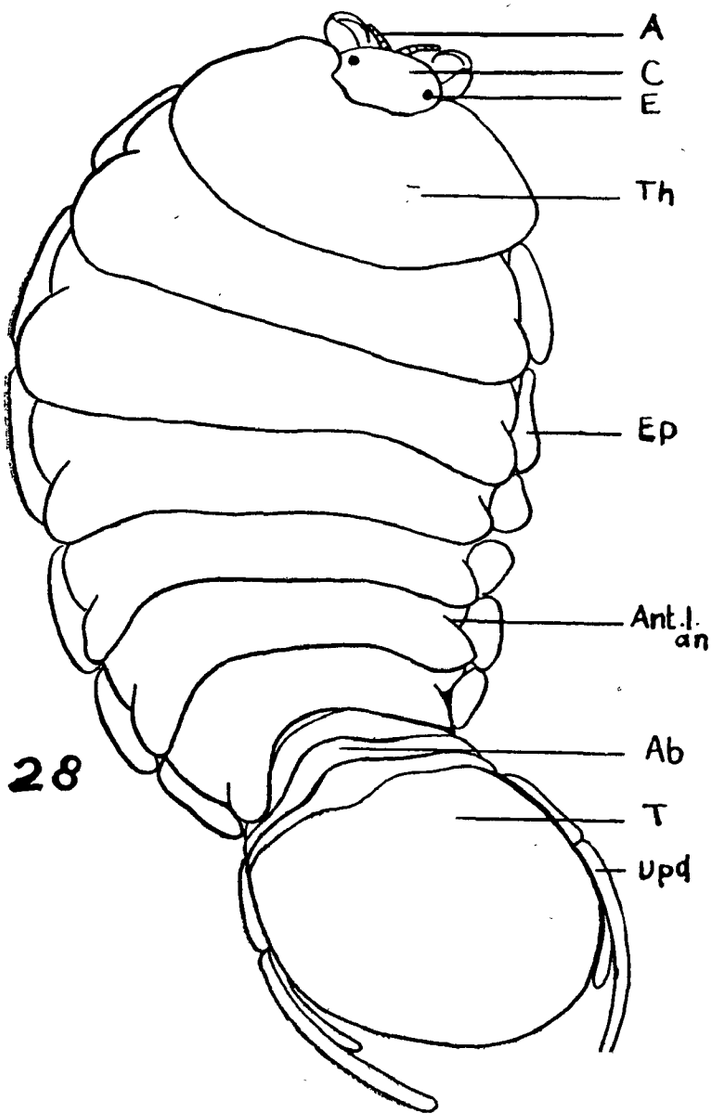
8. *Antero-lateral angles* are present from the fourth —7th segments and not marked in second and third thoracic segments as in the females. This has been omitted in Nair's account.

9. *Peraeopods.*—The inner and outer margins of the distal ends of the bases are produced into two short process in the seventh peraeopod of males. Peraeopods are not adequately described.

10. *Pleopods.*—In the mid ventral line two club-shaped penis (fig. 15) occur in the articular membranes existing between the last thoracic and first abdomenal segment. Similarly a pair of appendix masculina are also present in the endopodites of second pleopod.

11. *Uropods.*—Longer than telson.

Pleopods, uropods, and sex characters not described by Nair (1950).



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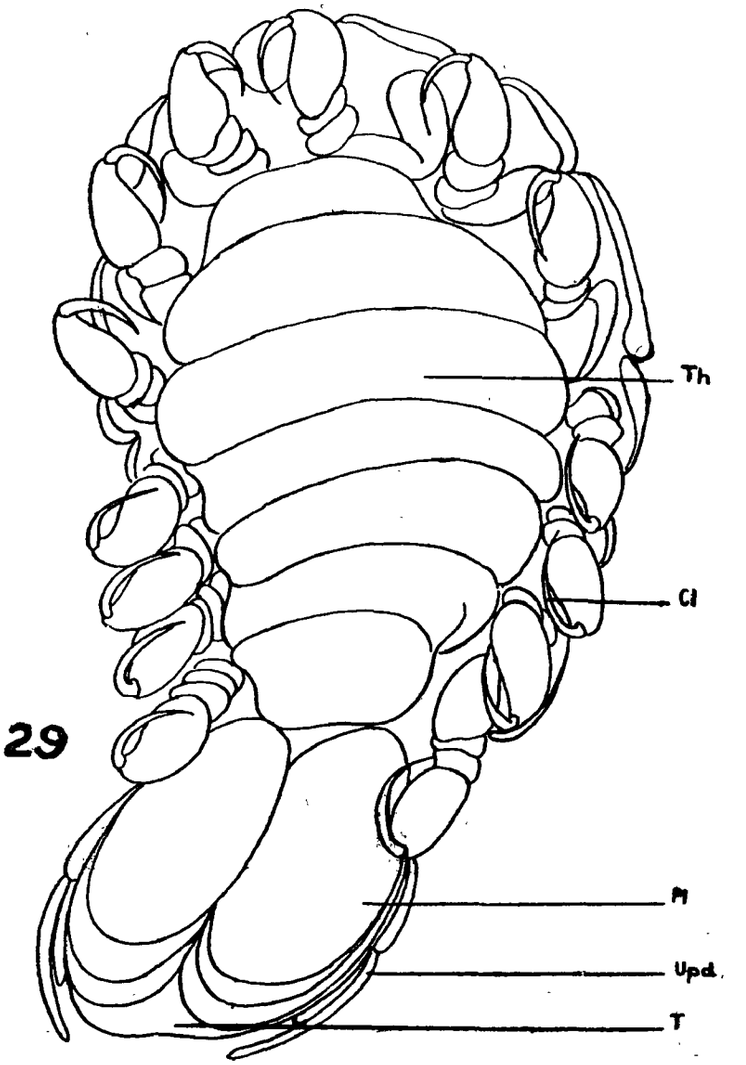

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A revised account of the specific characters of *Irona far* is given below :—

(1) Large sized female nearly $2\frac{1}{2}$ times as long as broad whereas male is thrice as long as broad.

(2) Female with yellow ground colour and dark brown segmental striations. Male brown ground colour and brown bands. The tips of claws black.

(3) Mandible very much similar to that in nanoides with a quasi-molar (stebbing) shorter than the palp.

(4) I Maxilla with only four spines (unlike in nanoides and melanosticta where it is said to be five).

(5) II maxilla unequally bilobed with four pairs of teeth.

(6) Conspicuously large membranous telson more than $1\frac{1}{2}$ times broader than long with a rounded posterior margin sometimes even wider than the widest region of the body.

(7) Uropods shorter than telson in female but longer in males.

(8) Epimera of second and third thoracic segments narrower and smaller than those of last four pairs which are broad and flat. In male the anterior two pairs of epimera are larger than the posterior four pairs.

(9) Antero lateral angles of all the thoracic segments excepting the first, marked by oblique grooves in females. In males those of second and third segments not marked off as in female, the last four segments only showing the antero lateral angles.

(10) Dark brown triangular areas at the bases of the dactyli in both sexes is very characteristic of the species.

2. *Irona robusta.*—Between July to October 1948 while collecting cymothoan parasites 90 specimens of this parasite were collected from the gills of *Tylosurus Lieurus* (Photos 5 and 6) of which 25 were males.

External features—Female (Photos 5 and 6).—The largest female measured 31 mm. in length (Figures 28 and 29)

Length—31 mm.

Breath—14 mm.

Telson—8×7.

Locality,—Madras.

Host.—Parasitic on gills of Tylosurus lieurus.

Body.—Asymmetrical, twisted to right or left so that one side is longer than the other.

Cephalon.—Small, squarish with two dark circular eyes located in the mid lateral margin, rather deeply sunk in the concavity of the anterior margin of the first thoracic segment.

Thorax.—The first segment is distinctly much longer than the remaining thoracic segment. The second and the third are nearly half the length of the first and the remaining four slightly shorter. The segments are longer at the sides than at the mid dorsal line and much longer on one side. Body is broadest at the third thoracic segment from where it gradually narrows up to the seventh segment, which unlike the rest is very concave posteriorly and lodges the abdominal segment. The epimera as usual are not distinct in the first segment. Those of the second and the third are narrow and do not reach the posterior margin of the segments. Those of the remaining four are much longer and larger on the longer side, the last two reaching the whole length of the respective segments. On the shorter side the last four are not longer than the preceding two but are short and slightly broader. Those of the fourth and fifth only nearly reach or do not reach the posterior margin of the segment. Those of the sixth and seventh reach the posterior margin of the segment.

The antero lateral angles are very distinctly marked on the last four segments faintly indicated on the second and the third while they are absent with first segment.

Abdomen is slightly broader than the seventh thoracic segment. The first abdominal segment is completely hidden and the second almost completely hidden by the seventh thoracic segment. The third is only partially covered laterally and the last two are fully exposed. Thus the last three segments are distinct and the second is faintly visible in the middle. The fifth segment is markedly longer than the proceeding ones.

Telson is broader than long, rounded nearly as broad as the last abdominal segment. The uropods (Figure 40) are much longer and reach beyond the posterior margin of the telson both the rami ending in rounded tips. The endopodite is much narrower and shorter than the exopodite.

Ventrally on the shorter side the four posterior pairs of legs (Figures 36 and 37) are seen closely set and smaller in size than those on the longer side. All the seven pairs of legs end in curved claws with sharp tips.

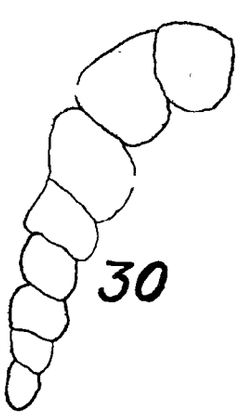
Colour.—White, with telson light grey in few.

I. Antenna (Figure 30).—Eight jointed, the joints gradually tapering. The terminal joint is rounded.

II. Antenna (Figure 31).—Nine jointed more delicate and longer than the first.

Mandible (Figure 32).—With a quasi-molar as in *nanoides* and *I. far* but extending anteriorly beyond the palp. It has a convex inner margin which carries a spine anteriorly and posteriorly. The palp is three-jointed and curved inwards. The distal joints being narrow and pointed. The protopodite is quite stout and longer than the palp but shorter than the quasi-molar.

I maxilla (Figure 33).—With four teeth one of which is conspicuous. *II. maxilla* (Figure 34) bilobed distally and broad basally. The outer lobe carries three curved spines directed outwards while the inner carries one spine only.



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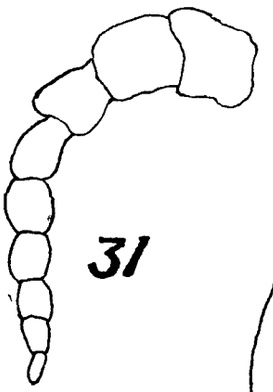

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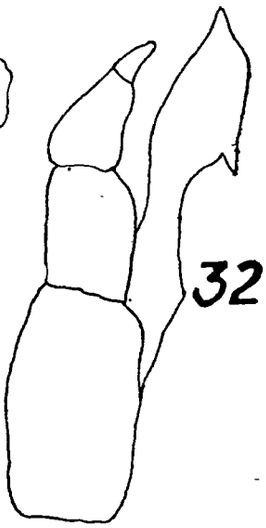

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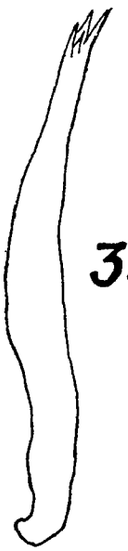

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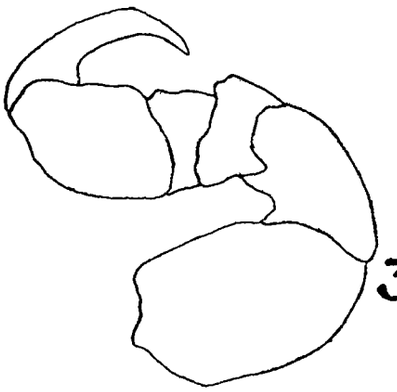

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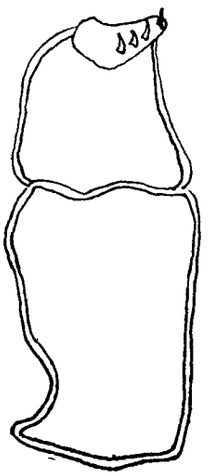

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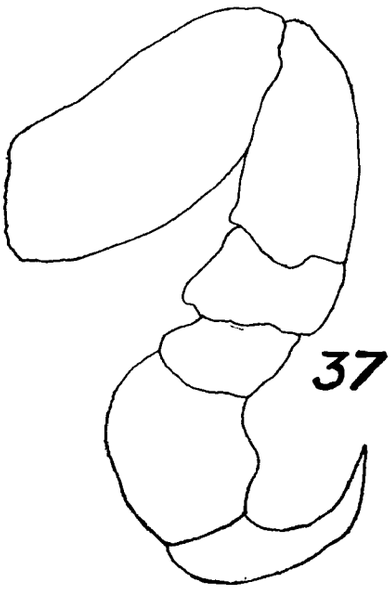

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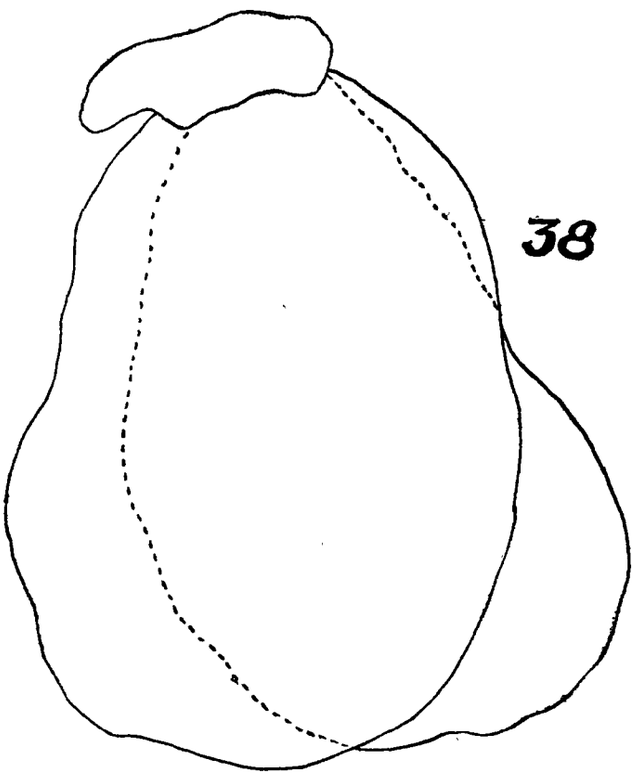

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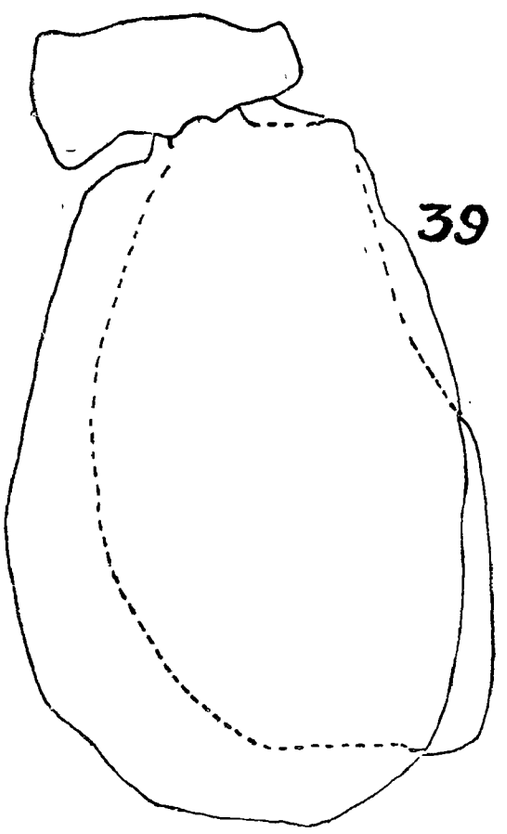

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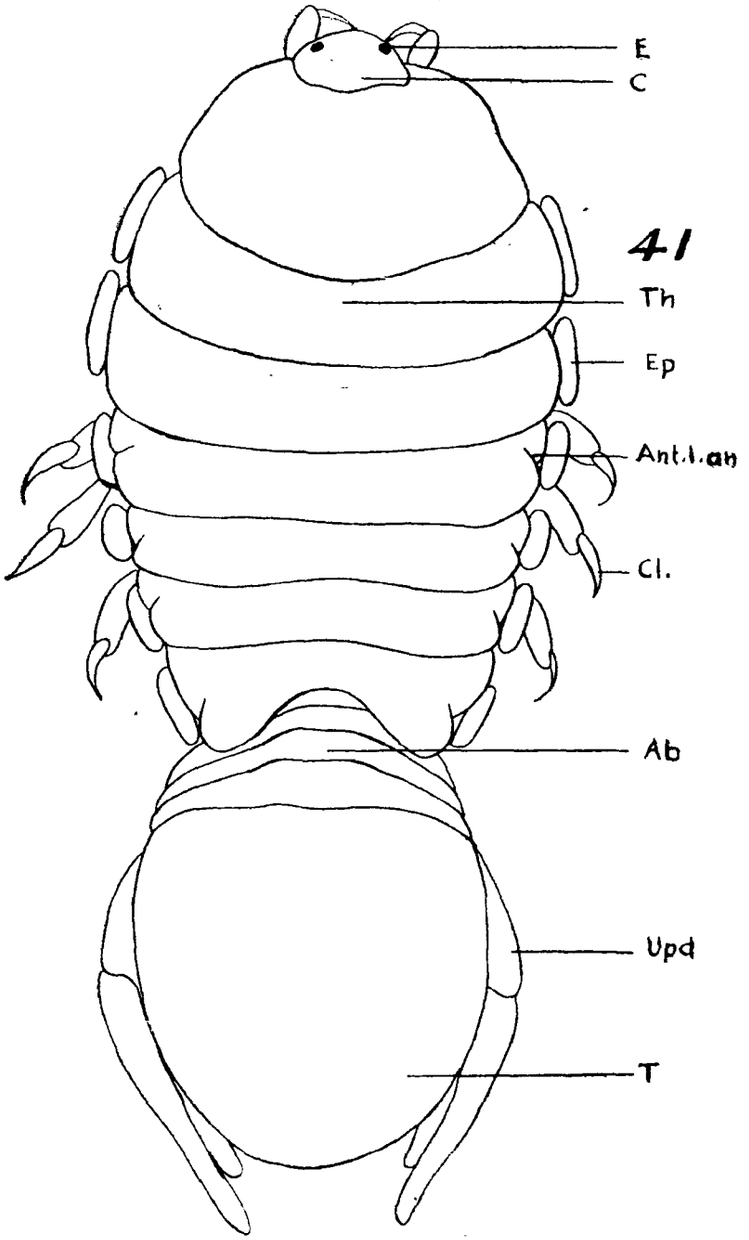
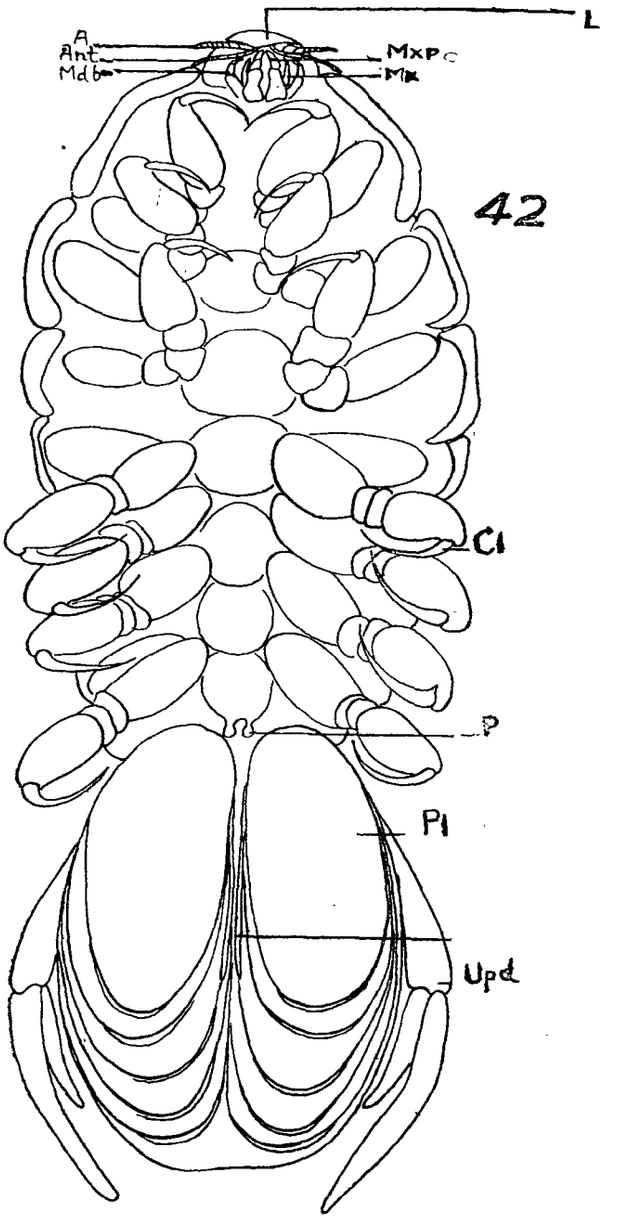




Eyes.—Very dark and seem to function.

The maxilliped (Figure 35) is three-jointed, the basal being the largest. The terminal joint is conical and carries four curved sharp spines directed outwards.

Male.—Length—20·5 mm.

Breadth—8 mm.

Telson—4·5 mm × 4 mm.

Colour.—Light purple or light brown in live specimens.

The largest male (Figures 41 and 42) so far collected is 20·5 mm. long and 8 mm. broad.

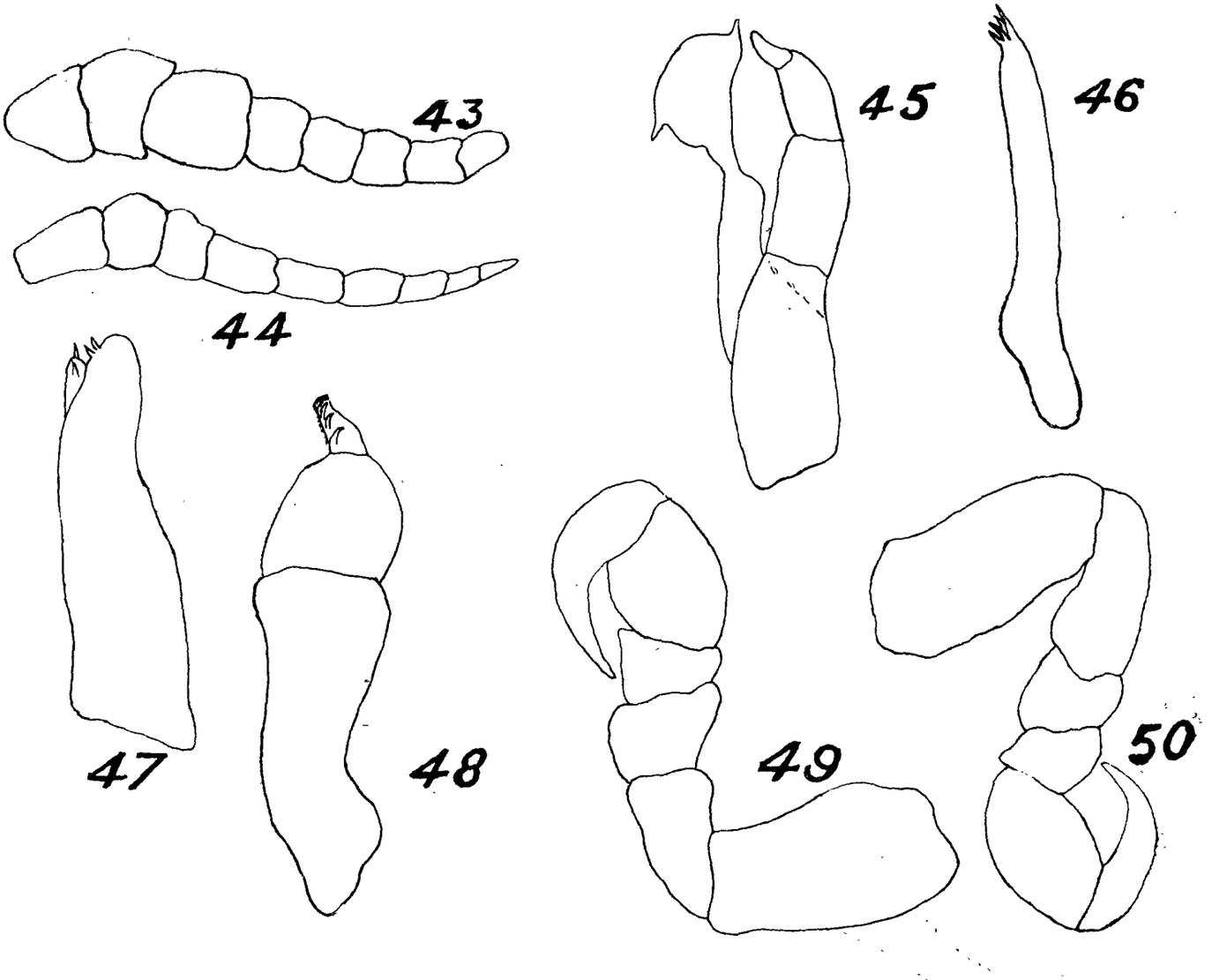
Body.—Symmetrical, pear-shaped broader at the anterior end and gradually narrows posteriorly.

Head.—Dark, brown in colour, semi-circular rather immersed in the thorax.

Thorax.—The first segment is markedly longer than the succeeding ones as in the female. The second and the third are nearly equal in length, the forth is slightly shorter in length and the rest gradually decrease in length. The thorax is widest at the second and the third segment from where it gradually narrows. The last thoracic segment is concave posteriorly and completely covers the first and part of the second abdominal segment. The remaining three segments are distinct, their length gradually increases posteriorly.—The second segment is more exposed than in the female.

Abdomen is almost as broad (Figure 54) as the telson which is slightly longer than broad. Uropods are longer than the telson.

The epimera of the second and third segment are the largest and only almost reach the posterior margin of the segment. Those of the last four pairs are nearly half the size of the preceding two and are placed slightly dorsally, i.e., above the level of the second and third epimera. Those of the fourth and fifth do not reach the posterior margin of the segment while those of the sixth



and seventh reach. The smallness of the last four pairs of epimera and the slightly dorsal position are interesting. The antero lateral angles of the last four pairs are only marked distinctly. Those of the second and third are not marked as in the female. (This has been observed by Barnard in the Male of *I. malanosticta* also).

The legs (Figures 49 and 50) are more slender than those in the female. The first three pairs are folded forwards and inwards towards the mouth, while the last four are kept folded backwards and outwards. The claws are sharp and curved and reach the base of the fourth segment.

Ventrally on the posterior margin of the seventh thoracic segment is present a pair of very short penis with rounded tips (Figure 51) . A pair of appendix masculina are also present in the endopodites of the second pair of pleopods (Figure 53).

The antennal pairs are smaller than the female but similar in structure (Figures 43 and 44).

Mandible (Figure 45)—The quasi-molor is shorter than in female and has a constricted neck region.

The I and II maxillae (Figures 46 and 47) similar to that of the female.

The maxilliped (Figure 48)—The appendage is more elongate. The basal segment is more than twice longer than the second one. The distant segment is veryshort conical and carries four outwardly directed curved teeth.

My observations based on 90 specimens of *Irona robusta* differs from the description of Nair in the following :—

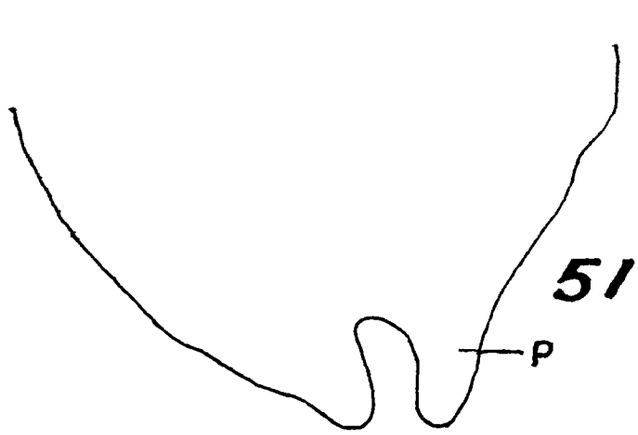
1. *Female—Colour*—White with telson always light gray in live specimens colour of telson not mentioned.

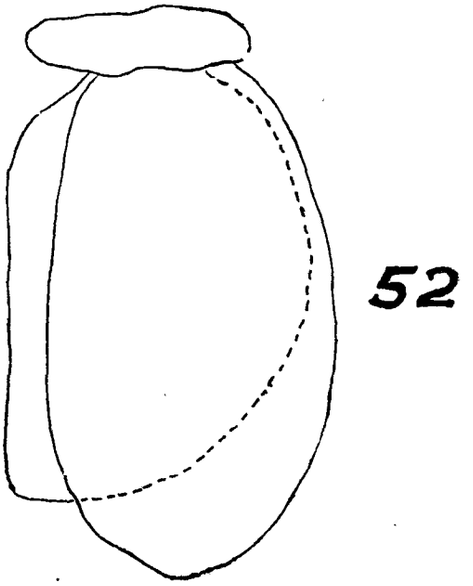
2. *Size* parasites ranged from 20—31 mms: Nair has recorded a size range of 24—28 mms. only.

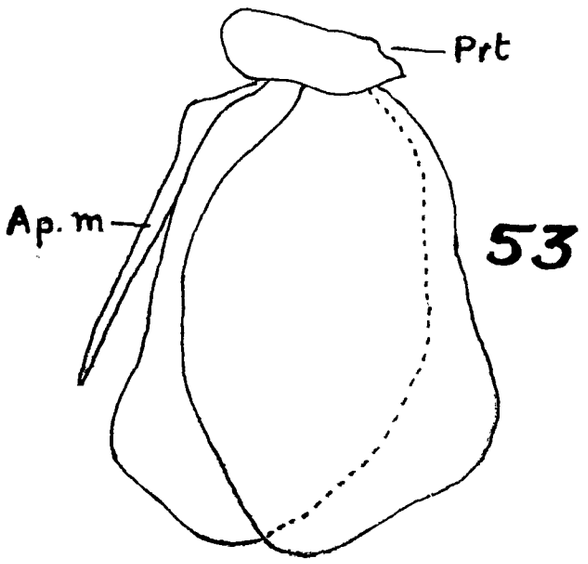
3. Description of abdomen, pleopods, etc., meagre and incorrect.

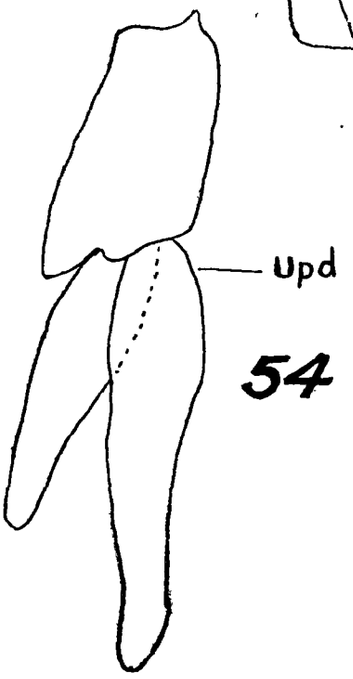
4. *Antero lateral angles* absent in first thoracic segment, faintly indicated in second and third and distinctly marked in the last four thoracic segments.

5. *Epimera*—Not distinct in first. Those of second and third are narrow and do not reach the post-margins of the segments. Those of fourth seventh are much larger and longer on the longer side, the last two reaching the whole length of the respective segments. On the shorter side those of fourth to seventh are much shorter than those of the second and third segments and are broader. Those of the fourth and fifth almost or nearly reach the posterior margin of the respective segments where as those of the sixth and seventh just reach the posterior margin of the respective segments. Description given by Nair is very incorrect.









6. *I. antenna.*—The terminal joint of the eight-jointed antenna is always rounded. This is not mentioned by Nair.

7. *II. antenna* always nine-jointed and *not eight jointed* as described by Nair.

8. *Mandible.*—(Figure 32) with quasi molar as in *I. nanoides* and *I. striata* but extending beyond the three-jointed palp. The palp is not two-jointed as described by Nair.

9. *II maxilla* (Figure 35) is distinctly bilobed with the outer lobe carrying three outwardly directed spines and inner lobe with one spine —not three on the inner and two on the outer.

10. *Maxilliped* (Figure 36) the number of spines in the distal segment of the appendage is uniformly four and not five as described.

11. *Pleopods* (Figures 38 and 39)—The exopodite of the pleopods are always broader than the endopodite and almost cover the latter. The exopodites are not narrower than the endopodites as described by Nair.

1. *Male—Colour.*—Light purple or light brown in live specimens. Males are more symmetrical than females. The colour is not mentioned by Nair.

The general description of males is meagre.

2. *I. antenna.*—Eight jointed with terminal segment rounded and blunt not more acute as described.

3. *II. antenna*—Nine-jointed. Details of joints not given.

4. *Mandible I and II maxilla* are not described.

5. *Antero lateral angles and epimera* not described.

6. The II abdominal segment is less covered in male than in females.

7. A pair of penis and a pair of appendix masculina are present in males which are not described by Nair.

A DETAILED KEY TO THE KNOWN SPECIES OF IRONA.

Species	*I. melanosticta.*	*I. foveolata.*	*I. nanoides.*	*I. nana*
Locality ..	S. Australia, Africa, Japan Sandwich Island.	S. Africa ..	Ceylon ..	America .. ..
Host	*Hyporhamphus intermedius Belona* sp. *Tylosurus chorum.*	....	....	*Hemiramphus* sp. ..
Other Characters : 1 Size ..	♂ 15×6 mm. ♀ 22×13 mm.	♀ 20·5 × 10·5 mm., 14·5×8·2 mm.	♀ 10×5·5 mm. ..	♀ 8—18 mm.
2 Colour	Yellowish white with faint bluish tinge. Telson except posterior margin bluish black.	Yellowish with dark dots. Telson, grayish, Epimera white. Lat. Angles of 5 ab. segments white. Almost whole telson is grayish.	Yellow, epimera whitish ..	Yellow with large or small dark branching spots arranged in transverse rows scattered over the middle of the body.
3 Head ..	♂ Proportionately longer in males.	....	....	Small, sub-triangular or sub-conical, $\frac{1}{3}$rd or $\frac{1}{4}$ th as wide as the 4th segment of the thorax. Much wider than long, deeply immersed.
4 Relative length to breadth.	♂ $2\frac{1}{2}$ times as long as broad. ♀ $1\frac{3}{4}$ times longer than broad	Nearly twice as long as broad.	Nearly twice as long as broad.	Body subovate or ovately produced, $1\frac{1}{2}$ or 2 times as long as broad. (5 : 3 or 2 : 1).
5 Upperlip (Labrum).	Faintly emarginate ..	Not four lobed as in *I. nanoides.*	....	....
6 I. Antenna ..	Peduncleand flagellum not distinct eight jointed.	Not described	*Eight jointed*	Rather compressed eight jointed and widely separated.
7 II Antenna ..	Ten jointed	Do.	Ten jointed	Nine jointed subfiliform ..
8 Mandible ..	Palp stout without setae.	No vomerine teeth in the quasimolar process, four spines in terminal joint. Stout first joint for the palp. Protopodite with a quasimolar process.	Not described	Not described .. ..
9 Maxilliped ..	Apex with three hooked spines.	Not described	Two apical hooks plus one Subapical hook.	Do.
10 I. Maxilla ..	Apex with three spines the other two appear to be broken off.	Do.	Tipped with five spinules ..	Do.

the known species of Irona

I. far.		*I. renardi.*	*I. robusta.*	
Madras		S. Australia	Madras.	
Hemiramphus far		*Tylosurus ferox T. macleayana*, and other T. species.	*Tylosurus Licurus.*	
♂	♀		♂	♀
12—18 mm. 16 × 5·5 mm.	22 × 9 mm. 18—26 mm.	20 mm. long	20·5 × 8 mm.	31 × 14 mm.
Brown ground colour with dark brown striations. Sometimes few of the anterior or posterior thoracic segments without striations. Epimera and telson white.	Yellow with dark brown or black transverse segmental striations. Epimera yellow or white. Telson white.	....	Light purple or light brown. Head dark brown in colour.	White with telson always light grey.
Dactyli with brown tips: Brownish circular areas at the junction of the dactyli with propodi in all the peraeopods of both sexes is characteristic.				
Small roughly triangular.	Very small and nearly one fourteenth of the total length and is deeply set in the thoracic segment.	....	Semi-circular; rather immersed in the thorax.	Small squarish and deeply sunk in the first thoracic segment.
Nearly thrice as long as broad.	Nearly 2½ times as long as broad.	....	Nearly 2½ times as long as broad.	More than twice (nearly 2¼ times) as long as broad.
Simple	....	....	....	....
Eight jointed ..	....	Eight jointed	Eight jointed ..	Eight jointed.
Nine jointed ..	....	Nine jointed	Nine jointed	Nine jointed.
Palp not setose in females. Similar to that of nanoides, the quasi-molar process with anterior brown spine and posterior white sharp tooth.		Not described	The quasi-molar is shorter than the palp with a constricted neck region.	With a quasi-molar extending anteriorly beyond the palp. The palp is three jointed.
Varying from 4 to 8; usually 4—3 apical and 1 sub-apical spine.		....	The basal segment is more than twice longer than the second. The distal very short and carries four outwardly directed curved spines.	..
Four spines one of which is largest		...	Same as in females ..	With four teeth one of which is conspicuous.

Species.	*I. melanosticta.*	*I. foveolata.*	*I. nanoides.*	*I. nana.*
11 II. Maxilla	Two lobes each bearing three hooked spines.	Not described	A membraneous apical margin plus a process carrying small hooked spines.	Not described.
12 Nature of abdomen.	....	Lateral edges of first pleon alone overlapped. The five segments are very distinct.	First two pleon are overlapped, third and fourth and fifth distinct, short but wider than telson.	....
13 Pleopod	First and second exopodites broader but shorter than Endopodites. Male stylet shorter than endopodite extending two-thirds of it. Peduncle with prominent epipod.	....	.. .	....
14 Telson	♂ Almost long as broad, apex broadly rounded. / ♀ As long as broad.	Pockmarked, very thin, large membraneous sometimes with distinct, very faint median keel on the dorsal surface.	Almost semi-circular and narrower than the last three pleon segments.	Narrowly sub-triangular, little narrower than 5th abdominal segment. Almost $1\frac{1}{2}$ times broader than long, $1\frac{1}{2}$ times longer than other abdominal segments.
15 Uropods	Much longer than telson. Inner ramus one-third as long as telson, outer $1\frac{3}{4}$ times as long as telson.	Shorter than telson, outer ramus shorter than the inner and with large and sub-acute end.	Shorter than telson, subequal oval branches little longer than peduncles.	Longer than telson, outer longer acute, sickle-shaped and flexuous. Inner shorter.
16 Epimera	♂ Pendulous Second and third deepest, posterior margin truncate, fourth small, fifth to seventh sub-equal and posterior margin rounded. / ♀ Second and third narrowest, fourth much the largest, sixth and seventh intermediate in size.	Second, third and fourth very narrow fifth broader and posteriorly more produced. Epimera of sixth and seventh much broader and more produced rising above the dorsal surface of the thorax and turned outwards and upwards.	Sixth and seventh are much broader and produced posteriorly than others. On each side they rise considerably above the lateral part of the dorsal surface so that these are turned outwards and upwards.	Epimera usually unequally produced.' First three epimera narrow long and posteriorly rounded. The other three pairs rounded short wide, gradually increasing in width and truncately rounded. Anterior three do not reach the posterior margin of the segments but the three posterior epimera almost reach the posterior margin of the segments.
17 Antero-lateral angles.	Second and third segments not marked off by oblique grooves in males as in females. Females sp. curved to the left.	Not described	Figure shows in only fourth fifth, sixth and seventh segments in females.	Not described.

the known species of Irona—*cont.*

I. far.		*I. ronardi.*	*I. robusta.*	
Bilobed with four sets of two spines each. Thus total of 8 spines.			Same as in females ..	Bilobed outer lobe carrying three spines and inner carrying one spine.
♂ Only first segment is hidden. The remaining four are very distinct.	♀ First pleon completely hidden. Second overlapped partially, laterally the last three very distinct and second quite distinct.	Not described	♂ Second Abdominal segment is less curved than in females.	♀ Broader than seventh thoracic segment. First segment completely and second almost completely and third partially hidden by last thoracic segment. The last two are fully exposed. Fifth segment markedly longer than the preceding four.
In the one pleopod, exopodites and endopodite equal in length. Exopodite of eleven longer and the stylet as long as the short endopodite, No epipod in the peduncle.		Eleven pair of pleopods with a pair of appendix masculina in the endopodites.	Second pair of pleopod with a pair of appendix masculina in the endopodites.	♀
Nearly 3½ times as long as the other pleon segments together. Large and white membraneous. More than 1½ times broader than long.		Not described ..	Slightly longer than broad.	Broader than long.
♂ Longer than telson. Exopodite longer than endopodite.	♀ Shorter than telson, protopodite of females with a internal distal spine.	....	♂ Longer than telson ..	♀ Much loner than telson
♂ Those of second and third are larger than those of the following pairs. The posteri r four pairs are smaller of which the last is the largest. All are narrow and elongate. Not oval or flattened as in females.	♀ Those of second and third segmont narrower and elongate those of the last four segments broad, oval and flattened.	....	♂ Epimera of second and third segment are the largest and almost reach the posterior margin of the segments. Those of the last four pairs are nearly half the size of the preceding two and placed slightly dorsally above the level of the second and third epimera. Those of fourth and fifth do not reach the posterior margin of the segments. Those of sixth and seventh reach.	♀ Second and third are narrow and do not reach the posterior margin of segments. Fourth to seventh are much longer and larger on the longer side. the last two reaching the whole length of the segments. On the shorter side, the last four pairs of epimera are not longer than the preceding two, but are short and slightly broader.
♂ The last three only are clearly marked, that of fourth faintly indicated. Absent in the first three segments.	♀ Antero-lateral angles of all thoracic segments but first are clearly marked off.	....	♂ Absent in the first segment marked only in the last four pairs of thoracic segments	♀ Absent in first segment. faintly indicated in second and third segments and distinctly marked in the last four thoracic segments.

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KEY TO LETTERING.

1. A.—Antennule.
2. Ab.—Abdomen.
3. Ant.—Antenna.
4. Ap.m— Appendix masculina.
5. Ant. I. an.—Antero-lateral angle.
6. B.—Basis.
7. C.—Cephalon.
8. Cl.—Claw.
9. Ca.—Carpus.
10. D.—Dactylus.
11. E.—Eye.
12. En.—Endopodite.
13. Ep.—Epimera.
14. Ex.—Exopodite.
15. I.—Ischium.
16. Msp.—Marsupium.
17. Mdb.—Mandible.
18. Mdb. plp.—Mandibular palp.
19. Me.—Merus.
20. Mx.—I Maxilla.
21. Mx. II—II Maxilla.
22. Mxp.—Maxilliped.
23. P.—Penis.
24. Prt.—Protopodite.
25. Pro.—Propodus.
26. Pl.—Pleopod.
27. Pig. sp.—Pigmented spots.
28. Sp.—Spines.
29. T.—Telson.
30. Th.—Thorax.
31. Upd.—Uropod.
32. Q.M.P.—Quasi-molar-process.

ON THE LARVAL STAGES OF IRONA FAR

BY

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Though the adult of different species of *Irona* are described, the larval stages have not been described in detail so far. Schioedte and Meinert (1884) describe only the '*Pullus Stadii secundi*' of *I. renardi* and *I. nana* with figures of the larva and terminal segment of a typical peraeopod. In the description, the antennules are said to be eight jointed and antennæ nine jointed.

Hansen has recorded '*Pullus stadii primi*' of *I. foveolata* and has figured telson and uropods and second leg. The uropods are shown longer than telson with the outer rami longer than the inner rami unlike in the adult. No description is however given except that the young one at this stage is very similar to those of genus *Livoneca* drawn by Schioedte.

This is the first detailed description of both '*Pullus stadii primi*' and '*Pullus stadii secundi*' of any species of *Irona*. As both the stages of the larvae were found in large numbers in the marsupia of berried females of *I. far*, the larvæ as well as all the appendages have been drawn with the aid of camera Lucida and described in detail.

On the ventral side of the adult female is found a marsupium formed by four pairs of foliacious, striated white oostegites. This marsupium forms a cradle for the developing young. 225 to 400 larvae are found closely pressed and packed within each marsupium. Larvae of two stages were observed.

LARVA OF I STAGE

Colour and size.—(Fig. 1) is light purple or greenish in colour with prominent black eyes. Numerous stellate pigment cells lie scattered all over the dorsal region of the larva. The tips of the claws are not pigmented. The pigmented areas at the bases of the dactili found in the adult are not observed at this stage. It ranges in length from 2·5 mm. to 3·75 mm.

	Length.	*Breadth.*
Size	2·6 mm.	×0·9 mm.
Head	0·3 mm.	×0·45 mm.
Thorax	1·1 mm.	×0·9 mm.
Abdomen	1·2 mm.	×0·5 mm.
Telson	0·46 mm.	×0·4 mm.

General appearance.—The larva as early as this stage looks *slightly asymmetrical* and probably indicates *the sex. The smallest larva is about 2·6 mm. long and 0·9 mm. wide at the broadest region of the body.* It is nearly thrice as long as broad. The *cephalon* is about one-fourth the length of the thorax and proportionately much larger than in the adult. It is nearly one and a half times broader than long and has a broad front anteriorly from which the antennal pairs are seen to spring. The eye is 0·25 mm. long with a diameter of 0·1 mm. granular, black, marginal and occupies the entire lateral margins of the cephalon behind the antennal pairs. The *thorax* is markedly wider than the abdomen which is nearly as long as the former but narrower. The relative length of the thoracic segments at this stage varies. The broadest region is that of the fourth and fifth and sixth segments. It is nearly twice as broad as the abdomen. The first six segments show a pair of appendages each while the last is without any as usual. The limbs are very slender, cylindrical and provided with simple straight claws whose tips are sharp. They are all similar, varying, only in size. The last thoracic segment is clear even in the earliest larva of the I stage and is slightly narrower than the preceding segment while it is broader than the abdominal segments.

The *abdomen* is markedly narrower than the thorax, and nearly as long as the thorax (1·2 mm. ×0·5 mm.). The first three segments are longer than the fourth and fifth and the posterior angles are more pronounced. The telson is well developed, shield shaped, with a broad anterior margin 0·5 mm. wide, while posteriorly it is narrower with a rounded tip. It is longer than broad. All the pleopods are similar. No sexual characters can be observed at this stage.

Appendages—The Antennule.—(Fig. 2) is eight-jointed as in adult, flat and broad and blunt tipped. All the joints except the last are short, roughly squarish and devoid of setules while the last is rounded distally and shows the rudiments of five to six aesthetases.

The Antenna.—(Fig. 2) is nine jointed and *much narrower and more delicate than the antennule* and tapers to a pointed tip. The fourth, fifth and sixth segments are longer than the rest. The tip carries the rudiments of four aesthetases.

The Mandible.—(Fig. 3). The bilobed quasi molar of the adult is not developed. The palp is thick, three-jointed, of which the second is the longest while the terminal is short with a rounded tip.

The I Maxilla.—(Fig. 4) is a simple appendage Unlike in the adult it is devoid of any spines or even rudiments of them.

The II Maxilla.—(Fig. 5) is bilobed. The outer lobe is much larger and longer than the inner. The teeth seen in the adult are not developed.

The Maxilliped (Fig. 6) is well developed, three-jointed and about 0·21 mm. long. The basal joint is the largest with a length of 0·11 mm. while the second is slightly shorter and 0·08 mm. long. The third is the shortest about 0·02 mm. long and shows at its summit a short conical tooth directed outwards. The other teeth have not yet appeared and this is the only difference from that of the adult.

The I Thoracic appendage.—(Fig. 7) is nearly 0·88 mm. long. Its claw is nearly as long as the propodus and is about 0·2 mm. in length. The *III limb* (Fig. 8) is longer than the first and is about 1·14 mm. long. The claw is stouter and stronger here, longer than the propodus and measures about 0·33 mm. The *last limb* VI pair (Fig. 9) is slightly shorther than the third and is about 1·08 mm. long. The claws are clearly marked from the

limbs and are not curved. The segments are simple and devoid of spines or setules at this stage.

A typical pleopod (Fig. 10) at this stage is about 0·425 mm. long and has a distinct long protopodite 0·12 mms. × 0·09 mm. which is proportionately very much longer than in the adult. The rami are flat foliaceous and spring from a broad base. The exopodite is broader than the endopodite and measures 0·3 mm. ×0·15 mm. while the latter is narrower measuring nearly 0·31 mm. and 0·11 mm. Their margins particularly those of the exopodites are finely and microscopically wavy and devoid of setules. The *uropod* (Fig. 11) is 0·51 mm. long with a short thick basal protopodite 0·02 mm. × 0·125 mm. The exopodite and endopodite are longer than the telson and end in rounded tips. The exopodite is 0·31 mm. × 0·11 mm. and longer than the endopodite. The latter is 0·25 mm. ×0·12 mm. shorter but broader than the former. The spinous processes in the adult is not observed here. As in the pleopods, the margins of the rami are microscopically wavy indicating the rudiments of the formation of setules.

LARVA OF II STAGE

Very soon this larva passes into the next stage. The larva of II stage differs from that of I stage in the following characteristics :—

(1) Size, colour, shape.

(2) Structure of cephalic appendages.

(3) Structure of few anterior thoracic appendages.

(4) That of abdominal appendages.

(5) In the development of statocyst in the exopodite of the uropod.

The larva (Fig. 12) is about 3·75 mm. long. The hitherto scattered pigment cells arrange themselves in transverse series along the anterior and posterior margins of the segments. It is faintly but distinctly striated at this stage. The larva is greyish in colour. The tips of the claw are not pigmented and the pigment dots at the bases of dactyli are also not recognisable even now.

Total length—3·75 mm. ×1·1 mm.

Head—0·5 mm. ×0·75 mm.

Thorax—1·5 mm. ×1·0 mm.

Total length abdomen—1·6 mm. ×0·8 mm.

Telson—0·6 mm. ×0·6 mm. and 0·05 mm. posteriorly.

General appearance.—The body has become narrower and more elongate so that the thorax looks slightly broader than the abdomen. The abdomen which was much narrower has become broader. The larva is about $3\frac{1}{2}$ times longer than broad. The head is roughly semi-circular and the broad front has narrowed slightly and bent downwards. The eyes are 0·28 mm. long with a width of 0·25 mm. and have become rounded and occupy most of the mid lateral region of the cephalon. The anterior four thoracic segments are longer than the posterior three. Of the former, the third is the longest and about 0·33 mm. long. The broadest region is that of third and fourth segments. Of the three posterior segments, the last is the shortest. It is nearly as broad as the first pleon segment. The epimera are faint and flabby. The abdomen is not constricted from the thorax. The latter gradually continues as the broadabdomen which is 1·6 mm. without uropods and 1·8 mm. including the uropods. It is longer than the thorax. Telson is nearly as broad as long. There is no apical constriction here as is observed in *I. foveolata* (Hansen). The pleopods and uropods are microscopically fringed with long setules.

Appendages.—Antennules (Fig. 13) is nearly 0·47mm. long. It has not increased in length but is very different in structure. The three basal segments which are square have become 0·075 mm. long and are the longest. The fourth and fifth segments though smaller than the former is stouter than the sixth. The sixth seventh and eighth are elongate, and narrower than the rest (0·017 mm. diameter). The distal segment is very elongate and ends in a rounded tip and carries two aesthestase setae. Of these the posterior is longer and 0·085 mm. long while the anterior is shorter and only 0·065 mm. long. The distal anterior margin of the sixth segment carries 2 short aesthestase setules while that of seventh carries one. The distal segment has become very finely delicate in this stage. The segments have become much narrower, elongate and setose and very different from that of the I stage larva where they are stout flat and stumpy.

The *Antenna* (Fig. 14) has become comparatively longer and larger in size. From 0·5 mm. it has grown to 0·6 mm. long. Here the segments do not show any difference in the general shape as in the antennules. All the segments are more or less rectangular and elongate. The fifth and sixth are the largest and have a diameter of 0·058 mm. and the eighth is the shortest while the ninth is conical, fine tipped and ends in a tuft of five to six aesthestases. The appendage is 0·05 mm. thick at the base and 0·015 mm. at its tip. The fifth segment bears one asthestase setae in the distal anterior margin and three such at the inner margin. The sixth and eighth segments bear one and two such setae in their distal anterior margin. Ordinary setae are not found in any of the segments. Such specialized setae are said to be associated with the sense of smell and occur in the antennules and often in the antennae of most crustacea. [Lankester (1909)]. The cuticle here is extremely delicate. These are slender and tubular showing a partician in the middle when they are long. In the shorter tufts such particians are not conspicuously observed.

The *Mandible* (Fig. 15) is 0·36 mm. long including the setules of the palp which is nearly 0·25 mm. long. The segments of the palp are narrower than those of the I stage. The protopodite has become longer and is about 0·9 mm. long. The distal region of the protopodite which was simple, rounded and setose has become expanded and modified into a quasi molar like process much like that of the adult. The anterior tooth of the process is not brown as in the adult. I *maxilla* (Fig. 16) is about 0·18 mm. long and 0 032 mm. at the base and 0·0175 mm. at the tip. At this stage it shows four more or less similar conical sharp teeth as in the adult. The teeth are about 0·016 mm. long. II *maxilla* (Fig. 17) is about 0·175 mm. long and 0·015 mm. broad at the base. Distally it is slightly narrower. The plain lobes of the larva of I stage now show four conical spines 0·0175 mm. long in each lobe distally as in the adult. They are not located as four sets of spines. Most probably the differentiation and location of these spines take place at a still later stage. The *maxilliped* (Fig. 18) is nearly 0·28 mm. long and 0·08 mm. broad at the base. The basal segment is rectangular, larger and measures 0·135 mm. × 0·08 mm. The second is slightly shorter than the first but as broad as that segment and measures 0·11 mm. × 0·08 mm.

The distal segment is the shortest, conical measuring 0·035 mm. × 0·0175 mm. and shows at its summit three outwardly directed curved teeth. The fourth one at the base has not developed yet. The teeth are nearly equidistant from one another.

The six pairs of thoracic appendages at this stage show a marked increase in length and size. The first three pairs differ much from the last three pairs and show very elongate, curved and toothed dactyli and are thus best adapted for clinging to a suitable host. The structure and number of these teeth are variable. The propodus of all the appendages show three short strong spines at their inner margins while the carpals of second to seventh also show one short spine each. The I *thoracic leg* (Fig. 19) has grown to about 1·1 mm. long. The claw is 0·31 mm. long and carries nine to eleven short conical teeth at its basal inner margin. The tip is plain and long and used for clinging. The merus and carpus are nearly equal and short. The propodus at its inner margin shows three conical spines. The III *thoracic leg* (Fig. 20) is about 1·3 mm. long and longer than the first. The basis is much enlarged here while the merus is more elongate than the first pair and is as long as the *Ischium*. The carpus is the shortest segment and unlike in the first carries a tooth at its anterior inner margin. As in the first, the propodus is nealry as long as the basis and bears three spines at its inner margin. The dactylus is much longer, is 0·38mm. long, is greatly curved and shows about eleven to thirteen longer conical teeth. The free tip of the dactylus is also comparatively longer here. The second pairs are similar in structure and present the following characteristics. *Last thoracic leg* (Fig. 21) is about 1·19 mm. long and is slightly shorter than the third leg. As in the first pair, the merus and carpus are short and equal in length. The carpus carries a spine at its inner margin. The propodus as in all carries three spines. The dactylus is 0·28 mm. shorter than those of the anterior pairs and more curved but simple as in the larva of the I stage. The pleopods are all similar but are much different from those of the I stage larvae.

A typical pleopod (Fig. 22) is nearly 0·48 mm. long. The protopodite is differentiated into coxopodite and basipodite, is broader than long measuring 0·175 mm. × 0·2mm. The proximal segment, coxopodite is much shorter and slightly narrower than the distal basipodite and is 0·065 mm long and 0·16 mm. broad. The distal basipodite is twice as broad as long 0·2 mms. × 0·1 mm. and is modified for swimming. The inner distal margin of the basipodite carries a tuft of coupling hooks (retinacula) (Fig. 22) Each retinacula consists of four simple long curved hooks directed backwards and outwards measuring about 0·06 mm and a longer pinnate setule 0·8 mm. long. These hooks are used in coupling together the appendages of each pair so that they can work forwards and backwards efficiently as paddles. Such retinacula have been observed from some adult free-swimming isopods. Here retinacula are absent in the adult. The exopodite is 0·3 mm. × 0·18 mm. broader than the endopodite with a narrow distal end. The endopodite is 0·29 mm. × 0·14 mm. is slightly narrower than the exo and broader at its distal end. The free distal margins of both the rami are fringed with long, pinnate setules of about 0·07 mm. length. The outer margin of the endopodite which is overlapped by the exopodite is devoid of setules while, that of the exopodite is setose to nearly half its length from the base. The basal inner margin of the endopodite shows a number of small simple setules. Perhaps these also aid in coupling the appendages together. Both the rami serve as respiratory and natatory organs. The latter function is indicated by the marginal setae and the presence of group of coupling hooks on the inner margin. The *uropods* (Fig. 23) shows a marked change. These also are fringed with pinnate setules but their position differs. Each is about 0·75 mm. long, and the protopodite measures 0·29 mms. × 0·15 mm. The exopodite is 0·4 mm. and 0·13 mm. broad while the endopodite is 0·27 mm. × 0·14 mm. and shorter and broader than the former. Unlike the pleopods the outer margin of the endopodite overlapped by the exopodite is fringed with pinnate setules.

The entire outer margin of the exopodite is smooth and non setose while three-fourths of the inner margin from the distal end is fringed with pinnate setae ranging from 0·09 mm. to 0·12 mm. in length. At the distal margin of the exopodite, outer to the pinnate setules, two long sharp simple spines are observed of which outer is short and 0·05 mm. long while the inner is longer and about 0·07 mm. long. The occurrence is interesting and their function is not known. Two such spines are said to occur in the larva of I. *nana* and one in I. *renardi*. Another interesting feature is the occurrence of an oval statocyst. 0·15 mm. × 0·1 mm. in the middle of the exopodite. A few muscles are seen to pass from the inner wall, towards the centre and seem to support a statolith mass. In *Anthura gracilis* and a species of *Anthuridae, Thielmann* has described statocyst in the anterior part of telson. These are the only isopods where statocysts have been observed. To my knowledge no statocysts have ever been observed in any of the larval stages. This is of great interest. The entire structure and development of the statocyst in the embryology of I. far will be dealt with in detail in due course.

The mouth parts of the larvae have become adapted for biting and sucking like those of the adult. Olfactory setules and statocysts are developed. The thoracic limbs specially the anterior three pairs are best adapted for clinging and attachment. The pleopods and uropods are fringed with pinnate setules and coupling hooks. Thus the larva of II stage is well adapted for a free swimming life. These larvae are supposed to leave the marsupuim before the development of the last thoracic limbs. An attempt is being made to investigate the complete life history of this parasitic isopod.

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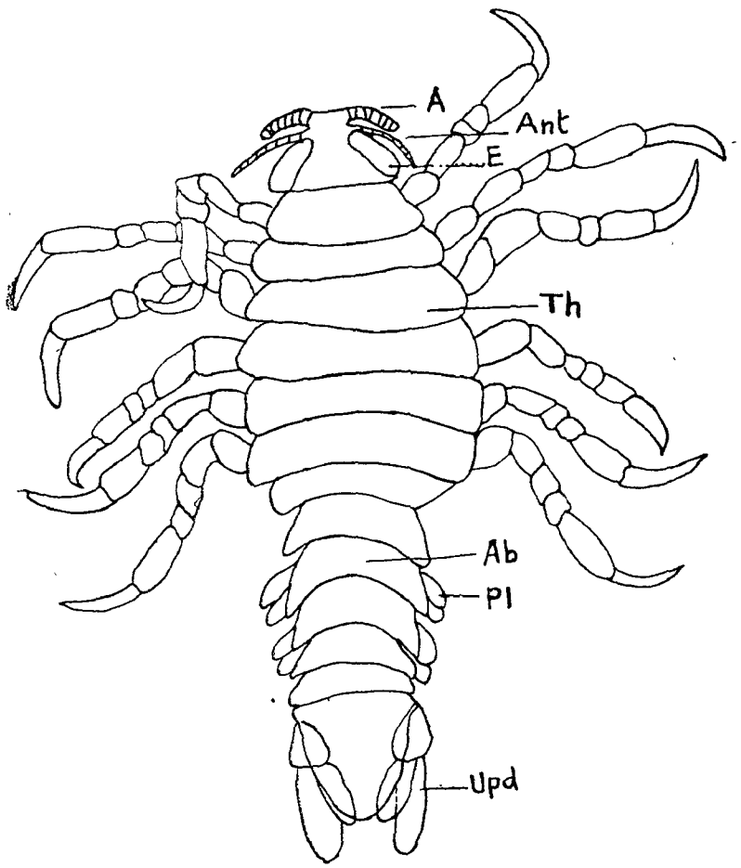
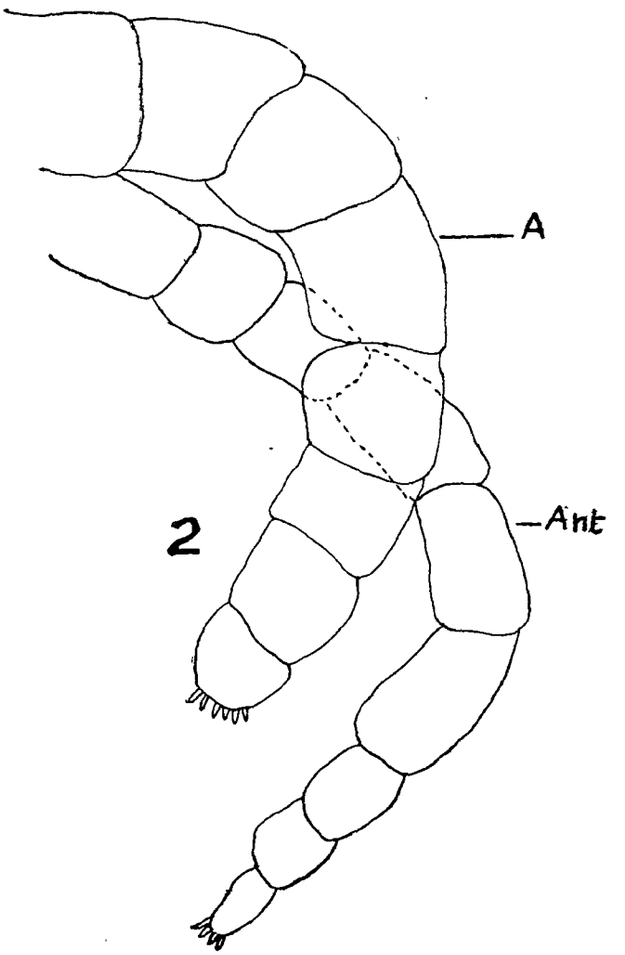
EXPLANATION OF FIGURES.

1	Larva of first stage	x 40	13	I antenna	x280
2	The antennal pairs	x280	14	II antenna	x280
3	Mandible	x280	15	Mandible showing quasimolar process ..	x280
4	I. maxilla and labrum	x280	16	I maxilla	x280
5	II. maxilla	x280	17	II maxilla	x280
6	Maxilliped	x280	18	Maxilliped	x280
7	First thoracic leg	x280	19	First thoracic leg	x 80
8	Third thoracic leg..	x280	20	Third thoracic leg	x 80
9	Sixth thoracic leg	x280	21	Sixth thoracic leg	x 80
10	A pleopod	x200	22	A pleopod	x200
11	The uropod	x200	23	Uropod	x200
12	Larva of II stage	x 40			

KEY TO LETTERING.

1	A—Antennule.	14	L.—Labrum.
2	Ab.—Abdomen.	15	Me.—Merus.
3	Ant.—Antenna.	16	Prt.—Protopodite.
4	Aesth.—Aesthestase.	17	Prp.—Propodus.
5	B.—Basis.	18	Pl.—Pleopod.
6	C.—Cephalon.	19	P.S.—Pinnate setule.
7	Cl.—Claw.	20	Rte.—Retinacula.
8	Ca.—Carpus.	21	Sp.—Spines.
9	D.—Dactylus.	22	St.—Statocyst.
10	E.—Eye.	23	T.—Telson.
11	En.—Endopodite.	24	Te.—Teeth.
12	Ex.—Exopodite.	25	Th.—Thorax.
13	I.—Ischium.	26	Upd.—Uropod.





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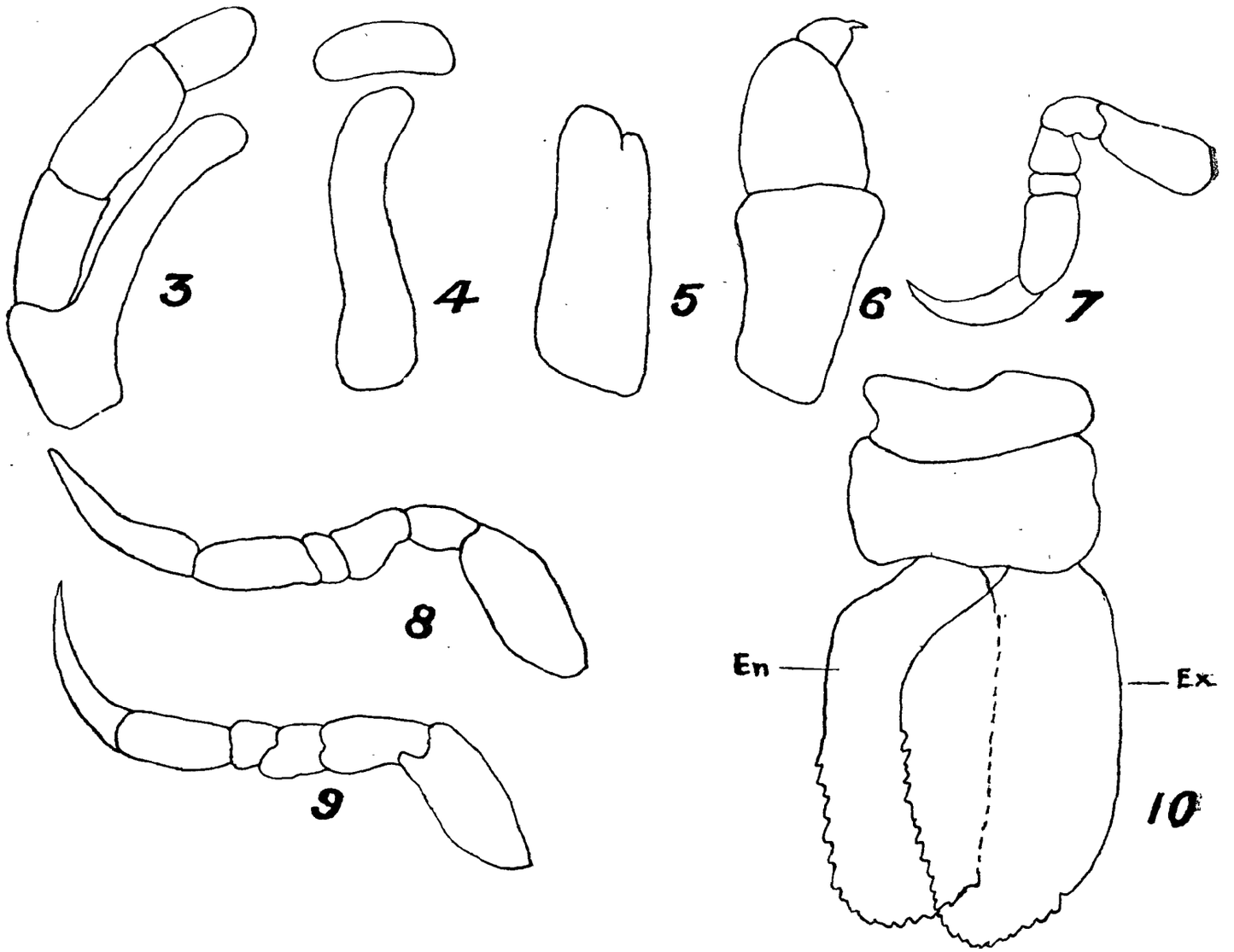
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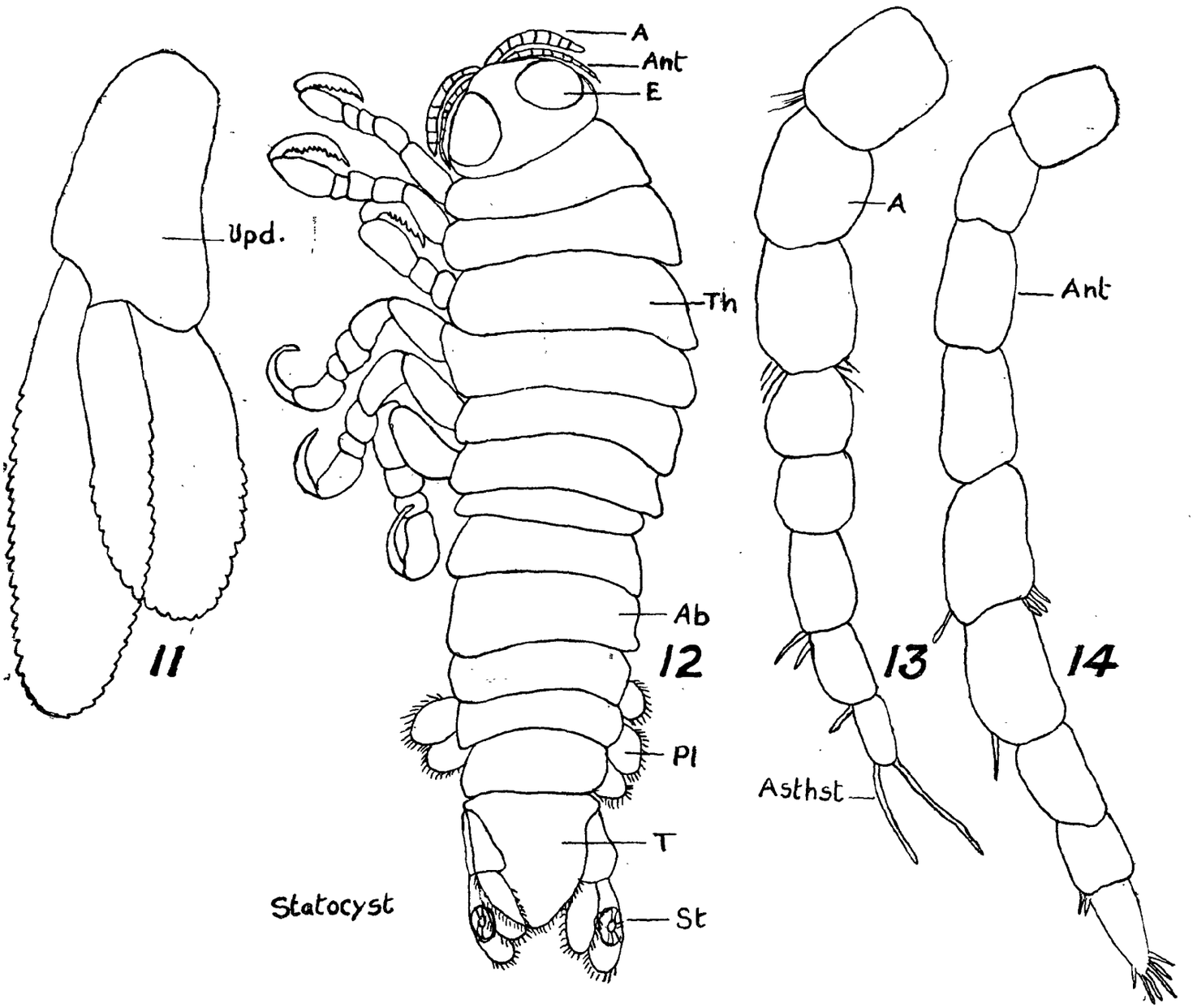
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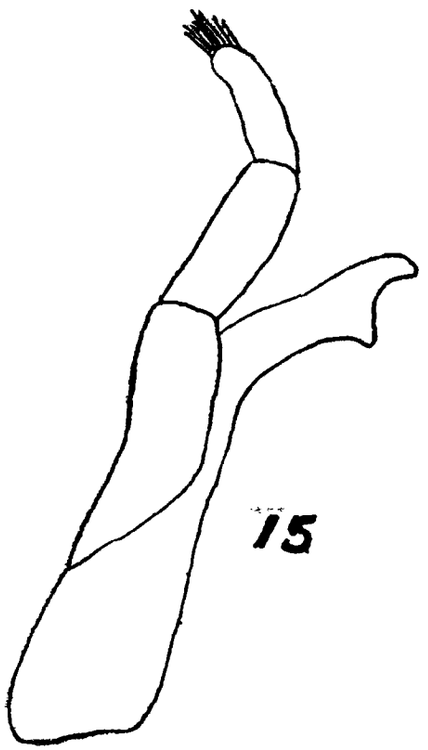

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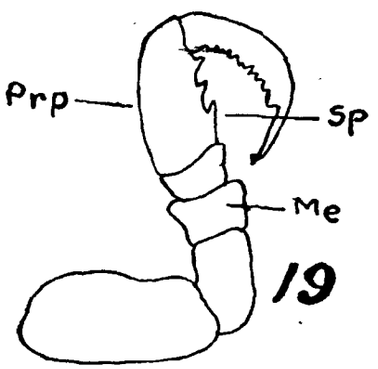

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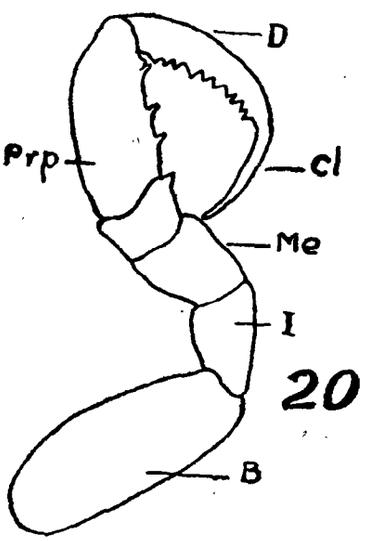

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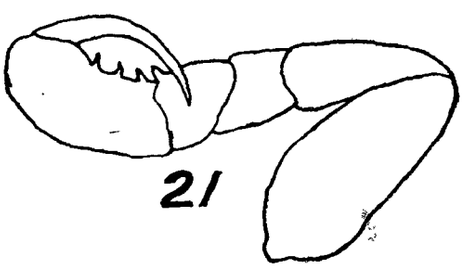

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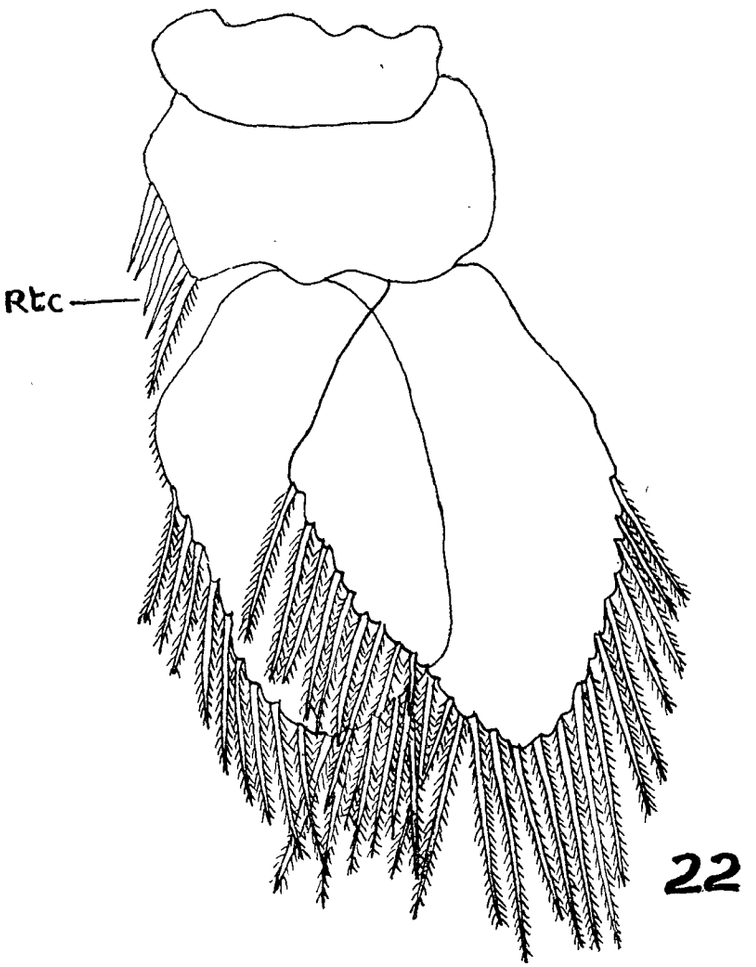

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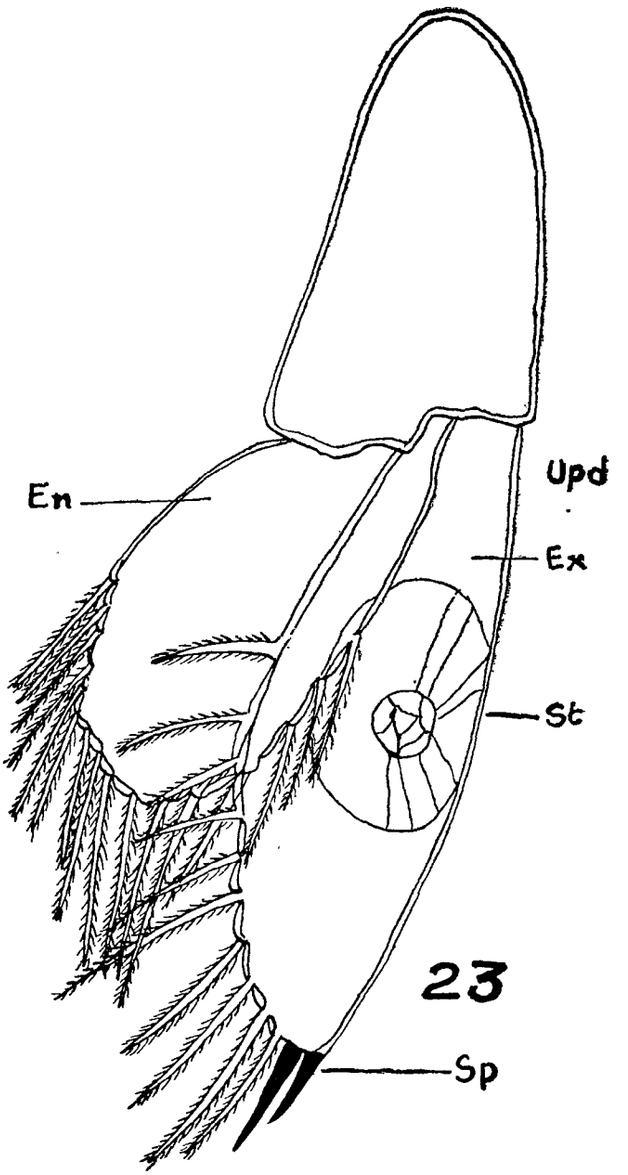

23

PRELIMINARY NOTE ON THE BIONOMICS AND FISHERIES OF THE GIZZARD SHAD, CHATOESSUS NASUS IN ENNORE AND PULICAT BACKWATERS

BY

P. I. CHACKO, A. RAJAGOPAL AND P. MOHANAKRISHNAN.

The gizzard shad, *Chatoessus nasus* contributes to moderate fisheries in the backwaters of Ennore and Pulicat. Statistics of landings of this fish during the triennium, 1959-60, 1960-61 and 1961-62 are given in Table I. The annual catch varied from 8,186 to 19,464 pounds in the Ennore backwater and from 19,939 to 44,829 pounds in the Pulicat backwater. Whereas the fishery has doubled in Ennore it has declined by more than 50 per cent in Pulicat.

Material for this investigation was obtained mostly from Ennore creek and few samples from Pulicat lake. Almost all the specimens were examined in the fresh condition itself, a few being preserved in 5 per cent formalin and examined at a convenient time later. During the period of investigation (1959-1962) a total number of 677 fishes were examined and their standard lengths were taken according to the usually accepted method, namely, from the tip of the snout, when the mouth is closed to the base of the hypurals.

There is difference in the length-weight relationship of male and female individuals. The rate of increase in weight by the fish is little as the fish grows in length up to 110 mm. Then the female fish starts to gain weight up to 180 mm. with a brief pause between 140 and 150 mm. The increase in weight is more rapid after 180 mm. In the case of male, it gains in weight when it reaches a length of 120 mm. and up to 140 mm. There is a pause for the next 10 mm. length and thereafter it begins to gain in weight but not so fast as in the female. Throughout the investigation fishes of the length group, 80 to 120 mm. occured in majority. Fish of length more than 190 mm. are rare. The minimum and maximum size of fish examined is 62 mm. and 229 mm. respectively. The maximum weight attained by the fish is 313 gm.

According to the available material both male and female start breeding when 120-140 mm. in length and spawns when 170 mm. in size. There is a second spawning when 230 mm. in size.

The fish is omnivorous in its feeding. Sand grains were found invariably indicating browsing at the bottom. But mostly it feeds at midwater and consumes what small organisms that come in their way. The following were noted in the stomach contents examined :—

(*a*) *Diatoms* :—*Asterionella*, *Bacillaria*, *Biddulphia*, *Chaetoceras*, *Coscinodiscus*, *Navicula*, *Nitzschia*, *Pleurosigma*, and *Rhizosolenia*.

(*b*) *Filamentous green algae* :—*Spirogyra*.

(*c*) *Blue-green algae* :—*Oscillatoria*.

(*d*) *Protozoa* :—Foramminiferan shells, *Tintinnus* and *Peridinium*.

(*e*) *Coelenterata*.:—Small medusae (rarely).

(*f*) *Annelida* :—Polychaete larva of *Tomopterus*.

(*g*) *Mollusca* :—Larval bivalves and larval gastropods.

(*h*) *Crustacea* :—Copepods, Nauplii larvae, Mysis, Zoea, amphipods and young prawns.

(*i*) *Miscellaneous* :—Organic debris and sand grains.

The fish is caught with stringless cast net (operated by one person), Siruvalai (5 persons), Thattu valai or Oei Valai (10 persons), Konda valai (2 persons), rod and line and occasionally with gill net. Operation of siru valai and thattu valai yields good catches. When the water level is high during flood season another fishing net called Kattu valai (stake net) is operated.

Daily catches are transported to Madras City markets and sold to the public in the fresh conditions.

Three parasitic isopods are found to attack the fish. They are *Cymathoa*, *Anilocra* and *Cerolina*. They are found in the gill region and eat away the gill filaments of the fish.

TABLE I

Showing weight of Chatoessus nasus *landed at Ennore and Pulicat backwaters in* 1959-62 (*Pounds*).

Month.	*Ennore backwaters.*			*Pulicat backwaters.*		
	1959-60.	1960-61.	1961-62.	1959-60.	1960-61.	1961-62.
(1)	(2)	(3)	(4)	(5)	(6)	(7)
April	563	2,949	3,367	2,540	2,994	3,084
May	709	2,166	1,110	3,829	3,084	..
June	1,070	192	1,223	2,803	4,535	1,814
July	1,163	1,348	3,412	4,192	3,357	1,089
August	1,318	2,448	3,548	3,246	2,722	1,905
September	1,045	2,127	276	3,829	1,361	1,814
October	757	1,017	790	12,338	726	1,361
November	2,139	..	840	9,516	..	3,348
December	46	590	757	1,348	3,985	..
January	21	1,352	1,208	..	3,357	..
February	258	68	1,873	..	2,250	3,265
March	297	1,072	1,060	1,179	3,010	2,259
Total ..	8,186	15,429	19,464	44,820	38,381	19,939

FOOD AND FEEDING HABITS OF PERCHES OF TUTICORIN COAST, GULF OF MANNAR

BY

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A preliminary study of the stomach contents of some fishes obtained during survey of the pearl bank Thollayiram par, in 1954 and 1955 was made by Chacko (1959). He found pearl oyster shells in three specimens of *Abalistes stellaris* and suggested that more investigations should be undertaken to ascertain the food and feeding habits of the fishes of pearl banks and their inter-relationships. Chacko and Rajendran (1956) cited the importance of perch fishery in Tuticorin, and indicated the important fishing grounds of these perches in the vicinity of the pearl banks. With a view to continue the work on food and feeding habits of fishes of the pearl banks and to acertain the role played by the perch, *Lethrinus* (Velameen) which has been found by Herdman (1957) to feed upon immature oysters, the present investigation was taken up in 1957.

The stomachs of perches were collected from landing place where the fishermen gut the fishes for salting and curing. The samples were then preserved each separately with a label indicating the date, species and length of the fish. Stomachs of *Serranus undulosus*, and *Lethrinus nebulosus* were obtained in larger numbers than that of other perches. The food was analysed quantitatively and qualitatively for six months from June to November 1957. No definite conclusions could be arrived at beyond indicating certain possibilities, as such work based on small number and within a short period has its own limitations.

RESULTS

I. *Serranus undulosus*. (Local name: *Kalawa*). This fish is common in the catches of fishermen. Ninety stomachs were examined out ofwhich fifty-four were found empty. The length of fishes varied from 30 cm. to 90 cm. The organisms present and their percentage are shown in Table I below in the descending order of percentage.

TABLE I.

Serial number and name of ingredient in stomach.	*Percentage.*
1 Sardines	51·40
2 *Leiognathus*	25·22
3 Miscellaneous parts of fish	9·60
4 Crabs	6·00
5 Prawns	3·10
6 Sand grains	2·18
7 Young *Saurida tumbil*	1·30
8 Other miscellaneous items	0·95
9 Fish scales	0 25

From the above table it is seen that *Serranus undulosus* feeds mostly on fish which forms 87·77 per cent of the total ingredients, of which nearly 51·40 per cent is composed of sardines. Crustaceans contribute to 9·10 per cent and hence form only a minor item of food. The presence of sand grains 2·18 per cent indicate occasional bottom feeding habits. Though pearl oysters have not been noticed in the stomach contents, the bottom feeding habits of the fish indicate that they might occasionally feed upon organisms such as young pearl oysters also occurring at the bottom.

II. *Lethrinus nebulosus*—(Local name: *Velameen*).—This fish is also common in the catches of the local fishermen. Eighty-nine stomachs were examined of which thirty were found to be empty. The length of the fish varied from 24 to 95 cms. The organisms present and their percentage are shown in Table 2 below in the descending order of percentage.

TABLE II.

Serial number and name of ingredient in stomach.	*Percentage.*
1 Sardines	38·56
2 Other fishes	31·40
3 Flat fishes (*Pleuronectidae*)	8·54
4 Pearl oyster shells, flesh and young oysters.	7·70
5 Crabs and appendages	6·44
6 Prawns	3·30
7 *Echinoidea* (Sea urchins and Clypeaster).	1·80
8 Algal matter	1·30
9 Bivavle shells, sand grains, fish scales, etc.	0·76
10 Polycheate worms	0·20

It is seen that *Lethrinus nebulosus* feed mostly on fishes which forms 78·50 per cent of their stomach contents, crustacians form 9·74 per cent and pearl oysters 7·70 per cent, the other food items being of minor importance. This fish feeds at the sea bottom on the fauna and flora there as indicated by the presence of flat fishes, pearl oysters, seaurchins, clypeaster, algal matter, bivalve shells, polychaete worms and sand grains. *Lethrinus nebulosus* feeds mostly on fishes but is a potential enemy to pearl oysters. This requires further observations.

III. *Aprion pristipoma*—(Local name: *Lomia*).—Out of the twenty-six stomachs examined twenty four were empty. The remaining two contained only a small percentage of sand grains. The length of the fishes varied from 31 cm. to 81 cm.

IV. *Serranus salmoides*—(Local name: *Pandari*).—Out of the thirteen stomachs examined eight were empty. The remaining five contained sardines, exoskeleton of crabs, mytilus shells and sand grains. The length of the fishes varied from 40 to 100 cm.

V. *Lutjanus malabaricus*—(Local name: *Kuruvalai*).—The two stomachs examined contained, flesh of fish, gastropod shells, appendages of crabs, vertebrae of fish and sand grains. The fishes measured 51·4 cm. and 96·4 cm.

VI. *Lates calcarifer*—(Local name: *Koduwa*).—The single stomach examined of the fish of 54 cm. in size, contained one prawn 7 cm. in length.

ACKNOWLEDGEMENTS

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MURREL CULTURE AS A COMMERCIAL FISHERY IN MADRAS STATE

BY

SRI T. M. ARUMUGAM, M.A.

" Murrel " is the popular name given to the bony fishes belonging to the piscine group *' ophiocephalidae '*. The latin nomenclature *' ophiocephalus '* means snake headed fish (ophis=snake, cephalus=head). Bloch so named the genus owing to the heads of these having a resemblance to those of serpents. The scales on the head are enlarged and thickened resembling the shields (plates on the head) of a snake unlike those on the body which are of the normal cycloid type

SHAPE

The body of murrel is elongated and sub-cylindrical anteriorly, i.e., the head is flat. Eyes are lateral. Gill openings are wide, the membrane of the two sides being connected beneath the isthmus. There are enlarged and pointed teeth in the jaws giving a very good grip for the fish to hold on to the prey firmly when caught in its mouth. A cavity exists above the true gill chamber called supra-branchial cavity, in which bony laminae tinged with blood vessels, are present. These serve as air sacs for the fishes to breathe when out of water. Due to such an amphibious mode of respiration, the murrel is able to live for lengthened period out of its natural element, i.e., water.

It has a single, long spineless dorsal fin and a similar but shorter anal fin, a more or less circular caudal fin and a thoracic ventral fin. Due to the breadth of its body, the murrel is able to progress in a serpentine manner on ground, chiefly by means of its pectorals and caudal, first one of the former being advanced and then its fellow alternatively. Due to the capacity of this fish to live outside water, to breathe atmospheric air and to move or crawl to a certain distance on ground when moist, some jugglers in China and India, exhibit these fishes walking on the land amusing the onlookers and thereby earn some money. The murrels secrete a lot of slime over their body like eels but not to such a great extent, so that these escape by being slippery while being caught in hand.

DISTRIBUTION

Murrels are freshwater fishes distributed through out India, Burma, Ceylon and the East from elevated localities and the most Inland Districts, to within the influence of the tides. They inhabit both the ponds and rivers and are able to change their place of abode by traversing moist pieces of ground intervening between one piece of water and another. When tanks dry up, these fishes get buried in the slush and hibernate. With the onset of rain these become active again which make some Indian rural folk erroneously to consider them as having descended with the downpour of rain.

O. striatus and *O. punctatus* are very commonly found in ditches, ponds, reservoirs while *O. marulius* are found in rivers where it prefers deeper sections with sandy bottom and submerged rocks. *O. gachua* occurs mostly in rivers than ponds and frequents backwaters with tidal influence.

Generally murrels living in tanks and swamps, delight in basking at the shallow and grassy edges so that they can take in with ease the atmospheric air for purpose of breathing and at the same time capture any prey like frogs, tadpoles, etc., that may uncautiously come close to their lair. Murrels prefer dirty to clean water, perhaps for purposes of hiding. Periodically they stir up the sediment and secrete a quantity of mucus when they appear to be delighted, their colours become quite vivid and then they take to other favourite resort just beneath the surface of the water amongst the weedy margins. When the water becomes settled and clear, it becomes excited and change their resort.

ECONOMIC IMPORTANCE

Murrels are ranked highly with the carps in Bengal. In Punjab, these are regarded as an excellent food fish. In South India, murrels are sought after as a delicious fresh-water food fish. In Burma, Telaings consider the variety, ophiocephalus striatus (Day) as efficacious in cases of sickness. When a person is sick, they purchase a big sized fish of O. striatus, a rope is inserted by the sick through its nostrils like bullock and a group of relatives of the sick gather round it, dragging it round and round to propitiate the offended spirit causing sickness to the individual. Then the fish is offered to the spirit. This religious ceremony is said to remove the illness from the sick man.

The river murrel, *O. marulius*, is not relished in some parts of Bengal and Burma. In the lower parts of Bengal, people abstain from eating this variety on religious grounds. Karens in Burma think that these fishes were formerly men, changed into fish for their sins and so they believe that men eating these fishes, will be transformed into lions (Mason).

The flesh of the fish living in streams and rivers tastes better than those bredinponds, the latter having a muddy flavour. The murrel unlike other freshwater fishes, has a single vertebral column to be reckoned with in the cooked stage and offers safer and delicious culinary effect on its consumers. The flesh of this fish is also not so soft as that of carps and on cooking gives an agreeable flavour. The fish gives better taste when sauce is made with it than when fried.

CLASSIFICATION

The different species are somewhat difficult to distinguish from one another owing to the similarity in colour, the changes in growth due to age and locality and the slight variation in the number of rays of fins and scales. The young ones, as a rule, are of a more or less orange or scarlet colour and possess bright longitudinal bands in the immature stage. Those residing in backwaters, have a purplish tinge.

The colour of the adults vary from olive green to dark brown above, white or deep orange below with brownish

irregular streaks and spots on the sides. The body colour, as stated above, also changes according to the colour scheme of the surroundings when excited.

Day (1865) described 9 different species but he was doubtful of two species being genuine. Jerdon (1848), Hamilton Buchanan, Bloch, Bleeker, Sykes, Mc Clelland, Shaw, Gunther, Lacepede, Peters (1868) and Cuvier and Valenciannes, have all studied these fishes and described them.

The table appended, gives the distinguishing features of classification of the different species of murrel recorded by Day.

However, the following are the important species available fairly commonly in South India:—

Scientific name.	*Tamil name.*	*Telugu name.*	*Malayalam name.*	*Punjab name.*
Ophiocephalus striatus, (Day)	Verahl ..	Korāmeenu ..	Vral ..	Kubrah.
Ophiocephalus marulius, (Blochi)..	Avuri ; Poo-Verahl ..	Poochepa Poomatta ..	Vrahl ..	Sawol Dowlah.
Ophiocephalus punctatus, (Blochi)	Koravai ..	Matta ; Matta gidasa	Koravai ..	Duchinge.
Ophiocephalus gachua, (Ham)	Para Koravai ..	Thullurayis ..	Koravai ..	Doariah.

FEEDING HABITS.

Murrel is an omnivorous and predatory fish. It feeds on worms, insects, small fishes, tadpoles and frogs. Eating the young ones of its own race is not uncommon. They assist in keeping water pure by destroying either animal or vegetable substances that might come in their way.

The fry of murrel especially those of *O. striatus* and *O. marulius*, are predominantly insectivorous in their feeding habits. They feed mainly on dipteran larvae. Copepods like diaptomus and cyclops also are ingested. Cannibalistic tendencies are sometimes noticed. The young ones of *O. punctatus* feed on protozoans (*Paramoecium, vorticella, stylonichia*), daphnids, copepods, dipteran larvae, ephemeropteran larvae, chironomid larvae and filamentous algae.

O. marulius is highly carnivorous in the adolescent and adult stages. They feed on live fish (minnows) and frogs. Only in about 10 per cent of the cases examined, had the fish ingested dead fish and kitchen refuse of animal nature. They are also very cannibalistic so much so in domestic wells and other small pieces of water, no more than a single individual survives. In one instance, a large specimen was noticed to have snapped up fowls and crows which happened to fall into the well.

O. striatus is also predaceous but to a lesser degree than *O. marulius*. It feeds on small fishes, frogs, worms and insects.

O. punctatus has a very negligible piscivorous tendencies. They feed chiefly on aquatic insect stages such as larvae of ephemerids, chironomids, dragon flies, water beetles like cybister and aquatic bugs like Notonecta and Belostoma. Crustaceans like copepods (diaptomus and cyclops) cladocerans and shrimps are also found eaten by this fish. Caterpillars, small rabs, molluscs (*pila* and *Ariophanta*) and weeds like *spirogyra* and *hydrilla* were observed in the gut contents. Fish contributed to only a very low percentage in the natural diet though under aquarium conditions, *O. punctatus* is noticed to swallow small live minnows.

BREEDING HABITS.

Murrels are monogamous. i.e., the sexes are separate. Noticeable sexual dimorphism in the female being much larger than male, is described [Alikunhi (1947)]. It is the reverse in the case of *O. suratensis*. They attain maturity at the size of 30 to 35 cms. (12 to 14 inches) in *O.marulius*, 25 to 30 cms. in *O.striatus* and 12 to 15 cms. in *O.punctatus*. They build nests for laying their eggs. The nest is but a shallow depression cleared in the weedy margins by pieces of weeds bitten off by the breeding ones. Some breed in wells or stone-margined receptacles for water like dilapitated fort moat waters as in Arni, Gingee or others in holes and crevices of boulders among weedy margins of the river banks. While the nests of *O. striatus* are wide and formed in deeper waters, those of *O. punctatus* are formed among the bushes in the shallow crevices at a depth of ($1\frac{1}{2}'$) 44 cms. in ponds, those of *O. marulius* in not more than (4′) 122 cms. depth and (2′) 61 cms. away from weedy margins under shade, from interweaving stems and blades of *vallisneria-O. striatus* is said to construct its nest with its tail among the vegetation near the edges of the tanks. While it bites of the ends of the weeds which grow in the water, the ova are deposited.

Strong parental care of the eggs and young ones in murrel, is an important feature. The male keeps guard and if it is captured or killed, the partner takes the job. The parents, however, jealously guard the eggs and do not seem to take any food during the period of guarding. They look after the young ones till they are able to fend. As the shoals of fry move, the parents hover over the shoal like a parachute. When the young ones grow to independent size, they are driven out or sluggish ones are devoured by the parents who, no longer, cherish the idea of guarding them. It is desirable, at that time, to extricate the young ones which are about 7·5 to 10·0 cms. (2—4 inches) in size from the adults. *O. punctatus* however, abandon their young ones when they are (2 inches) 5·0 cms. long.

Murrels become mature in the first year itself and begin to breed prolifically thereafter. Murrel breed twice a year. It is, however, doubtful whether the same pair participate in the function. The breeding season coincides with the monsoonic months in the case of *O. striatus*, *O.punctatus* and *O.gachua* but not so in the case of *O. marulius*. The breeding seasons are from January to February and June to July in *O.striatus* January to February and July to August in *O.punctatus*, March to June and October to December in *O. marulius*, and December to January and June to July in *O. gachua*. The eggs are large, transparent, golden-yellow or ambre coloured and pelagic. The egg contains a single large oil globule above the golden-yellow yolk. The eggs are 1·25 m.m. in diameter. Oviposition takes place in the night. The eggs laid vary in number from a few hundreds to a few thousands up to

4,000, depending upon the age and size of the fish. Alikunhi (1946) recorded broods of 1,222 fry of 3 to 4 m.m. and 448 fry of 6 to 8 m.m. of *O.punctatus* in Chetpet swamps in the month of December and several pairs guarding the broods. The oval mass are spread like a sheet on the surface in the sub-circular area in the centre of the nest.

The average time of hatching of eggs is 24 hours depending upon the strength of the sun. Within about 8 hours the outline of the embryo becomes evident from the yolk mass, the eyes and auditory sacs are developed within 16 hours. The heart begins to beat and the yolk sac circulation starts soon after this. While hatching, the embryo rotates within the egg sac. On hatching, the larvae measure 3·25 m.m.

The various stages of development of the egg are given below :

Day.	*Length in m.m.*	*Principal changes.*
(1)	(2)	(3)
1	3·5	Yolk sac circulation established black pigment cells develop in the eye region.
2–3	4·5–5·0	Pectoral fins develop-mouth opens respiratry movements begin.
5	6·5	Larvae leave the surface and swim freely at all levels-light yellow spots appear over eggs.
7	7·0	Caudal appendages appear.
12–15	8·0	Posterior end of notochord bent up.
28	9·10	Caudal rays branched and articulated with the basal cartilage—Larvae rise to the surface and begins to gulp air.
37	10	Dorsal and anal rays appear.
40	10·25–13	Rudiment of dorsal and anal fins appear and separated from caudal.
63	17	End of larval development-body organs become established.
73	25	Fry in an active state and plays about hiding in mud.

The process of larval development is more or less the same among the different species except for some accelerated rate of growth in the pre-larval stages in *O. punctatus*. The larvae or fry wander together in rows as if they are moving in a procession, to the bottom sand, on the third day.

CHARACTERISTIC COLOURS OF FRY

O. striatus.—The body is of brown and pink on fourth day. On either side of the body there is a broad reddish orange band (almost to the height of myotomes or body segments) extending from the eye on each side with rounded edges at the base of the caudal fin. There is a light golden occipital point and the base of the anal and dorsal fins, is black along the whole length. This livery persists till the fry reaches a length of about 40 m.m. (three months old fry). Then the colour changes.

O.punctatus.—The body is of black and yellow colour when 4 days old. The colour changes to dark olive along the back and sides becoming slightly pale laterally with close set strips along the sea. Then three longitudinal, golden yellow bands appear on the sides extending from the snout to one-third of caudal fin. Anteriorly one of them thins out and meets its fellow on the tip of the snout, then continues and extends along the base of dorsal fin to the root of the caudal fin as a median dorsal band. This median band is narrow but more distinct in younger stages and has two spindle shaped patches in front of dorsal fin.

As it grows to about 5 cms. (2 inches) in size, the median band disappears, the dark dorsal colour changes into dirty brown patches coalescing with the golden bands, which however persist on the head for a longer time.

O. gachua.—early fry.—There are two horizontal bands of dark brown colour one dorsal and one ventral with a pigmented area between them along the mid-lateral line. Of the two, the ventral band is more conspicuous being very broad on the abdomen and tapering gradually into a sheath posteriorly. A number of pigmented spots are found on the head, a cone of which occurs behind each eye. Scattered spots are found on the continuous median fin.

Later fry.—Body is of pale olive brown and sides are crossed with 10 or 12 bands with their apices on lateral line pointing forwards.

O.marulius.—The fry are golden yellow in colour. When the fry are (an inch) 2·5 cms. in size black pigments appear on the dorsal and the ventral sides, leaving a yellow band on the lateral line. There is often a large ocellus with a light edge on the last rays of dorsal fin. Caudal fin barred or spotted with white or orange.

METHOD OF CAPTURE

Murrels are usually caught by hook and line with live bait such as frogs or minnows. A simple type of trap called the 'murrel noose' (Kannikodi in Tamil), is also used. This is a small bag like structure, two feet long, made of palmyrah fibres or weeds and open at one end the diameter being just about the thickness of a murrel of good size. These are set in shallow waters along the margin among weeds. As the murrel has a habit of swimming into shallow waters and hunting for its prey at night, it unwarily enters those traps and gets caught. Once it enters, it cannot go back as the gills and the pectoral fins will retard the way. The entrapped fish is removed in the next morning.

Is some places like 'Veeranam' tank in South Arcot district, murrels are enticed by lights in the night and when they approach, they are speared with a crude steel weapon or spear.

Usually the capture of murrels becomes prominent during hot weather when shallow, rain-fed and river-fed tanks and ponds, go dry in South India. In every village the fish population including the murrel collection in the bottom of the tanks, falls an easy prey to the cast nets and hand nets of the villagers.

CULTURAL IMPORTANCE

Murrel forms a major bulk of the indigenous fishery of the tanks and ponds of Madras State. Of the four common available species, three species, *O. striatus*, *O. marulius* and *O.punctatus*, contribute to the normal murrel fishery. Two of these three species are carnivorous and even cannibalistic. It is well suited for pisciculture on account of its hardy nature and the ease with which it can be transported and planted. Though it is predaceous, it can be reared in isolated waters. It is easy to collect the eggs of the murrel and hatch them. But it is difficult to rear them into larvae. After a certain stage, they require a special type of live food in the shape of worms, aquatic insects, tadpoles, etc., whereas the adult fishes thrive well on any live food. To secure fry for stocking, a few select breeders can be released in ponds with shallow margins and with plenty of weeds suitable for nesting and fed on a diet of small carps, tadpoles and frogs. After the breeding season, when the fry are abundant, these must be transplanted to marshes teeming with the special type of live food mentioned above and reared to a marketable size.

The earliest attempts in murrel culture in Madras State was by Mr. H. C. Wilson, pisciculture expert of the department in Sunkesula fish farm situated on the banks of the river Tungabadhra near Kurnool. The murrel fry or brood were caught by the use of a special device called the ' Murrel Brood Trap '. It is a square wooden frame of about 91 cms. (two feet) long each and 20 cms. (two feet) high with a fine wire mesh bottom. The frames are pierced with a number of holes. Each frame is made with a sleeve in the top edge so that a number frames can be inserted one over the other. When a brood of murrel is noticed, they are trapped by sinking one or more frames piled up till the edges of the topmost frame stand above the level of water. The eggs most frequently turn opaque due to the attack of water flea and daphnids. When the fry grow to a fairly big size, they are transferred to nursery ponds. Transport of murrel fry is usually made when the usual orange red colour of fry is about to disappear.

Adult murrels never keep in good condition on a diet of artificial food. To maintain a few of them in a pond, an abundance of weeds and a diet of live minnows, carps, tadpoles and frogs are quite essential. In view of the above difficulty, planting them in natural, shallow swamp with abundant vegetation and insect larvae was found to be the best method of culturing the fish. So Mr. H. C. Wilson the pioneer of Inland Fish Culture in our State, selected a vast swamp, Edrur swamp about six miles from Sunkesula and stocked it with the young ones. The adults were fished out annually and stocked in market ponds for regular supply to the Kurnool market. The difficulty of rearing fry was thus counter-acted by the ease of transport. As the fish has accessory respiratory organs to breathe atmospheric air, it would live out of water for a fairly long time.

Taking advantages of this habit special " Murrel carrier " was designed to transport murrels over long distances without water. It is a special kind of tin carrier with a perforated lid and locking arrangement. The carrier itself can hold trays of about 15 cms. (6 inches) height each. One or two murrels are placed in each tray with moist weed to keep the gills wet and to prevent the fish from fighting with its compatriot. The carrier, after filling, is locked up and transported. No water is put in except for sprinkling the weeds with water to keep them wet. In this position they stand transport very well over long distances and can be marketed fresh on reaching its destination.

In Punjab, murrel culture was tried in Madhopur. Five pairs of murrels kept in a tank bred. The fry were grouped and kept separately and fed with different kinds of food, viz. (*a*) goat's liver, (*b*) silk-worm cocoon and (*c*) a mixture of wheat flour, silk-worm cocoon and goat's liver. It was found that those fry fed on (*a*) grew fastest while those in other categories were the bleakest. Further 76 robust fry were stocked in a tank. After a time, only 46 adult fishes of about 35 to 70 cms. (14 to 28 inches) and six fry of about 15 to 18 cms., were caught.

In Bombay, 278 fingerlings of murrels of about 5·0 to 8·0 cms. (2–3 inches) were stocked in a pond in June 1938. Only 42 murrels could be recovered when fished in April 1939. The growth recorded among the recovered ones, however, was phenomenal attaining a maximum of 48 cms. (19 inches) in about 10 months. This encouraged hopes of extensive murrel culture in tanks and ponds. Similar venture of stocking during the next year proved useless. The only difference between the two experiments was that some Megalops were stocked in addition in the first case and not in the second case. It was therefore evident that Megalops served a greater cause as food for the rapid growth of murrel than anything else.

The experiments in Punjab and Bombay make it clear that, under ordinary circumstances, the murrel is not a suitable fish for culture in ponds and lakes. But marshy and swampy areas like Edrur swamp in Kurnool, weedy patches of swamp in Poongar below the Bhavanisagar Dam, in the township below the Bhavanisagar fish farm, etc., which are unsuitable for quick growing carps, can be used profitably for murrel culture provided sufficient live food in the form of tadpoles and frogs, minnows, insects, etc., are made available.

The murrel is comparable to the carnivorous, large mouth Bass of U.S.A. (*Micropterus salmoides*) which is extensively farmed in weedy marshes. Americans have an admirable prolific forage fish, the Blue gill sun fish (*Lepomis macrochirus*) which breeds in large numbers and provide abundant food to the carnivorous Bass. *Tilapia mossambica* Peters imported into India in the recent years, stand a fair comparison as a forage fish to the Blue-gill sun fish. In fact, *Tilapia* is growing so prolifically that the department had to think about exterminating them in certain ponds and tanks. For example, Mariamman Theppakulam in Madurai, was one such tank. The stocking of *Tilapia* yielded some very good results in the first few years of its stocking. In later years, the breeding of this fish became abundantly prolific and the average off-take size of the fish was very small resulting in its poor demand among the consuming public. So measures for mitigating the breeding potentialities and increasing the growth rate of *Tilapia*, had to be thought of. Introducing murrel in association with *Tilapia*, was thought of and murrel fingerlings were introduced into the pond. The results were expected to be bright and encouraging. But it was not so. Yet the matter continues to be adverse as regards *Tilapia*. Though occasional murrel catches were found to give encouraging results, the desired effect was not achieved. Probably *Tilapia*, which is also monogamous like murrel and has similar breeding habits of laying fairly large number of eggs in pits and getting them fertilised has gone ahead of murrel in its properties of parental care and has the

advantage of keeping the fertilised eggs in its mouths unlike the murrel in the nest or crevices, free from all the ravages of the open life in the medium. Its decompressed and broad bodily shape with median fins, have an adverse effect on the voracious avidity of murrel. Thus the experiment did not prove successful. As in Bombay, some other varieties of less harmful fish is to be tried as forage fish for the success of murrel culture. Small minor carps like *Cirrihina reba Barbus spp.* minnows, top minnow, etc., may have to be tried as forage fish for the murrel.

Another instance of ineffectiveness of murrel is recorded by De Zylva. (Ceylon) (1958) Gowrami (*Osphronemus goramy*) which was stocked in some garden ponds in Peradeniya hills in Ceylon, got washed off by sudden floods and the stock seem to have been carried over by floods to the plains through the Mahaweli River. The river gets divided into three branches in the plains before joining the sea. In a village named Allai on one of the branches, murrel population seem to have been predominant when De Zylva visited the place for the first time about 10 years ago. During his second visit, he found that, in the catches, Gowrami predominated forming 90 per cent while murrel formed only 10 per cent. This shows that there was no inhibitive influence of murrel on the growth of Gowrami though murrels were present in the area. Here too the causes may be simple as in the case of *Tilapia*. Gowrami is a fish having decompressed body and having a very pronounced type of parental care. Gowrami lays its eggs in an advanced type of nest built of weeds like bird's nest and the eggs which are fairly large and whitish like pepper corn, are laid in it and guarded by the parents vigilantly. In such circumstances, the approach of murrel to the brood of Gowrami, will be a formidable task. Choosing the proper species of fish with which to stock the farm ponds is one of the most difficult and important decisions facing the pond owner and biologist in America. Great variation in fishing success in lakes containing marshy species has led to trials of a single species or a very simple combination of species.

The success of a species depends largely on its ability to survive and reproduce in the environment and its ability to compete with other species for food and space. Balance of the fish population is important since too few or too many replacements will offset the annual harvest and will usually result in over-population of one or other species if a combination is used. The best single combination in general use today in America, nay in the world, is the Blue gill-Bass combination. It has given the highest return. But fish Bass and Blue gills became good game fish for the owners to devote attention upon.

Various experiments were done to use different combination. Bass with a variety of Sun fish, called Redear Sun fish (*Lepomis microlophus*) was tested. It proved futile because this fish could not produce enough young ones to keep the population in balance. Further the fish is susceptible to sudden changes in temperature. Another fish, Round Flier (*Centrarchus macropterus*) was used in combination with Bass. This fish reproduced earlier than Bass and thus did not produce the desired effect. Certain other fishes tried, did not spawn in the ponds and exhibited low growth and this proved futile. Gizzard Shad (*Dorsoma cepedianum*) was tried with Blue-gill Bass combination. The shad competed very adversely for food with Blue-gill. Since Gizzard Shad would not take in bait or lure, the adults could not be thinned out or controlled by angling. They grew so rapidly that in one or two years, they became too large for the Bass to eat and so over-populated the pond and ultimately curtailed their own survival rate. So Bass yield also went low. Gold fish (*Carassius auratus*) which feed on insects, plankton and plant material was used as a forage fish. For some time it produced large numbers of young ones on which the large mouth Bass fed and grew. However, gold fish grew rapidly and unto a large size this Bass could not eat them. The pond became over populated with gold fish. Blue-gills, however retained the production of gold fish by eating their eggs. Golden shiner (*Notemigonus crysoleucas*) was tried in combination with the Blue-gill. But these competed directly for food and large shiners have been known to eat small fish. Slow growth and limited spawning period eventually led to the complete elimination of this fish by Bass. Top minnow (*Gambusia affinis*) was tried in combination with the Blue-gill Bass combination. These were also entirely eliminated in a few months by the Bass.

In such combination experiments, it is therefore essential to provide some control over the adult forage fish when they become too large for the piscivorous fish to eat. Many forage fish cannot be used because there is no way to control the adults and over-population results. The Blue-gill, however, suited admirably as it breeds throughout summer (May to October) providing a continuous crop of small fish as food for the Bass.

In over ten years of experimentation, the Blue-gill Bass combination has yielded an annual catch of 175 to 200 lb. of fish per acre. The Bass made up of 20 to 61 lb. of this yield in different ponds. Blue-gills and Bass maintained their numbers even under intensive fishing pressure. Paid fishermen could deplete the pond population by 50 per cent only and the catch per unit effort fell low.

The stocking rate for such combination was 100 Bass and 1,000, juveniles or 1,500 fingerlings of average 2 inches length of Blue-gill Sun fish per acre. Bass begin to spawn after they have spent two or three full seasons. So they must be fed well to grow. Since the Blue-gill spawn in their first year at least 50 per cent of the first planting should be of adult size to enable the fish to breed and over-populate the source to begin with. The subsequent crop was maintained naturally by the progeny of adults planted first. The Bass begin to feed on the progeny and keep control over the Blue-gills.

In America, there are over a million small farm ponds. Fish cultivation in these farm ponds is on increase. Some produce as much as 200 lb. of fish (91 kgs. per acre) by the popular Blue-gill Bass combination culture. Blue-gill sun fish (*Lepomis macrochirus*) is one of the widely distributed sun fish belonging to the Perch family. Its weight averages $\frac{1}{4}$ lb. and sometimes weigh 1 lb. Its colour varies usually with faint bars and dark lobes extending back from the gill covers. In short, it resembles *Tilapia*. It is found in Central States in America as far as Colorado. They thrive in farm ponds and lakes. Blue-gill are reported to attain 2 cms. (0 7 in.) $2\frac{1}{4}$ months [Surber (1948)] and 8 cms. (three inches) in 8 months [Bennett (1948)]. One year old Blue-gills average about 24 cms. (9·5 inches) in length, two years old about 14 cms. (5·5 inches), three years old about 6·6 inches and four years old about 20 cms. (8·0 inches). Under very

favourable conditions the growth average 15 cms. (six inches) in 17 months [Krumholz (1949)]. The increase in weight averages 300 per cent in 10 months in Blue-gills [Rounsefell and Everlast (1958)] Blue-gills mature in about twelve months. In America Basses are the finest of fresh water game fish which includes thirty and odd species. These live in warmer lakes and ponds of America and are widely distributed in the native waters. These fishes build nests and the male guards eggs and fry as in murrel. This also belong to perch family. Bass fry are 28 cms. (eleven inches) after thirty days of hatching and attain a growth of 14 cms. (5·6 inches) in 5 months. It becomes mature at the end of two to three years of age. Similarity of the problems of Bass culture in combination with the Blue-gill Sun fishes, arises in the case of murrel culture in our waters which requires deep study with different varieties of the economical forage fishes available in our waters.

As already mentioned, murrel forms an important indigenous fishery in our inland waters. The murrels form the third most important variety of Inland fishes next to carps and cat-fishes in the Madras State, as evidenced by a statistical study made of weight and value of fish supplies of about 50 inland centres in the various districts (Andhra, West Coast and Tamil Nad regions) of the composite Madras State for the quinquennium (1948 to 1952) (Chacko and George) *vide* annexure for the figures of murrel supplied alone tabulated for Andhra West Coast and Tamil Nad regions). It will be noted that there was a significant increase in the total availability of murrels year by year in the Tamil Nad regions during the five years showing an increase of more than 200 per cent at the end of the five years. This shows that murrels form an important fishery in the present Madras State. As separate figures for later years are not available, the progress in the murrel fishery could not be further discussed. Fishing season for carps, cat-fishes and murrels in inland waters generally occurs from January to June which coincides with the period when most of the inland waters go dry.

The importance of the murrel fishery in other areas is also discussed here. In the detailed account of fish supplied to Rajahmundry town in Andhra region, it was noted that murrel formed nearly 4·5 per cent of the total annual fish supply, the supply being uniform throughout the twelve months unlike other fishes. The average rate fetched was Re. 0·31 to 0·34 per kg.

The detailed study of fishery in the Kanigiri-Duvvuru Reservoir in Nellore district was conducted in 1951 by the Department. This reservoir is one of the largest irrigation tank in composite Madras State extending to about twenty square miles with a FTL of 22 feet and an embankment of over fifty furlongs. It holds a permanent supply of water from Pennar river through the Sangam Anicut and irrigates about 90,000 acres of land. The total landings of the reservoir were about 248 tons per annum with an average lease amount of Rs. 17,000 per annum. Though the reservoir was being stocked with one of the major carps, (*Labeo fimbriatus*), by the department for fish production, the major portion of the fishery was contributed by the murrels, *O. striatus* and *O. punctatus*. The productivity of the reservoir worked out to 38 kgs. per acre (84 lb.) whereas the maximum and average production of fish per acre from lakes of similar area according to Rounsefell's estimate (1946) are 26·4 kgs. (58·1 lb.) and 13·5 kgs. (29 lb.) respectively. Even in such a highly productive lake, the murrels predominated. The fishing tackles used and their average catches per fishing day are given below :—

	Fishing tackle.	*Average catch per net per fishing day.* LB.
1	Wall net	25
2	Stake net	12
3	Cast net	16
4	Dip net	2
5	Basket trap	2
6	Plunge basket	½
7	Hook and line	1

A survey of the fisheries of the Kadamba tank in Tirunelveli district, a river-fed irrigation tank of about 1,650 acres with a surplus weir of 460 feet long and a FTL of 18 feet irrigating about 2,776 acres revealed a natural fishery of murrels *O. striatus*, *O. punctatus* and *O. gachua* besides other fauna. It was fetching a nominal rental of Rs. 80 to 100 only per annum. After departmental take over and development by introduction of some major carps and Chanos, the fishery of the tank was considerably developed. In 1950–51 the total departmental catch was 20,250 lb. and those of the licencees were 160,775 lb. the estimated total catches being about 1·8 lakhs of lb. Of these, murrels formed 4,098 lb. i.e. about 20 per cent of the total catches of the department. Analytical data of licencees catches were not given to assess the potentiality of total murrel population in the tank for that year. However, the high percentage of murrels in the departmental catches may be taken as an index of overall population of the tank. The occurrence of *O. gachua* in the tank denotes the migratory habit of this fish from the river feeding the reservoir. This reservoir, as of late, became naturally populated with another salt water fish, *Etroplus surantensis*, due to migration from the Thambraparni estuary through the Srivaikuntam channel.

Poondi reservoir formed in 1944 is another river fed reservoir. It is 12·5 square miles in extent with a FTL of 137 feet mainly intended to augment the supply of drinking water to Madras City. In 1948 this reservoir accounted for a total landings of 136 tonnes valued at Rs. 38·600. In the qualitative and quantitative analyses, the murrels came third in order of abundance, *Cirrhina reba* and *Notopterus* occupying the first two ranks. Murrels formed nearly 5·4 per cent of the total catches.

Murrels are also recorded as forming natural fishery in higher elevations as well as in Kodaikanal lake [Chacko (1950)], in Ippur fish farm in Nellore district (Wilson) in Malampuzha reservoir in South Malabar [Achuthan Nair (1954)] in Chetpet fish farm in Madras and in other inland waters during 1946–47 [Chacko (1948)]. In the Chetpet farm the murrels breed prolifically during the rainy months. Observation on the breeding habits rate of growth, age maturity and food of fry and fingerlings were made in Chetpet farm under the Madras Rural Piscicultural Scheme (Alikunhi, Chacko and others). The developing eggs of murrels were collected and reared to hatchling size in the laboratory. The results compared well with the rates of growth recorded by Willtey (1909) and Raj (1916). In a natural pond, a brood of fry of an average length of 30 mm. was found to have grown by 12 mm. in 18 days. In a second pond, fry of 47 mm. of average length, had grown to 55 mms. in 21 days. In a third pond, the fry of average length of 47 mm. have

grown to 70 mms. in 26 days and to 109 mms. in 60 days. Thus the average rate of growth of 1 mm. takes from 1 to 3 days in murrels. Tagging experiments were also conducted. The studies revealed a fair growth of 44 mm. per month. Three hundred fingerlings were transferred to a small tank which contained plenty of forage fish. The size weight relationship of these fingerlings was studied. It was found that the fingerlings have reached an average size of 19·8 m.ms. 9 ins. and an average weight of about 80 gms in 4½ months. While the total length increased by about three times the length at stocking, the weight increased by about sixteen times. (Alikunhi, 1946-47).

In the rivers, *O. marulius* is reported to grow to a size of 122 cms. (4 feet). A big murrel of about 120 cms. weighing about 4 kgs. (9 lb.) was caught in Poondi below the anicut in 1949 by me. In irrigation wells, with plenty of fauna like small minnows and frogs, they grow to a size of 40 cms in one year (MD. Menon). According to Chacko (1953), these attain a length of 76 cms. (13 ins.) and a weight of about 2 kgs. (4 lb.) at the end of the first year. Since *O. marulius*, the river murrel, is predaceous and cannibalistic, it prefers live fish and frogs for its forage. It is therefore suitable for uncleared swamp farming and for culture in large irrigation wells. In farm ponds and tanks it could be only cultured in combination with a suitable forage fish or fishes like *Tilapia*, top-minnows and small minor carps.

O. striatus, the murrel, is reported to grow in tanks to a maximum size of 91 cms. (3 feet). In tanks containing a very large population of insects worms and frogs they grow to a size of 36 cms. in one year. The attainment of a growth rate of 30 cms. and a weight of 3 kg. (1½ lb.) in the first year by this fish were recorded (Chacko 1953). This is useful for culture in ' Punjai ' irrigation tanks, deep domestic wells and weedy ponds. Its predaceous nature will however, require it to be reared alone or in combination with fast breeding fishes like minnows, top-minnows, *Barbus*, *Rasbora*, etc., which breed prolifically and hence no artificial food is necessary. Otherwise it is to be fed with artificial food like kitchen refuse, offal, etc.

O. Punctatus grow to a maximum size of 26 cms. In ponds containing large quantity of insects and minnows, it grows to a size of 21 cms. in the first year. It is very useful for culture in fortified swamps and shallow muddy waters like those of paddy fields, small pools, tanks, ditches and wells. Because of its very low piscivorous habits the fish can be tolerated in regular fish ponds also. The diet being arthropodan and varied, the feeding problem can be easily solved in its culture.

RECOMMENDATIONS

The fry and fingerlings *O. marulius* can be collected from the deeper river sections having sandy bottom and submerged rocks from May to August and November to February from the Bhavani river and the Cauvery river systems. The fry and fingerlings of *O. striatus* and *O. punctatus* can be collected in large numbers from the paddy fields and uncleared tanks and swamps of the State during the monsoonic months. The fry are very delicate until the larval colouration is changed. Only when the post larval colouration develops the young ones stand transport well. The adolescent and adult murrel can be transported for less than 48 hours packed in wet moss in special container because of their air breathing habit. Since the collection and transport of fry and fingerlings for stocking do not offer much difficulties, this fish is admirably suited for long distance transport.

As murrels grow faster on live food and attain considerable size for marketing in a relatively short period, and as many varieties of uneconomical and small sized fishes like minnows, top-minnows, Barbus and other minor carps are available in Madras, experiments on culture of murrel in combination with other fishes may be tried as in America. As there are a number of village ponds full of vegetal and other faunal populations in the various blocks, development of fisheries on this line is worthy of consideration. Since an average yield of 175 to 200 lb. per acre is easily achieved in colder countries like America the biological productivity in the tropical areas in our Madras State may be capable of a two-fold increase with the assistance of fertilisers. Organic fertilisers are in-advisable. According to Swingle and Smith (1950) inorganic fertilisers are more valuable. Organic fertilisers are unpredictable of results, and ruin the aesthetic value of a pond and are liable to transmit parasites and diseases. Further larger amounts of organic fertiliser are required in comparison with the inorganic e.g., one ton of manure equals roughly 100 lb. of 10-5-10 NPK. Inorganic fertilisers, can be prepared with accurate amount of desired elements. They are cleaner and they can be more easily applied to provide a more desirable pond.

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Table of distinguishing features for classification of Ophiocephalus spp.

Distinguishing features.	*Marulius.*	*Leuco-punctatus.*	*Pseudo marulius.*	*Barca.*	*Micropeltes.*	*Striatus.*	*Stewartii.*	*Gachua.*	*Punctatus.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1 Fin Formula	D—45–55	47–53	52	47–52	43–46	37–45	39–40	32–37	29–32
	A–28–36	28–35	35	34–36	27–30	23–26	27	21–23	21–23
	L1–60–70	59–60	64	60–65	95–110	50–57	47–50	40–45	37–40
	L. tn. $4\frac{1}{2}$–$5\frac{1}{2}$	$4\frac{1}{2}$–5	6/14	5/13	7/13	$4\frac{1}{2}$–$5\frac{1}{2}$	$4\frac{1}{2}$/9	3/7	4–6
	13–13	13–13				9–10			9
	P–18	18	17	16	15	17	17	15	17
	V–6	6	6	1/5	1/5	6	6	6	6
	C–14	14	15	19	15	13	14	12	12
2 Caudalfin to the total length	6–$7\frac{1}{2}$	6	..	$4\frac{1}{2}$–$5\frac{1}{2}$	$6\frac{1}{2}$–$7\frac{1}{2}$	6	$5\frac{1}{2}$	$5\frac{1}{2}$–6	$5\frac{1}{4}$–$6\frac{1}{4}$
3 Height of body to the total length ..	7–$7\frac{1}{2}$	$7\frac{1}{4}$	4 2/3	$5\frac{1}{2}$–$7\frac{1}{2}$	6–$6\frac{1}{2}$	6–8	7/8	6	$5\frac{1}{2}$–7
4 Length of head to the total length ..	4–5	4	$3\frac{1}{4}$	4–$4\frac{1}{2}$	$3\frac{1}{2}$–$3\frac{3}{8}$	$3\frac{1}{3}$–4	4	$3\frac{1}{2}$–$4\frac{1}{4}$	$3\frac{1}{3}$–$3\frac{3}{5}$
Rows of scales between mouth and base of dorsal fin.	16	16	16	15	22	18–20	13	12	12
6 Rows of scales between eye and angle of pre opercle.	10	10	10	9	16–17	9	5	4–5	5
Colour of fish—									
(i) Young	Orange banded, having white spots and a black light-edged ocellus at root of caudal fin.	Orange banded, having white spots, no caudal ocellus.	Orange banded, a black spot at the base of caudal. Greyalors and lighter on the sides and below. A black ocelles at the base of caudal.	Dark violet colour, spotted on body and fins.	Young scarlet with 2 black bands; grey with black spots.	Dark grey passing in stripes into the white of the abdomen.	Purplish, spoted with black.	Pectoral banded * vertical fins edged with red. Greenish above.	
(ii) Old	Greyish green.	Greyish green. Abdomen Orange Numerous white spot on the body.			Greyish brown with small brown on the sides.				
8 Length of fish	(4 feet)	3 feet or more.	3 feet.	3 feet.	Atleast 3 feet .	3 feet or more.	10 inches.	13 inches.	12 inches.
9 Distribution	Through out India to China.	Deccan and sea coasts of India to China.	India.	Large rivers of Bengal and Assam.	Western coast of India to Siam and Malaya.	India to China, swampy and grassy tanks, fresh-water 3 feet or more in depth.	Cachar and Assam.	India, Burma and Andamans, wells, etc.	India and Burma nearer the sea coast and back-waters, prefers stagnant waters to running water.

* Spotted or banded vertical fins dark with a light edge.

Landings of murrels in various districts of composite State of Madras, 1948-52.

	1948.	1949.	1950.	1951.	1952.	Total for five years.
	LB.	LB.	LB.	LB.	LB.	LB.
Andhra Region.—						
Srikakulam	27,520	..	..	15,400	2,560	45,480
Vizagapatnam	..	29,918	39,730	45,971	69,771	185,390
West Godavari	231,221	256,481	131,495	524,618	89,696	1,233,511
East Godavari	165,571	85,970	96,437	53,547	137,595	539,120
Krishna	105,928	23,563	271,261	186,479	141,182	658,413
Guntur	235,325	164,532	317,176	16,638	16,670	750,341
Nellore	41,180	18,047	48,080	22,204	18,101	147,612
Kurnool	1,852	2,367	4,525	4,275	..	13,019
Bellary	..	..	2,391	80	380	2,851
Anantapur	415	1,533	15	..	..	1,963
Chittoor	3,114	2,199	11,065	6,071	1,053	23,502
Cuddapah	..	..	81	42	..	123
Regional total	812,126	584,610	922,256	875,325	497,008	3,671,325
West Coast Region.—						
Malabar	7,568	14,442	10,522	13,188	7,925	53,645
South Kanara	14,920	967	16,724	19,189	9,302	611,102
Regional total ..	22,488	15,409	27,246	32,377	17,227	664,747
Tamil Nad Region.—						
Chingleput	1,983	14,145	4,100	2,335	16,952	39,515
North Arcot	1,360	3,006	2,297	2,596	..	9,268
South Arcot	20,075	11,875	3,854	..	..	55,804
Salem	2,616	225	..	..	..	2,841
Coimbatore	6,467	855	2,088	344	..	9,754
Thanjavur	12,950	65,559	41,589	167,480	4,867	292,445
Tiruchirappalli	32,246	..	84,504	6,526	187,250	310,526
Madurai	14,708	20,427	5,619	2,903	5,178	78,835
Tirunelveli	3,820	3,406	4,286	4,420	3,958	19,890
Ramanathapuram	..	..	5,933	4,677	1,364	11,974
Regional total ..	96,234	119,498	154,270	191,281	219,569	830,852
Total for the composite State—						
Weight in lb.	930,848	719,517	1,103,772	1,098,983	713,804	5,166,924
Value in Rs.	317,768	219,269	342,031	350,322	309,749	931,339

FOULING ORGANISMS OF THE EDIBLE OYSTER CULTCH IN THE ENNUR BACKWATERS

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INTRODUCTION

Studies on organisms which settle on objects kept exposed in sea water have been made by several Indian research workers such as Paul (1942), Kuriyan (1950), Kuriyan and Mahadevan (1953) and Daniel (1954-55). Similar settlement was observed in brackishwater also while conducting experiments on edible oyster spat collection in the Kortalaiyar estuary for a period of two years, eight months from January 1957. This settlement was of special interest as it played an important role in the collection, culture and growth of edible oysters.

OBSERVATIONS

Rectangular boxes each 4 feet long, $2\frac{1}{2}$ feet broad and 6 feet high with adequate space for free inflow and outflow of water were implanted in 6 feet to 8 feet of water over the oyster beds in the estuary. Each box was fitted with three crates. Each crate carried four tiers of country roofing tiles, coated with a mixture of sand and lime and dried. The oyster larvæ settled on these along with a variety of other organisms which varied in their occurrence from time to time. Monthly examination of the cultch for oyster spat revealed the presence of these fouling organisms which consisted of sedentary forms, temporary occupants, and permanent inhabitants of the cultch.

Many of these were keen competitors with the oyster spat for food and space. Certain of these organisms were predators that preyed on the oyster larvæ while some were mud-dwelling forms that accumulated large quantities of silt thereby fouling the settling substratum of the oyster larvæ.

One set of the cultch was completely cleaned every month before replacement so that a clear picture of the organisms which have settled down during each month could be had. A second set was cleaned of all organisms except the oyster spat to enable a study of their growth. A third set was replaced as it was after examination to enable a study of the growth, increase, decrease and mortality of the fouling organisms as well.

The organisms collected from the cultch on these occasions have been identified and classified as follows :—

Protozoa—Vorticella sp.

Coelenterata.—Laomedia spinulosa Bate, Obelia sp. Zoanthus sp. Alicia sp.

Platyhelminthes.—Planarians.

Polyzoa.—Membranipora membranacea.

Echinodermata.—Salmacis virgulata, Ophiocnemis marmorata.

Mollusca.—Meretrix casta, Mytilus viridis, Modiolus undulatus, Modiolus metcalfei, Modiolus striatulus, Arca complanata, Venerupis macrophylla (Deshayes), Patella sp. Nassa jacksoniana, Avicula sp., Libitina sp., Cerithidium fluvialis, Cerethium erranosum, Ostrea madrasensis, Anomia sp., Vivipara sp., Nuculana mauritiana, Nudibranchs.

Annelida.—Hydroides norvegica gunnerus, Dasychone cingulatus, Sabellaria sp., Amphinome sp. Phillodoce sp., Marphysa sp., Eunice sp., Serpula vermicularis., Lycastis sp. Eurythoe sp.

Cirripedia.—Balanus amphitrite variegatus, Balanus amphitrite communis.

Decapoda.—Metapenaeus monoceros, Metapenaeus dobsoni, Penaeus indicus, Penaeus carinatus, Alpheus sp., Palaemon sp. Ozius rugosus, Grapsus strigosus, Pilumnus vespertilio, Gonisoma crucifera, Clibanarius olivaceus (Henderson).

Amphipoda.—Corophium madrasensis (Nair), Stenothoe gallensis, Elasmopus pectericrus (Bate).

Isopoda.—Cirolana pleonastica (Stebbe), Cirolana elongata (Mike Edwards), Idothea gracilleria (Dana).

Arachnida.—Pycnogonids.

Pisces.—Arius sp., Gobius sp., Boleopthalmus sp.

Algae.—Enteromorpha sp., Gracillaria sp., Lyngbya sp.

Sixty-three organisms including spat of *Ostrea madrasensis* and excluding diatoms and algal spores were recorded during the studies. The occurrence of these organisms varied from month to month. Forms which were absent in certain months, were rare in other months, common sometimes or even plentiful or swarming depending upon favourable or unfavourable meteorological and hydrographical conditions. Certain forms present in one year were totally absent in the other. Thus *Gracillaria sp. Lyngbya sp., Anemones, Palaemon sp., Salmacis virgulata* and *Arius sp.*, recorded on the cultch in 1957 were absent in 1958 while, Molluscan eggs, Ophiocnemis and Dasychone which were not observed in 1957 were collected in 1958. The following tables I and II give an idea of the seasons of occurrence of these organisms in 1957 and 1958 while Table III shows the changing metorological and hydrographical conditions experienced during the various months of the year April 1957 to March 1958.

TABLE I—*Showing the relative abundance of Organisms on the Oyster Cultch in 1957.*

Organisms	*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)
1 *Gracillaria sp.*	F	..	..	..	..	..	..	..	..	F	..	C
2 *Lyngbya sp.*	F	..	..	..	..	..	..	..	..	..	..	C
3 *Entermorpha sp.*	..	..	F	F	..	F	..	..	..	..	..	C
4 Encrusting sponges	..	..	F	F	F	F	..	..	..	..	..	..
5 Anemones	..	..	F	..	..	..	..	F	..	..	..	..
6 Hydroids	..	..	..	F	F	..	F	..	..	F	..	C
7 Polychaetes	F	R	F	C	C	C	C	C	C	F	..	..
8 *Hydroides norvegica*	..	..	S	C	C	C	C	C	C	F	F	C
9 *Modiolus undulatus*	F	R	S	C	C	C	C	C	C	F	..	F
10 *Meretrix casta*	F	..	..	F	..	F	F	F	F	..	..	..
11 *Cerithidium fluvialis*	F	C	S	C	C	..	..	..	F	..	..	..
12 *Lamellibranchs*	..	..	F	C	C	C	C	C	C	F	..	..
13 *Nudibranchs*	..	R	..	F	F	F	..	F	..	..	..	..
14 *Anomia sp.*	..	F	F	F	F	..	..	..	..	..	..	F
15 *Mytilus viridis*	..	..	F	C	C	P	P	C	C	F	..	..
16 Planarians	..	..	..	..	F	F	..	..	..	..	..	..
17 Gastropods	..	..	..	..	..	F	..	F	C	F	..	F
18 *Balanus amphitrite*	R	F	S	C	C	C	C	C	..	F	..	S
19 *Cirolana pleonastica*	F	..	F	C	C	C	C	C	C	..	..	F
20 Amphipods	F	F	S	C	C	C	C	C	C	F	F	F
21 Crabs	F	..	C	C	C	C	C	C	..	C	..	C
22 Hermit crabs	..	..	F	C	C	..	..	C	..	C	..	..
23 *Penaeus sp.*	..	..	F	..	..	..	..	..	F	R	..	P
24 *Membranipora sp.*	..	F	F	..	..	F	F	..	F	..	F	C
25 Alpheids	..	..	..	F	..	F	..	..	F	..	..	..
26 Gobeids	..	..	..	F	..	..	F	F	..	..	..	C
27 *Palaemon sp.*	..	..	..	..	F	F	..	F	..	..	..	..
28 *Salmacis virgulata*	..	..	..	..	..	F	..	..	..	..	..	..
29 *Arius sp.*	..	..	..	..	..	..	..	..	..	R	..	..
30 *Ostrea madrasensis*	F	C	C	C	R	P	R	F	C	..	P	S
Nature of the bar	Open.	Open.	Open.	Open.	Open.	Closed on 14th June 1957.	Closed.	Opened on 28th August 1957.	Closed on 27th September. 1957.	Closed.	Opened on 4th November 1957.	Open.

R indicates Rare.
F „ Few.
C „ Common.
P „ Plenty.
S „ Swarming.
„ Nil.

TABLE II.—*Showing the relative abundance of Organisms on the Oyster Cultch in 1958.*

Organisms.	*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)
											Cultch washed away by floods.	
1 *Gracillaria sp.*												
2 *Lyngbya sp.*												
3 *Entermorpha sp.*	P	C	C		C	P	C					
4 Encrusting sponges				C	C	P	C	F				
5 Anemones												
6 Hydroids	F	C	C		F	F	F					
7 Polychaetes	R	R	F	C	S	S	C	F	C	C		
8 *Hydroides norvegica.*	C	C	S	P	P	P	C		C	C		
9 *Modiolus undulatus*		R	F	C	C	P	C		C	R		
10 Meretrix casta				F	R							
11 *Cerithidium fluvialis*		F										
12 *Lamellibranchs*			F	F	R							
13 Nudibranchs				F								
14 *Anomia sp.*	F	F	F	F	R							
15 *Mytilus viridis*			F	F	R							
16 Planarians		R	R	F	C	F						
17 Gastropods	F		F		C			C				
18 *Balanus amphitrite*	C	C	S	C	S	P	C	C	C	F		
19 *Cirolana pleonastica*		F	F	F	P	P	C		C	C		
20 Amphipods	F	C	C	C	P	P	C	C	C	F		
21 Crabs	F	F	F	F	C		F	F	F			
22 Hermit crabs				F	F	C		C				
23 *Penaeus sp.*	C	C										
24 *Membranipora sp.*	P	P	C	R	R							
25 *Alpheids*	C				F	F		C		C		
26 *Gobeids*		R	R					C	C	C		
27 *Palaemon sp.*												
28 *Salmacis virgulata*												
29 *Arius sp.*												
30 *Ostrea madrasensis*	S	P	C	C	F	F	R	F	R			
31 Molluscan eggs			R							C		
32 *Ophiocnemis marmorata*					R							
33 *Dasychone cingulatus*		C	F	C								
Nature of the bar	Open.	Open.	Open.	Open.	Open.	Closed on 10th June 1958.	Closed.	Closed.	Closed.	Opened on 19th November 1958.	Open. Heavy floods and rain.	Open.

TABLE III.—*Showing Metereological and Hydrographical conditions of Ennur Backwaters from April 1957 to March 195* .

	April 1957.	*May* 1957.	*June* 1957.	*July* 1957.	*August.* 1957.	*Septem-ber.* 1957.	*October* 1957.	*Novem-ber.* 1957.	*Decem-ber.* 1957.	*Janu-ary.* 1958.	*Febru-ary.* 1958.	*March* 1958.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Average atmospheric temperature (°C.).	31·15	32·80	32·80	31·15	30·60	30·00	29·5	28·9	28·9	28·4	28·9	30·6
Humidity (percentage). ..	69·00	79·00	77·00	74·00	76·00	80·00	80·00	84·0	83·0	80·0	79·0	89·0
Rainfall (mm)	..	0·5	1·3	117·1	24·1	117·3	156·2	444·0	2·0	9·1	..	..
Surface temperature (°C.) ..	25·0	31·2	30·6	28·9	27·25	28·9	30·6	28·9	29·5	28·9	28·4	31·2
Specific gravity	1·024	1·026	1·026	1·024	1·013	1·021	1·005	1·010	1·021	1·022	1·023	1·023
pH	8·1	8·1	8·2	8·1	8·1	8·1	8·2	8·1	8·2	8·2	8·2	8·3
Turbidity (cm.)	24	56	45	44	39	45	60	46	46	58	66	63
Salinity (°/1000)	43·96	40·11	47·07	43·79	30·35	37·25	31·93	26·84	35·14	41·39	43·76	45·96
Dissolved oxygen (cc./L.)] ..	3·63	4·62	5·81	6·92	4·90	3·22	4·98	7·00	4·41	4·69	3·85	4·34
Barometer reading (inches)..	30·4	30·2	30·2	30·2	30·2	30·2	30·4	30·5	30·5	30·5	30·5	30·5
Condition of bar	Open.	Open.	Closed.	Closed.	Open.	Closed.	Closed.	Open.	Open.	Open.	Open.	Open.

Oyster spat are noticed from nine to eleven months in the year. There is a minor peak period in March-April and a major peak period in December-January. There is a marked decrease in spat fall soon after the bar closes in June and there is a peak period of spatfall after tides have been regulated following the reopening of the bar. A heavy mortality of 75 per cent to 95 per cent of Oysters and spat is noticed in October-November during the north-east monsoon.

Balanus amphitrite is present for ten months in the year. 75 to 95 per cent mortality was recorded in January, February and October, November in 1957 and in October, November, December in 1958. An abundance was noticed in March and December 1957.

Hydroides norvegica is available for nine to ten months. They are found in good numbers throughout these months and are particularly abundant in March, April and May.

Modiolus undulatus is available from eight to eleven months in the year. It is present in large numbers from April to July. Many other *lamellibranchs* are also present but *Modiolus undulatus* is most common among them. *Mytilus viridis* was present for eight months in 1957 but was available only for three months in 1954.

Crabs and hermit crabs appear commonly in March, April, May when larval organisms which form their food are in abundance.

Most organisms including the *Lamellibranchs, Gastropods,* Hydroids, Anemones, Echinoderms, Planarians and Nudibranchs are carried into the estuary with the tides in the months following the opening of the bar.

Amphipods and Isopods form almost permanent abodes in the cultch and are available almost throughout unless washed away by heavy floods during the north-east monsoons.

In general, there are two main seasons of occurrence for all estuarine organisms. Most organisms prefer the summer months of April, May, June when high temperature and corresponding high biological activity results in a rapid increase and growth of organisms. The other period is the post-monsoon period of December, January, February at the close of the north-east monsoon when the bar has been forced open and free tidal influx not only carries in larval forms but also encourages spawning of organisms. The months of July to November are unreliable months as the estuarine organisms tide over a very crucial stage in their life history. The sudden changes in hydrographical conditions due to rain and floods cause the death of settling organisms and also reduce their food supply leaving the survivors, if any, in a very poor condition.

All sedentary forms and most other settling organisms are competitors with the oyster spat for food and space. Some however like the crabs, hermit crabs and gobeids are predators, that feed on the settling oyster larvæ themselves. Certain forms like amphipods and mud-dwelling polychætes not only compete for food and space but also spoil the settling space of oyster spat by accumulating silt.

Among the competitors for food and space, the barnacle *Balanus amphitrite,* the tube dwelling polychæte *Hydroides norvegica* and the *lamellibranch Modiolus undulatus* rank first, second and third respectively in their order of importance. All three of them are present for long periods and the first two are highly resistant to unfavourable conditions. They increase very rapidly covering every inch of settling space meant for the oyster spat and even grow over the oyster spat smothering them and preventing their natural free growth by suppressing them and incidentally cutting short their food supply also.

DISCUSSION

Certain of the marine foulers recorded by Kuriyan (1950) and Daniel (1954) have also been recorded in brackish-water. Their seasons of settling are however not the same. Thus Hydriods have been recorded throughout the year by Kuriyan, and from August to March by Daniel. In brackishwater they have been recorded from March to June and in October, December in 1957 and January to

March and May to July in 1958. Similarly *Membranipora* has been recorded as abundant in August, September by Kuriyan and as occurring in small numbers only from April to September and January to March by Daniel. In brackishwater it has been recorded in small numbers in March, April, June, July, September, November and December in 1957, and in large numbers from January to March and rarely in April, May in 1958.

Hydroides norvegica has been recorded by Daniel (1954) as being abundant in the teak planks exposed and not exposed to wave action within the Madras harbour during its peak period of occurrence in November, December and as being rare on the test planks exposed to the natural conditions of the open sea. This variation in the time and intensity of occurrence of the same organisms is due to several factors. Even in sea water much depends on whether the object is immersed in a sheltered position or is exposed to the currents of the open sea, whether it is subject to wave action or not and a host of other similar factors. In an estuary although the waters are sheltered other factors interfere such as drought in summer, fresh water floods during the north-east monsoon, free tidal inflow with the opening of the bar and the cessation of tides with the closing of the bar.

Further settling does not depend on prevalent hydrographical conditions alone. Daniel has recorded a certain ecological succession in the occurrence of fouling organisms, and states that this involves definite relations between organisms and is occasioned by factors of the environment some of the earlier forms being essential for preparing the substratum for the establishment of the later forms and that in Madras the primary film consisting of diatoms is followed by barnacles and tubiculous polychaetes and then polyzoans and molluscs. Besides the seasonal cycle this ecological succession is also noticeable in estuarine waters. Daniel has recorded that oyster spat suppress the growth of *Balanus amphitrite* by attaching to its sides.

In the course of the experiment it was noticed that during oyster spat fall freshly immersed cultch did not show settling while those which had been in the water for at least a week's time had a good settlement. The primary film is thus necessary for settlement but in the case of the oyster cultch it will be noticed that the swarming period of the oyster spat is only followed by the swarming period of the barnacle *Balanus amphitrite* and the tubiculous polychaete *Hydroides norvegica*. The settling of oyster spat precedes the settling of these two and not as Daniel has recorded them, preceding the settlement of polyzoans and molluscs including oyster spat.

The reason for this difference in the order of succession may be the effect of light and the colour of the substratum on the particular organism as suggested by Kuriyan and Mahadevan (1953). This may depend on the relationship the organisms bear to the cultch material as suggested by Chidambaram and Dinamoni in their experiments in 1949–50 with oyster larvæ and cultch of varying material where settlement of oyster spat on wood was found to be comparitively poor. Daniel has recorded his settling on teak planks which is probably a favourable substratum for barnacle settlement whereas the harder substratum of the country tile with its coating of calcium, probably required for the hardening of the shell of the oyster spat is preferred by the oyster and hence the quicker settlement of oyster spat preceding the barnacle settlement.

As a result of the subsequent settlement of barnacles and polychaetes which increase very rapidly when they are allowed to remain covering the settling space of the oyster spat as well as the oyster spat that have settled, the growth of the oyster spat is suppressed due to the overcrowding. Where the foulers were cleaned periodically the oyster spat showed approximately 10 mm. growth per month so that in a year's time it was possible to get healthy oysters of 90 mm. to 120 mm. size range fit for consumption.

CONCLUSION

If the proper substratum for the collection of oyster spat is used one can be certain of getting an abundant settling of oyster spat during the favourable season when oyster larvæ are present in large numbers. The cultch should be placed just in time to get a primary film and not long enough for other organisms to settle. Once they have been collected they have to be protected in specially fenced portions in the deeper waters where they may be kept free from silt which has a smothering action. Periodical cleaning to remove silt and foulers without damage to the spat must be a part of the programme as it will ensure a good crop of well fattened oysters for the year. The later settlement of the foulers, especially the three main competitors of food, settling space and growing space of the oyster spat, namely, *Balanus amphitrite*, *Hydroides norvegica* and *Modiolus undulatus*, respectively enable one to eradicate them more easily than would otherwise have been possible.

The study of the fouling organisms on the edible oyster cultch throws light on the habits and inter-relationship of these organisms with the oyster spat and opens up a new vista in the annals of edible oyster farming. Careful and methodical preparation of suitable cultch, collection during the precise time, rearing of the spat, keeping the mortality rate as low as possible on the basis of the knowledge gathered on the edible oyster spat and their associations, will ensure a maximum production of oysters fit for the table in one year. As there are two peak periods of oyster spat settlement it will be possible to get two harvests of full grown oysters annually.

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SWARMING OF THE BRITTLE STAR, OPHIOCNEMIS MARMORATA (LAMARCK) IN THE ENNUR BACKWATERS

By

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INTRODUCTION

The Brittle star, *Ophiocnemis marmorata* (Lamarck) is of common occurrence in the shore-seine catches along the Madras Coast. Gravely (1941) mentions its occurrence commonly on the sandy sea bottom of the Madras Coast and its availability in the fishing nets brought ashore. Chacko, Abraham and Andal (1953) have recorded this Ophuiroid as living attached to the frilled oral arms of the jelly fish *Acromitus flagellatus* (Haeckel) in the Pulicat lake, which is a brackishwater swamp that has several connections with the Bay of Bengal. Panikkar and Prasad (1952) mention that of several specimens of the *Scyphomedusae, Rhopilema hispidum Maas* observed by them in June-July 1950 very near the shore in Palk Bay, ten live specimens were collected with innumerable specimens of *Ophiocnemis marmorata* in association with them.

OBSERVATIONS

The Ennur backwater is the estuary of the Kortalaiyar river. This brackish water area is in connection with the Bay of Bengal for at least six months in the year, between October of the one year to April of the succeeding year. Even though, daily hydrographical and biological observations were made in this estuary since May 1955 there were no instances of collection of *Ophiocnemis marmorata*. But on 24th April 1958, there was phenomenal swarming of this brittle star to a distance of one mile up the river. They were found in clusters one on top of the other on floating pieces of wood overgrown with *Balanus amphitrite* and on drifting clumps of live filamentous algæ (predominantly of Enteromorpha) and clinging in masses to the sub-umbrellar surface and oral arms of every live specimen of the jelly fish *Acromitus flagellatus* (Haeckel) available at the time. The ophuiroids were small measuring from 2·5 cm. to 5 cm. diametrically from arm-tip to arm-tip. The appearance of the jelly fish in the backwater was however not sudden and they were already available in swarms at the time. Young stages of these jelly fish of less than one centimetre diameter had been available in the estuary since December 1957 ; these had grown into adult forms 15 to 30 cm. in diameter. It was interesting to note that it was not possible to obtain a single specimen of the jelly fish that was not infested by the ophuiroid. Each jelly fish harboured not less than fifty ophuiroids and in some there were as many as a thousand. The association which was first noticed on 24th April 1958 continued till 30th April 1958 after which the disappearance was as sudden as the appearance.

Besides *Acromitus flagellatus* specimens of *Chrysaora helviola var calliparea* (*Dactylometra quinquienha*) were also available in the estuary at the time. These had entered the estuary at the beginning of April 1958 from the sea and were available till the end of May 1958 in the ratio of one to every hundred of *Acromitus*. The ophuiroid was not found in association with *Chrysaora helviola* in any instance.

A study of the meteorological and hydrographical conditions, before, during and after the incident was made. The bar was open throughout and there was free tidal inflow. New moon was on 19th April 1958, five days before the swarming occurred. Tides were higher during this period than the usual and the sea was rough. Full moon followed on 3rd May 1958, three days before which the ophuiroids disappeared. Cloudy weather and rain followed the full moon.

Meteorological and hydrographical ranges for the period 15th April 1958 to 7th May 1958 were as follows :—

Humidity.—76–92 per cent.

Maximum atmospheric temperature—27·8–32·2° C.

Minimum atmospheric temperature—26·8–31·1° C.

Barometer reading—30·3–30·5 inches.

Transparency—63–78 cm.

Specific gravity—1·022–1·024.

Surafce water temperature—27–32·8 °C.

PH.—8·0–8·3.

Dissolved oxygen—1·75–4·83 cc./L.

Salinity—33·94–44·46. °/°°

The sky was clear till 3rd May 1958 after which it was cloudy. Rain of 0·65 and 2·2 inches was recorded on the 6th and 7th May 1958, respectively.

Meteorological and hydrographical conditions on 24th April 1958 when the phenomenon occurred were as follows:-

Maximum atmospheric temperature—31·7° C.

Minimum atmospheric temperature—30·6° C.

Humidity—92 per cent.

Barometer reading—30·4 inches.

Transparency—74 cm.

Specific gravity—1·024.

Surface water temperature—31·1° C.

pH.—8·2.

Dissolved oxygen contents—3·15 cc/L.

Salinity—43·22.° /°°

Sky—Clear.

A study of the readings showed that they were all higher than the minimum values recorded for the period, the increase being gradual. Humidity alone which was 76 per cent on the 23rd April 1958 shot up to 84 per cent on the 25th April 1958 and further to 92 per cent on the 25th April 1958 at which it remained for the period of the phenomenon till 2nd May 1958.

Three of the *Acromitus* carrying between 300 to 400 ophuiroids were put into the topmost crate of an oyster box fixed in the estuary for oyster spat collection on the 25th April 1958. The crate contained bent limed country

tiles, used as cultch. The tiles were arranged in tiers each tier alternating in direction with the previous tier being placed at right angles to each other and forming an adequate system of channels for the free inflow and outflow of water. The crate was re-examined the following month on the 27th May 1958 when it was noted that the jelly fish had probably died in confinement and had disintegrated only to be washed away by the current, and that only three specimens of *Ophiocnemis marmorata* remained. They were obtained from three different tiles in a healthy and well-fed condition. They measured 7 cm. diametrically, the growth in one month being 2 cm. at least.

The ophuiroids were not found in the natural estuarine conditions after this. They were however occasionally obtained from the sea. On 11th June 1958 a small specimen 2·5 cm. in diameter was found partly engulfed by a *Sphenopus* which was cast ashore. A week later a still smaller specimen, 1 cm. in diameter, was found washed ashore in an old cycle tyre.

DISCUSSIONS

The association of the Ophuiroid *Ophiocnemis marmorata* with the backwater jelly fish, *Acromitus flagellatus* (Haeckel) seems to be one of temporary commensalism. The normal habitat of the ophuiroids is the sea-bottom where they feed upon the minute organisms and organic matter contained in the surface mud. Their occurrence in the estuary is possible as the bar was open during the period of the incident, facilitating tidal ingress and egress and with it the migration of animals to and from the sea. The occurrence of the ophuiroid on floating masses of wood and algæ also, make it clear, that the *Acromitus* were used in the course of events as harmless objects of shelter available in the surface layers of water at the time. Their inavailability on *Chrysaora helviola* also found in the surface water at the time, makes this even more obvious. *Chrysaora* has been intentionally avoided because of the terrible effect of its powerful sting.

The phenomenon took place five days after new moon when tides were still high and the sea still turbulent. There is every possibility that violent current and churning of the bottom of the sea due to the turbulence had brought these forms to the surface as stated by Chacko (1942) or that upwelling and vertical circulation as described by La Fond 1954 and 1955 and La Fond and Bhavanarayana (1957) which is nothing uncommon on the east coast of India was responsible for the unusual incident. *Acromitus flagellatus* present in large numbers at the time, migrating in and out of the estuary lent very timely assistance in harbouring these homeless arrivals in their harmless protective sub-umbrellar surfaces. This association may as Panikkar and Prasad (1952) have noted help the ophuiroid to get distributed over a wide area.

The sudden disappearance of the ophuiroid is as amazing as their appearance. It is quite possible that they had returned to their normal habitat although many thousands perished by being washed ashore along with their algal or wooden rafts or by being dragged ashore by fishing nets. The survival and growth of the three ophuiroids in the oyster crate suggest the escape of many hundreds in a similar way. The occurrence of stray specimens of young Ophuiroids from the sea even after the incident show that they were not only present but were breeding in their natural habitat on the sea bottom once again.

This interesting association of the ophuiroid *Ophiocnemis marmorata* with the backwater jelly fish *Acromitus flagellatus* (Haeckel) is undoubtedly one of temporary commensalism where the jelly fish offers shelter and also remnants of the food it feeds on, enabling the ophuiroid to tide over adverse conditions.

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ON A SURVEY OF THE PEARL BANKS OF TUTICORIN, GULF OF MANNAR, IN 1961-62

By

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INTRODUCTION

The Pearl Banks of Tuticorin number about fifty-two extending from Vaipar periyapar in the north to Manapad periyapar in the south [Hornell (1922)]. Recently seven pearl fisheries have been conducted continuously from 1955 to 1961 as shown in Table I.

Table I.

Showing details of pearl fisheries from 1955 to 1961.

Year.	*Pearl banks exploited.*	*Total number of oysters fished.*	*Total revenue by Government.*
(1)	(2)	(3)	(4)
		RUPEES IN LAKHS.	
1955 ..	Thollayiram par ..	35	1·3
	Saithonpathu par		
	Kuthadiar par.		
1956 ..	Thollayiram par ..	21	0·4
1957 ..	Do. ..	111	1·6
	Kodamuthi par		
	Saithkudamuthu par		
1958 ..	Rajavukkusippi ..	215	4·6
	sothicha par		
	Karuval par		
1959 ..	.. ..	164	8·0
1960 ..	.. ..	168	2·2
1961 ..	.. ..	154	2·9

With a view to ascertain the particulars of pearl oyster population and the ecology of the banks a survey was conducted from December 1961 to February 1962; and the observations made are reported in this paper.

The following ten main productive banks (Fig. 1) were surveyed :—

1 North Thollayiram par

2 Karaikeluthi par

3 South Thollayiram par

4 Kudamuthi par

5 Sultan par

6 Nadumalaipiditha par

7 Periyamalaipiditha par

8 Karuval par

9 Thiruchendur poonthottam par

10 Manapad periyapar

The programme of survey was divided into three phases. In the first phase a preliminary survey was conducted of the first nine pars with the assistance of skin-divers. In the second phase aqua-lung diving and skin-diving were used in a detailed survey of the pars where oysters were detected during the preliminary survey. In the third phase the Manapad periyapar was surveyed with aqua-lung alone. As this par was far off from Tuticorin a separate camp was established at Manapad village for this purpose.

EQUIPMENT AND METHODS

Two canoes with two skin-divers in each were employed. A Paramantadi (professional pilot) located the banks. Two departmental officers (Sri Isaac Rajendran and Sri Kanakaraj David) equipped with aqua-lungs conducted the second phase of the programme along with the skin-divers. During the third phase Sri K. Nagappan Nair and Sri S. Mahadevan, Assistant Research Officers of the Central Marine Fisheries Research Unit, joined the party by using aqua-lungs. The departmental launch M.F.V. Goherkaleeli was summoned for this purpose. But this vessel went out of order on 19th December 1961 and thereafter the offshore fishing vessel (M.L. Sardinella) of the Government of India, skippered by Sri Hameed was used in the first phase. During the second and third phases two thirty-footer mechanised Pablo boats were used as survey vessels. The fauna, flora, depth, nature of bottom, number of oysters in each dive, etc., were all noted in a data sheet. Oysters when present were stored in tin containers and brought to the laboratory for age determination. The oysters were then put in mud pots, sealed and allowed to rot for determining their pearl content.

RESULTS

Oysters were found to exist only in three areas, namely, North Thollayiram par, Karaikeluthi par, and South Thollayiram par. Oysters were not found in the other seven pearl banks examined during the survey. The, summary of the daily operations are shown in Appendix I the fauna and flora frequencies in Appendix II, the length frequency distribution of random samples of oysters in Appendix III, and details of depth and nature of bottom in Appendix IV.

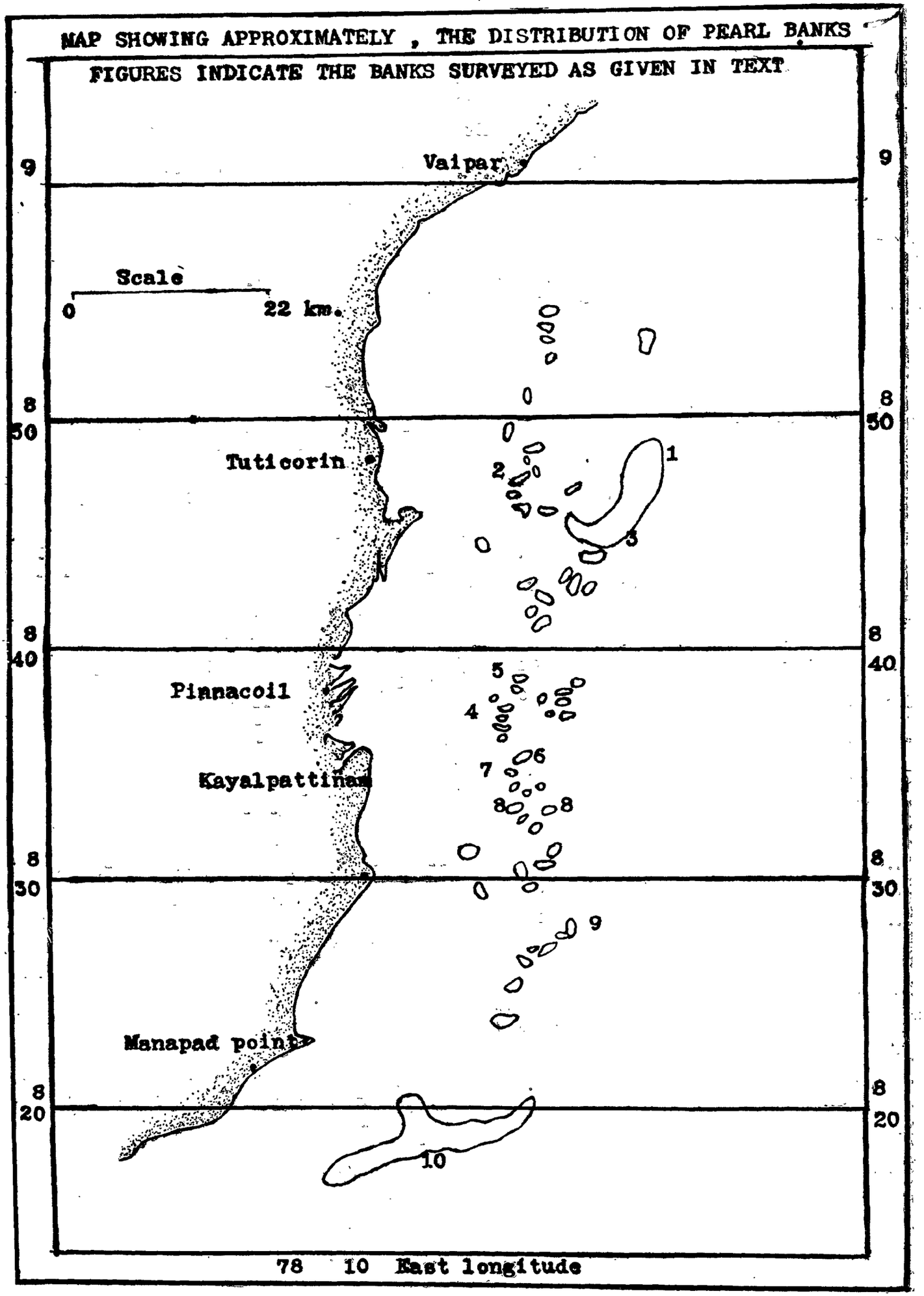
MAP SHOWING APPROXIMATELY , THE DISTRIBUTION OF PEARL BANKS
FIGURES INDICATE THE BANKS SURVEYED AS GIVEN IN TEXT
Vaipar
Scale
0
22 km.
Tuticorin
Pinnacoil
Kayalpattinam
Manapad point
9
8 50
8 40
8 30
8 20
78 10 East longitude

Fig.1.

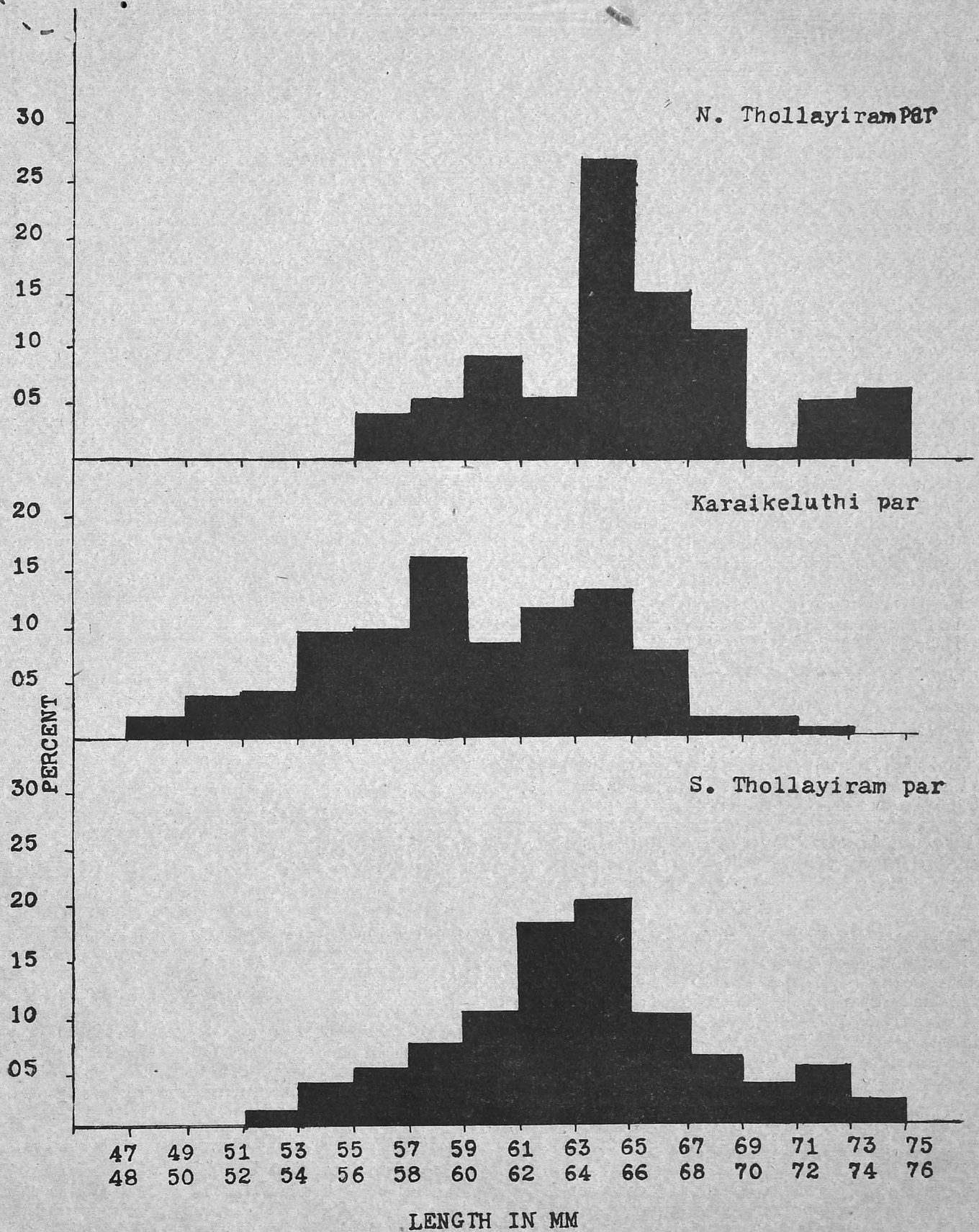

Fig.2. Showing length frequency of pearl oysters of the three pars

427-16—10

The number of oysters brought up by the skin divers in the first and second phases of the programme, in the three areas mentioned above and the catch-per-unit effort are shown in Table II.

TABLE II.

Showing the catch-per-unit effort of diving.

Name of pearl bank.	*Total number of oysters brought up by divers.*	*Number of dives made.*	*Catch per unit effort of diving.*
(1)	(2)	(3)	(4)
1. N. Thollayiram par—			
(*a*) First phase ..	352	264	1·3
(*b*) Second phase ..	173	80	2·2
2. Karaikeluthi par—			
(*a*) First phase ..	186	126	1·4
(*b*) Second phase ..	58	92	0·9
3. S. Thollayiram par—			
(*a*) First phase ..	122	104	1·1
(*b*) Second phase ..	73	53	1·4

AGE COMPOSITION OF THE OYSTERS

Devanesan and Chidambaram (1956) studied the growth rates of pearl oysters reared in cages in the pearl farm of the Marine Biological Station, Krusadi Island, and arrived at a hypothetical size composition of a random sample of thousand oysters from an imaginary bed, based on shell length and body weight. The age of oysters obtained during the present survey was determined using the following data arrived at by the above authors, for the average shell length value.

Age.	*II year.*	*III year.*	*IV year.*	*V year.*
Average shell length.	57 mm.	63 mm.	61 mm.	64 mm.

The length frequency distribution of oysters collected at N. Thollayiram par, Karaikeluthi par and S. Thollayiram par are also shown as histogram in Fig. 2.

From the histogram it is seen that the majority of oysters collected from N. Thollayiram par are of the size group 63–64 and 65–66, corresponding to the ages three and five years. In S. Thollayiram par besides the above groups another group also shows predominance, i.e., 61–62 corresponding to four years. In the case of Karaikeluthi it is more difficult to interpret. The vast majority of oysters are of the size group 57–58 and 59–60, corresponding to two and perhaps two and a half years. A good percentage also belong to the size groups 61–62, 63–64 and 65–66, corresponding to three, four, five, and perhaps of more than five years. It can also be noted that in the case of Thollayiram par, north and south sections, the distribution of length measurements of oysters is unimodal, whereas in Karaikeluthi it is bimodal.

ESTIMATION OF POPULATION

Hornell (1922) assumed that the area covered by a diver per dive to be three square yards. According to this 792 square yards (264 × 3) were covered and got 352 oysters in the first phase (Table II) at N. Thollayiram par. This works out to less than one oyster per square yard. In the second phase 173 oysters were obtained from 240 (80 × 3) square yards. This also works out to less than one per square yard. Similarly it is seen that the oyster population in the Karaikeluthi and S. Thollayiram pars to be less than one per square yard, showing thereby that the oyster population is very thin. The majority of oysters in the North and South Thollayiram pars being of an older generation may perish shortly, as the maximum life span of an oyster is about five years. Some oysters may be left over at Karaikeluthi as they are of a younger generation.

DISCUSSION

From the earliest times it has been noticed that there is irregularity in the occurrence of pearl fishereis of the Gulf of Mannar. Thus in his "History of East Indies" Velentyn quotes Governor Van Goens' Memoir, dated 1663 A.D. that "the banks of Gulf of Mannar (Island of Mannar) have given no profit, although the revenue from them was once most considerable....." Arunachalam (1952). It has also been found that the Indian Fishery was preceded by the Ceylon Fishery by two or three years. Whereas pearl fishery is annual in the Persian Gulf, it is intermittent in character in the Gulf of Mannar. Long interval of barren periods occurring between two fisheries. From 1930 till 1954 for over twenty years the pearl banks have been barren. It was only from 1955 to 1961 there had been continuous annual fishery in the Indian coast. Chacko and Rajendran (1955) have given an account of the gross revenue of pearl fisheries from 1663. It is seen from this that there had been only 32 pearl fisheries from 1663 to 1928. Hornell (1916) attaches much importance to fish enemies of oysters as the principal factor in the economy of the Indian pearl fisheries. He has witnessed the total destruction by predatory fishes, within a brief period of few weeks, of immense beds of young oysters in the Gulf of Mannar. He has concluded "when beds of oysters do come to maturity in spite of all dangers which have beset them the state should fish them vigorously and accept the proceeds windfall of revenue. Chacko (1959) found oyster shells in the stomach contents of *Abalistes stellaris*, thus strengthening the view of Hornell.

Devanesan and Chidambaram (1956) cited three main causes for this periodicity in the occurrence of pearl fisheries, namely, (1) over fishing, which upsets the balance of biological laws of environment, (2) the probable preponderence of females and the paucity of males and (3) the inability of scattered ripe females to produce necessary stimulus to the ripe males to induce them to eject their spawn on account of their separation by long distances from the nearest male. They pointed out that after every pearl fishsery there is inevitably a complete collapse and that rebuilding takes time, sometimes running to thirty years. From facts shown in Table I the above statement cannot be accepted completely but if the seven pearl, fisheries from 1955 to 1961 are considered as a single unit it may be possible to find a probable explanation for the present barren condition of the pearl banks off Tuticorin.

ACKNOWLEDGMENTS

I am greatly indebted to Sri P. I. Chacko, Assistant Director of Fisheries, Information and Marine Biology, Madras, and Sri S. H. Hussainy, Assistant Director of Fisheries, Tuticorin, for guidance and facilities given to me during this survey.

SUMMARY

1. A survey of ten important productive pearl banks of the central sector of the Gulf of Mannar was conducted

from 14th December 1961 to 28th February 1962 with skin-divers and aqua-lung equipment.

2. Oysters were found to be very thinly populated in the three areas, namely, N. Thollayiram, Karaikeluthi and S. Thollayiram pars.

3. The oysters collected belonged to third and fifth year classes at N. Thollayiram par, and third, fourth and fifth year classes at S. Thollayiram par, but they were found to be of a mixed population at Karaikeluthi par.

4. The probable causes for this condition of the pearl banks are discussed.

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APPENDIX I.

Summary of skin-diving operations carried out during the pearl bank survey 1961–62.

Date.	*Name of par.*	*Number of dives made.*	*Number of oysters.*
(1)	(2)	(3)	(4)
	I phasv.		
14th Decembar 1961	Thollayiram par, N.	46	44
18th December 1961	Do.	150	174
2nd January 1962	Do.	68	134
5th January 1962	Karaikeluthi, par	72	86
6th January 1962	Thollayiram par, S.	104	122
8th January 1962	Kudamuthi par,	32	No oysters.
10th January 1962	Sultan par,	64	Do.
11th January 1962	Kudamuthi par,	52	Do.
12th January 1962	Karaikeluthi par,	54	100
16th January 1962	Nadumalaipiditha par	44	No oysters.
17th January 1962	Periyamalaipiditha par	50	Do.
18th January 1962	Karuval par	48	Do.
19th January 1962	Do.	46	Do.
20th January 1962	Do.	36	Do.
22nd January 1962	Tiruchendur poonthottam par	36	Do.
23rd January 1962	Do.	42	Do.
24th January 1962	Do.	48	Do.
	II phase.		
19th February 1962	Thollayiram par, N.	80	173
20th February 1962	Karaikeluthi par	62	58
22nd February 1962	Thollayiram par, N.	100	196
23rd February 1962	Do.	120	504
24th February 1962	Do.	128	73
26th February 1962	Thollayiram par, S.	53	181
27th February 1962	Do.	140	21
28th February 1962	Do.	70	..

APPENDIX II.

Showing the flora and fauna frequencies of the ten pars surveyed in 1961-62.

—Absent.

0 Very poor.

00 Rich.

000 Very rich.

Flora and Fauna frequency.	*N.Thollayiram par.*	*Karaikeluti par.*	*S.Thollayiram par.*	*Kudamuthi par.*	*Sultan par.*	*Nadumalai piditha par.*	*Periyaalaim piditha par.*	*Karuval group.*	*Tiruchendurpoonthottam par.*	*Manapaduperyaikay.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Algæ—										
Caulerpa sp.	—	—	—	—	—	—	—	—	0	—
Halimeda	—	—	0	—	—	—	—	—	—	0
Spathoglossum	—	0	—	—	—	—	—	—	—	—
Ulva sp.	—	—	0	—	—	—	—	—	—	00
Padina sp.	—	0	0	—	—	—	—	00	0	—
Sargassum sp.	0	—	0	000	—	00	0	000	000	—
Gracilaria sp.	0	—	—	—	—	0	—	0	0	—
Porifera—										
Aulospongus	0	—	0	00	0	—	00	0	000	—
Phakeila	—	—	0	0	0	—	—	00	—	00
Raspailia	00	0	—	0	000	00	—	0	00	—
Megalopastas	0	—	00	—	00	—	—	0	—	00
Coelenterata—										
Alcyonium	—	—	—	—	—	—	—	0	00	—
Lytocarpus	—	—	—	—	—	—	—	—	—	00
Madreporarians	00	0	0	0	0	0	0	0	00	—
Arthropoda—										
Balanus	—	—	—	—	—	0	0	—	—	—
Mollusca—										
Xancus	0	—	00	00	—	0	00	0	—	—
Modiola	0	—	—	—	000	—	—	—	00	0
Pteria chinensis	—	—	—	—	—	—	—	—	—	—
Echinodermata—										
Crinoids	—	—	—	—	—	—	—	0	—	—
Pentaceros	0	0	00	0	—	00	—	00	00	—

APPENDIX III.

Length frequency distribution of random samples of oysters (P. Vulgaris) collected from the pearl banks of Tuticorin in 1961-62.

Length in mm.	*N.Thollayiram.*		*Karaikeluthi.*		*S.Thollayiram.*	
	Frequency.	*Percentage.*	*Frequency.*	*Percentage.*	*Frequency.*	*Percentage.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)
27–28	1	0·4	..	..	..	..
29–30	1	0·4	..	..	..	..
30–32	1	..	..	..	..	..
33–34	..	04	..	..	..	..
35–36	..	..	..	..	..	..
37–38	..	..	..	..	..	..
39–40	..	..	1	0·5	..	..
40–42	—	—	..	..	..	..

APPENDIX III—*cont.*

Length frequency distribution of random samples of oysters (P. Vulgaris) collected from the pearl banks of Tuticorin in 1961–62—cont.

Length in mm.	*N. Thollayiram.*		*Karaikeluthi.*		*S. Thollayiram.*	
	Frequency.	*Percentage.*	*Frequency.*	*Percentage.*	*Frequency.*	*Percentage.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)
43–44 ..	..	..	1	0·5	..	..
45–46 ..	1	0·4	..	..	..	..
47–48 ..	..	..	3	1·6	..	..
49–50 ..	1	0·4	6	3·2	..	..
51–52 ..	..	..	7	3·7	1	1
53–54 ..	..	..	17	9·1	3	3
55–56 ..	9	3·7	18	9·7	2	2
57–58 ..	12	5	30	16·2	5	5
59–60 ..	22	9·1	25	13·5	7	7
61–62 ..	16	6·6	12	8·1	10	10
63–64 ..	13	5·3	21	11·3	18	..
65–66 ..	64	26·6	24	12·7	20	..
67–68 ..	36	15	11	7·4	10	..
69–70 ..	28	11·6	2	1·3	6	..
71–72 ..	2	0·7	2	1·3	4	..
73–74 ..	12	5·0	1	0·5	5	..
75–76 ..	15	6·2	2	1·3	2	..
77–78 ..	4	1·6	1	0·5	3	..
79–80 ..	1	0·4	1	3·5	3	..
81–82 ..	..	..	..	..	1	..
83–84 ..	1	0·4	..	..	..	..
	240		185		100	

APPENDIX IV.

Details of depth and nature of bottom of pars surveyed in 1961–62.

Date.	*Station number.*	*Depth in fathoms.*	*Nature of bottom.*	*Name of par.*
(1)	(2)	(3)	(4)	(5)
14th December 1961	5	9½	Sand over rock.	N.Thollayiram.
18th December 1961	12	9–9½	Do.	Do.
2nd January 1962	30	10½	Flat rock.	Do.
5th January 1962	45	10½	Do.	Karaikeluthi.
6th January 1962	60	9	Do.	S.Thollayiram.
8th January 1962	72	7¾–8¼	Do.	Kudamuthi.
10th January 1962	79	9	Sand over rock.	Sultan.
11th January 1962	87	8	Do.	Kudamuthi.
12th January 1962	99	11	Flat rock.	Karaikeluthi.
16th January 1962	107	8–9	Sandy.	Nadumalaipiditha.
17th January 1962	117	9	Do.	Periyamalaipiditha.
18th January 1962	125	9	Flat rock.	Karuval.
19th January 1962	134	10	Sand over rock.	Do.
20th January 1962	145	9	Do.	Do.
22nd January 1962	150	8–9	Do.	Tiruchendur poonthottam.
23rd January 1962	157	8½	Coral on rock.	Do.
24th January 1962	165	9½	Flat rock.	Do.

A NOTE ON THE SHRINKAGE OF THE PERIOSTRACUM OF THE SACRED CHANK, XANCUS PYRUM, ON STORAGE

BY

P. I. CHACKO, S. T. CHARI AND P. JAYACHANDRAN.

The Sacred Chank *Xancus pyrum* contributes to a very important shell fishery along the coast of Madras State. It is abundant in the Gulf of Mannar. The chank fishery is State-owned; and on an average ten lakhs of shells are fished annually fetching a revenue of about 12 lakhs rupees. About 2,000 divers and their families depend on this fishery.

The population of chanks are exploited under strict supervision. In order to perpetuate the fishery, chanks of a diameter below 2¼ inches (57·150mm.) are prohibited from fishing. Though there are several practical difficulties especially when the fishery is conducted in the sea about 16 to 20 kilometres from the shore where the depth is about 20 metres, the effect of enforcement of this regulation is beneficial.

The chanks are used to make ornaments like bangles, rings, pendants, etc., and several types of curios. At present, the chank bangle industry is located almost entirely in Bengal. Therefore the chanks fished every year have to be stored in godowns for periods extending to five years till they are transported and marketed in Bengal. It has been expressed by the traders that the chanks are likely to get reduced in size during the period of storage. A study of this aspect has been conducted with the following results:—

The chank proper has such a hard shell that there is no shrinkage at all. But the external chitinous layer periostracum, gets dried and peeled off on storage. The effect of this has therefore been noted. A sample of 80 chanks of different sizes from lots of freshly captured chanks and of various periods of storage (one to three years) was collected from the chank godowns at Tuticorin and measured for their length and diameter and thickness of the periostracum. The thickness of the periostracum was measured by the optic lever method. The data are furnished in Table I.

The thickness of the periostracum ranged from 0·33 mm. to 0·080 mm. The percentage composition of the chanks samples with reference to the thickness of the periostracum is as follows :—

Thickness of periostracum mm.	*Number of chanks in sample.*	*Percentage to total number of chanks in sample.*
(1)	(2)	(3)
0·080	1	1·25
0·070—0·079	16	20·00
0·060—0·069	9	11·25
0·050—0·059	27	33·75
0·040—0·349	19	23·75
0·030 0·039	8	10·00

It is seen that chanks with 0·050—0·059 mm. thick periostracum are maximum, followed by 0·40—0·049 mm. group and that 0·050 mm. is the average thickness of periostracum of chank of varied durations of storage.

The periostracum shows maximum thickness of 0·080 mm. when the chank is quite fresh. The minimum thickness after long storage and shrinkage is 0·030 mm. The reduction in thickness is thus 0.050 mm. Consequently the maximum reduction in the diameter of a chank is 0·100 mm. provided the periostracum is peeled off. This is a very negligible shrinkage and does not affect the overall diameter of the chank. Even in the rare cases when the periostracum gets peeled off after very prolonged period of storage, the reduction in the diameter of a chank which originally possessed a periostracum of the maximum thicknesses of 0·080 is only 0·160 mm. This also is very negligible. Thus, practically there is no possibility of chanks getting reduced in size due to storage and thereby lowering the commercial value of the shells.

TABLE I.

Showing length and diameter of shell and thickness of periostracum of 80 chanks.

Serial number.	*Length mm.*	*Diameter mm.*	*Thickness of periostracum mm.*
(1)	(2)	(3)	(4)
1	165	83	0·075
2	153	82	0·072
3	170	90	0·073
4	140	75	0·040
5	165	80	0·045
6	179	90	0·050
7	145	75	0·060
8	120	70	0·050
9	155	83	0·035
10	175	90	0·030
11	135	72	0·037
12	145	75	0·039
13	110	55	0·042
14	115	56	0·045
15	120	71	0·050
16	130	71	0·072
17	125	71	0·075
18	180	90	0·050
19	150	74	0·055
20	155	83	0·052
21	140	75	0·062
22	120	69	0·073
23	170	85	0·076
24	173	87	0·078
25	110	60	0·080
26	130	71	0·042
27	112	62	0·035
28	115	64	0·038
29	113	61	0·045
30	125	70	0·047

TABLE I—*cont.*

Showing length and diameter of shell and thickness of periostracum of 80 *chanks.*—cont.

Serial number.	*Length mm.*	*Diameter mm.*	*Thickness of periostracum mm.*	*Serial number.*	*Length mm.*	*Diameter mm.*	*Thickness of periostracum mm.*
(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
31	119	65	0·049	56	142	73	0·072
32	134	75	0·050	57	118	57	0·055
33	149	75	0·032	58	119	53	0·045
34	129	71	0·035	59	172	91	0·055
35	117	63	0·055	60	145	75	0·055
36	121	70	0·062	61	138	71	0·062
37	111	61	0·071	62	145	76	0·073
38	118	62	0·075	63	148	75	0·071
39	123	69	0·043	64	105	57	0·052
40	111	55	0·051	65	115	56	0·043
41	105	54	0·053	66	145	75	0·052
42	108	53	0·048	67	110	55	0·047
43	117	57	0·053	68	115	56	0·048
44	118	54	0·062	69	130	72	0·056
45	125	71	0·058	70	125	69	0·049
46	118	56	0·073	71	135	75	0·052
47	175	90	0·075	72	179	90	0·063
48	165	89	0·055	73	145	75	0·048
49	155	85	0·053	74	110	56	0·052
50	147	73	0·062	75	118	70	0·048
51	134	69	0·052	76	170	90	0·052
52	128	71	0.063	77	155	82	0·045
53	145	72	0·053	78	165	81	0·052
54	114	56	0·043	79	147	75	0·062
55	112	52	0·055	80	144	73	0·071

ON THE POSSIBLE USE OF MAGNESIUM SULPHATE AS AN ANAESTHETIC FOR EXTRACTING THE SOFT PARTS OF THE CHANK FOR BIOLOGICAL STUDIES

BY

P. S. SAMBANDAMURTHY.

Moses (1922) has recorded that the study of the anatomy of the Chank *Xancus pyrum* (Linn) is not easy because of the impossibility of getting the animal intact from the shell and that the shell is also very thick and massive that only a hammer can break it and the chances are that when the hammer breaks the shell it also injures the soft parts within. Devanesan and Chacko (1944) developed a method by which the chank shell with animal is held in position by a bench vice, a few longitudinal and circular cuts are made on the shell by a hack-saw, and a few gentle taps by a hammer exposing the animal unhurt. In the course of tagging chanks at the Marine Biological Station, Tuticorin, for studying their growth and migrations one specimen was found having several polycheate worms lodged inside holes on its shell. This chank was kept in a finger bowl of ½ litre capacity in clean sea water at 4 p.m. on 30th March 1963, an attempt was made to extract the worms by adding magnesium sulphate to saturation point as an anaesthetic. The next day at 11 a.m. only one worm was found extruded out and the others were still alive lodged inside the holes. The water in the bowl showed some milky discharge and was emitting foul smell. But the chank was found to have retracted even its operculam much into the shell. With a pair of forceps the operculam was given a slight pull and surprisingly the entire animal of the chank came out intact without any difficulty. It was preserved in 5 per cent formalin, and the tissues hardened well and thus the animal was in excellent preservation for biological studies. It is evident that the large number of holes in the shell of this particular chank have facilitated the penetration of magnesium sulphate into the interior whorls of the chank thus dislodging it intact from its shell.

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NATURAL HISTORY OF DUGONG IN RAMESWARAM WATERS

BY

DAVIDSON THOMAS.

Dugong, the sluggish torpedo-shaped mammal of varying shades of grey and of dirty sand hew, known also as the Sea Cow, is a timid harmless animal grazing on the sea grass beds in sheltered bays. These are found to be inhabitants of certain restricted warmer waters in the Indo-Pacific region. In India it is found more abundantly in the Palk Bay and south coast of Gulf of Mannar of Ramanathapuram district and also in Tuticorin area. Near Cutch area also these are reported to be caught occasionally.

Known to the East Ramanathapuram fishermen for decades as *avulia* and *kadalpanni* (sea-pig), this marine mammal forms a successful shore-seine fishery in Rameswaram waters mostly between November and February. The shallow bays near Thondi, Devipattinam, Rameswaram and Kilakarai and the stretch of coral islands which are covered with sea grass are the usual grounds. The sea grass found in the area are *Cymodocea serrulata, Cymodocea rotundata, Cymodocea isaetifalia* and *Enhalus konigii*.

Dugongs are found to prefer feeding on the roots and runner stem of the sea grass rather than the leaves. Its broad and tough muzzle, with central vertical depression with hair-like growths, is used for uprooting and browsing on the sea grass roots. In some adults of about nine feet size, two tusks are noticed from either side of the upper jaw and muzzle, and these facilitates digging out the tubers and rhizomes of the sea grass. While a dugong is grazing in shallow water the tail could be seen at water surface, indicating that during feeding it supports its weight on its flippers.

Dugongs are often caught entangled in the turtle nets (gill nets) of 18-20 inches mesh size made of twisted cotton rope of about 1½ mm. thick or of twisted acacia bark fibre. Occasionally they are caught accidentally in the bottom set nets of 6 and 7 inches mesh size and also in Ray nets. The grounds where they are caught are usually covered with sea grass. Such grounds are located in the Palk Bay off Rameswaram Bay and Olaikuda and off Thondi and Sundarapandiapattinam up to 3–4 fathoms and in the shallow bays of Hare island, Appa Theevu (off Kilakarai) and near Manali islands (off Mandapam) in the Gulf of Mannar. Apart from being landed accidentally in the above nets dugongs are mainly captured in the Rameswaram Bay in shore-seine nets during the season, along with other fish. The bags and wings for these shore-seine nets are made out of sun-hemp grown in Vedaranyam (Thanjavur district).

Dugong herds are normally found in the shallow reaches of Rameswaram Bay feeding on the sea grass soon after the turbulent seas caused by the north-east monsoon and they disappear when the bay becomes little calm with the change of the winds towards east.

The refuse or faecal matter of the mammal are found along the coast of the Rameswaram Bay in globular floating mass 1–1½ inches thick, very similar to cowdung in texture. This betrays the presence of the dugong herds in the shallow bay.

From October to February, the Rameswaram Bay is usually not much disturbed by canoes and fishermen and it is in this quiet and calm atmosphere the dugong herds prefer to move closer to shore. But when disturbed they get scared and swim away.

In the Rameswaram Bay dugong herds have been observed between December–February, when these are landed. The normal size of the dugongs caught is 6–9 ft., weighing 400–600 lb. Smaller ones or baby dugongs are not very common in the catches. Most of these caught are dead when landed since in their attempt to escape they get hurt in the head region and die. Live dugong, landed are killed before cutting by a single hit on the head with a club, which is the vulnerable spot for the mammal.

The male and female proportion in the catches is about 1 : 6 or 1 : 7 ; indicating that one dugong bull has a harem of a number of cows. Many of the female members caught of size about 8 feet are often found to be in advanced stage of pregnancy. There are also adult females with the milking teats in well-developed condition. Unlike the terrestrial mammals the feeding apparatus provided for dugongs are peculiar. Only a pair of tubular structures about 2—2½ inches long and ¾ inch, thick on either side on the lower body and close to the base of the flippers, resembling a single teat of a cow are found. Well developed breast parts are not noticed. The mother dugong, gives its calf an utmost degree of care. Normally until it is strong enough to swim and defend itself, the young ones are clasped by the flippers. In calm undisturbed conditions, the mother is found to suckle its young by keeping it above water level. Usually only one calf is found along with the mother and so also one foetus has been observed in the womb of the adult female dugong caught. Some fishermen claim to have seen two foetus in the womb of a female dugong. But this is perhaps very rare. Young dugong below 3 feet in size are usually very rare in the shore-seine catches. But the young ones have been caught in the set nets and skate nets operated in deeper waters. Evidently the young ones keep themselves normally at safer distance from the shore, while the strong adults migrate and venture more shoreward and feed on the sea grass in clear water.

The flesh of dugong is considered a delicacy in some places and is much sought for. The flesh is more like pork meat and is relished by many people. In Rameswaram, the flesh of dugong is valued about 25 nP. per lb. After meeting local demand the cut slices are well rolled in salt and kept buried in mat covered pits, which drains off the water-content. After 3 days the pit is opened and the flesh dried well when it becomes hard and fibrous. This is exported to Ceylon where there is a ready market for this. The flesh is believed to be of medicinal value and said to cure all intestinal disorders. But it is believed that if taken by women in early stages of pregnancy causes abortion. The bones of the dugong are collected by poor people and sold to sugar factories and distilleries. The fatty layers are found in the abdominal walls of the dugong. These are separately collected and melted to produce oil.

This oil is consumed by people suffering from dysentery, intestinal ulcers and piles for which it is considered a remedy These are also used along with Damur for caulking boats and for application to canoes.

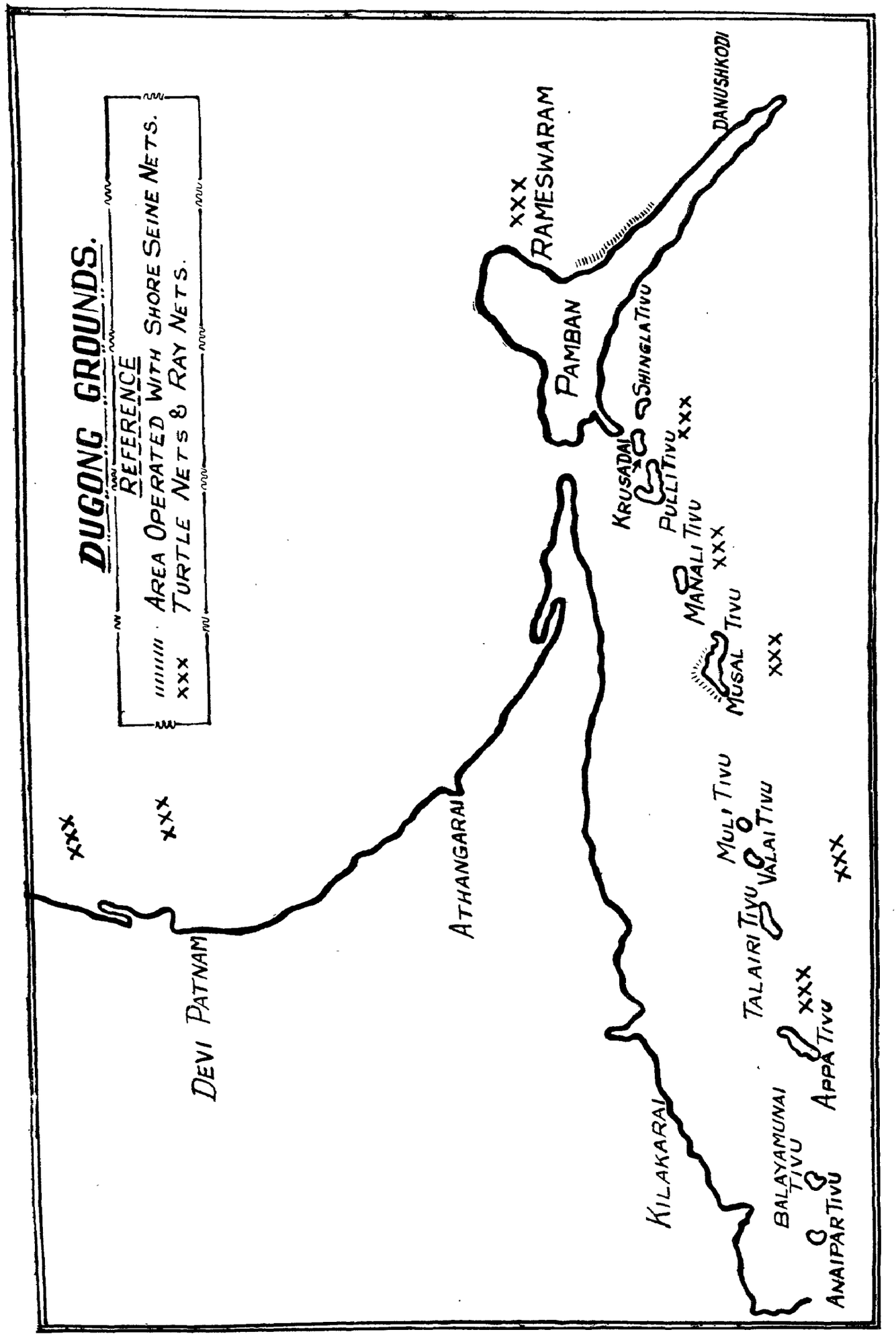
Since 1961, there had been a sudden show-down in the Ceylon market and the price for dugong flesh had come down considerably. The shore-seine fishermen are no more interested in the capture of dugong as a fishery because of the low value and difficulty in marketing and hence not much effort is made for the capture of dugongs now. The view held by some of the marine biologists that the dugongs are heading for depletion cannot be easily accepted atleast as far as our waters are concerned. More herds of dugong of 400—500 in number have been sighted in the areas than before. The congregation of dugongs in herds in the undisturbed shallow bay of Rameswaram and around the islands from November to February when the north-east monsoon is on, and then sudden disappearance after February when the easterly winds begin and the whole bay becomes more calm, indicate that the dugong herds move shore-ward when the sea is turbulent and the bottom mud layers become loose and slushy under the monsoonic conditions due to current and wave action. Stray catches of dugongs in the deeper areas in set nets and sometimes in drift nets by entangling are noticed during the other parts of the year. This proves that during calmer days these mammals are available in deeper waters.

Dugongs are considered quite hardy and could be kept alive in captivity without much care. Recently it was proved that they withstand rough handling. With a view to exhibit them in the National Agricultural Fair, Madras, January 1962, a dugong about 6 feet size was captured alive on 15th December 1961 in shore-seine net in Rameswaram Bay. This was transported in a net, without hurting its snout or head into the turtle pen bay (about a mile away) and kept tied to an anchor by its tail in the sea in one fathom depth. Nylon ropes were used for this purpose which caused some injury to the tail by abrasion. But this wound was soon found to heal up. On 26th December 1961, it was transported in a canoe to Mandapam and then loaded in a jeep trailor, giving a soft bed of sea grass of about 1 foot. Sea water was filled in the trailor, so that the water and sea grass immersed only half its body. I left Mandapam in the jeep with the dugong in the trailor at 4-30 p.m. on 26th December 1961 and reached Madras on 27th December 1961 at 6 a.m., covering the distance in the cool hours of the night. Then it was kept in the trailor till evening before it was transported to a cement tub filled with sea water. The mammal was constantly kept wet at intervals of about 30 minutes. It is clear, that, this mammal could stand such rough handling and shock taking all the bumps of the jeep trailor along the highways from Mandapam to Madras a distance of about 370 miles. Though this was found to be scared and restless during the first two days it got tamed thereafter in the tub and started moving. But care had to be taken not to hurt its snout and head.

Another dugong was captured alive on 15th January 1962 in the Rameswaram Bay. This was about 7 feet length and 310 lb. in weight. After keeping it in captivity in confined waters for 14 days, it was moved to Madras in a jeep trailor as in the previous case. At Madras it was transferred to a cement tub with sea water on 30th January 1962. Sea grass from Rameswaram was collected and sent to Madras to feed it.

It is interesting to note that for 10 days from 15th January 1962 the dugong was kept in confinement in the shallow backwaters of Karaiur, where the salinity of the water is much less. Being shallow, the temperature of water was found to be much more than the normal sea temperature during mid-day. However the dugong was found to be quite happy there in confinement. From this it is presumed that the dugong can be acclimatised to live in waters of lesser salinity. Certain members of this group in Amazon and Nile areas are said to ascend into the rivers. It would be interesting to train the dugong to live in waters of lesser salinity (brackish water) when it will become easier to keep this mammal in confinement in acquariums.

I am thankful to Sri H. K. Ghazi, I.A.S., Director of Fisheries and to Sri P. I. Chacko, Deputy Director of Fisheries, for giving me facilities and encouragement for this work.


DUGONG GROUNDS.
REFERENCE
AREA OPERATED WITH SHORE SEINE NETS.
TURTLE NETS & RAY NETS.
DEVI PATNAM
ATHANGARAI
KILAKARAI
BALAYAMUNAI TIVU
ANAIPAR TIVU
APPA TIVU
TALAIRI TIVU
MULI TIVU
VALAI TIVU
MUSAL TIVU
MANALI TIVU
PULLI TIVU
KRUSADAI
PAMBAN
SHINGLA TIVU
RAMESWARAM
DANUSHKODI

A NOTE ON SEWAGE FISH FARM, MADURAI

BY

D. SUNDARARAJEN, ASSISTANT DIRECTOR OF FISHERIES, MADURAI.

Madurai, the second largest city in the Madras State with a population of about five lakhs has an ideal sewage farm covering an area of 113 acres and yielding about 100 tons of grass per acre per year. The grass first planted about 30 years ago, continues to thrive and grow well even now. The farm is maintained by the Madurai Municipality. The annual income from the farm is over one lakh of rupees.

The farm which is situated about five miles away from the town receives about 2·0 million gallons of raw sewage per day without any form of pretreatment through cast iron pipes of 24" diameter. The farm land has a natural slope of 1 in 100 so that the sewage flows by gravity from the higher level to the lower end. It is divided into a number of smaller plots of about 2·5 acres in an area which is banked up and flooded with sewage once in eight days. The sewage water gradually percolates through the soil into the underdrainage system. The soil is composed of gravel and red loam and is therefore highly loose and porus. Underneath each plot, there are two rows of 3" earthware effluent pipes of 12" length and 3" internal diameter and loose jointed at a depth of 3—4 feet below the ground level for carrying the effluent. Over the pipes is spread stone metal of 1½" size to a height of 7" and over this is placed 5" thickness of small pebbles and over these there is a layer of earth of 2 feet in thickness. The effluent outlet pipes are located 33 feet apart at the lowest end of the farm and the effluent from these is collected in a common open channel and allowed to run to waste on the adjoining low land and made it unfit for any crop cultivation on account of high chloride content of the effluent.

The sewage of Madurai town is thus purified on the principles of "broad irrigation" and "intermittent down filtration". The disposal of the sewage effluent which ran into waste, in a profitable manner was thought of as an urgent necessity. Among various other possibilities it was considered that this problem can be profitably solved by the utilisation of the effluent for pisciculture as was practised in Germany and Bengal. The suitability of a sewage effluent for pisciculture is based on two tests recommended by the Royal Commission in sewage disposal 1898, i.e., the effluent should not contain more than 3·0 parts of suspended matter per 1 00,000 parts of effluent nor take up in 5 days at a temperature of 65°F more than 2·0 parts of dissolved Oxygen per 100,000 parts of effluent. Judged by these tests the effluent of Madurai sewage farm was found to the evidently suited for fish culture. The chloride content of the effluent is also higher than the influent (about 47·0 parts per 100,000) which makes it unsuitable for other purposes than fish culture.

With this object in view the Fisheries Department, suggested to the Madurai Municipality in 1949 for construction of a series of small ponds in the sewage farm site for conducting experiment on fish culture in the sewage effluent. Accordingly eight ponds of the following dimension were constructed to which the sewage water is let in :—

Pond No. I—Size 68′×66′×56′×32′

Pond Nos. II, III, IV—Size 55′×28′

Pond No. V—Size 75′×30′

Pond Nos. VI and VII—Size 144′×60′

Pond No. VIII—Size 800′×154′

These different ponds are used as nursery ponds, rearing ponds and stock pond. These ponds were taken over by the Fisheries Department on 13th February 1957 for a period of five years on the condition, that 50 per cent profit is payable to Madurai Municipality as compensation (*vide* G.O. Ms. No. 383, Food and Agriculture, dated 5th February 1958). The first consignment of *Tilapia* fingerlings was introduced in the Farm by Dr. Van Eleve, Director of T. C. M. Programme, United States of America, who was then touring in this State.

The fish farm is useful to rear the fry of *Rohu*, *Mrigal* and *Catla* into fingerlings and to supply *Tilapia* fingerlings for stocking inland waters of this district. The indegenous carp fingerlings are also temporarily stocked here before they are distributed to the provincialised water.

The results achieved from the Sewage Fish Farm for the past five years are furnished below :—

Year.	Quantity of fish produced.	Quantity of fingerlings taken out.	Expenditure.	Receipts.	Net profit.
	LB.	LB.	RS. P.	RS. P.	RS. P.
1957-58	10½	..	214 59	3 28	Ist year
1958-59	520½	7,180	144 25	304 31	176 44
1959-60	1,221	14,624	37 22	646 90	372 19
1960-61	427	30,970	17 73	653 50	635 86
1961-62	1,106	1,244,272	10 40	364 25	353 85

It may therefore be seen that this Fish farm is working on a profitable scale. The Fish farm is also utilised for the induced spawning experiments on major carps. The hydrological analysis conducted during the month of April 1962 reveal the following facts :—

Water quality.—The water has a very high carbonate alkalinity and low bicarbonate. Chloride was high indicating pollution. Very high pH was recorded and oxygen supersaturated. Fairly moderate phosphate was noted but nitrate was not present. Dissolved solids were high, but calcium was only moderate. High sulphate was noteworthy. Very high plankton content was noted but composed of only Scenedesmus and Anabaena. Soil condition fairly good.

Of late, in maintaining the Sewage Farm, it is observed that all the ponds are over-abundant in *Tilapia*, which compete severely with the other economic species. Unless *Tilapia* is systematically eradicated from this farm the growth of other species will be much affected resulting a poor performance in the farm itself.

CHEMICAL COMPOSITION AND FOOD VALUE OF CHANK AND PEARL OYSTERS

BY

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INTRODUCTION

Pearl and Chank Fisheries off the Gulf of Mannar and Palk Bay of the Madras Coast are State monopolies and their fishing is conducted under the auspices of the Fisheries Department of the Government of Madras. While chank fishing is an annual and regular affair the same cannot be said of the pearl fisheries due to certain ecological and biological conditions occurring in the pearl banks. The pearl fisheries have been conducted off Tuticorin for the past six successive years and the pearl banks are rationally exploited on a scientific basis after careful assessment of the growth, population and pearl bearing nature of the oysters in the various beds.

On an average about 8 to 10 lakhs of chanks (*Xancus pyrum*) are fished annually while 1½ to 2 crores of oysters (*Margaritifera vulgaris*) have been taken out on an average over the past five years. The present paper deals with the chemical composition of the flesh and shells of chanks and pearl oysters.

MATERIAL AND METHODS

Chanks.—The edible portion of the chank flesh which consists of the food of the animal is pulled out of the shell by means of sharp knife. Analysis has been conducted both on the raw flesh as well as on the boiled and dried chips of the flesh. The methods of analysis are similar to the well known standard methods of analysis of foods. The results are given in Table I.

Pearl Oysters.—The meat of pearl oysters are not consumed widely probably due to its unpalatable nature or due to its non-availability. However, it is known that pearl oyster meat is occasionally eaten if only they could be obtained in a fresh condition. It may be mentioned here that unlike other marine foods, the pearl oyster meat gets easily disintegrated due to its own autolytic enzymes and bacterial spoilage sets in rather quickly. For analysis, fresh oysters taken out from the sea during departmental inspections were utilised and analysed. The results of analysis are given in Table II. The amino acid composition of the oyster meat protein has been worked out by paper chromatographic techniques and the results are given in Table III.

DISCUSSIONS

It can be seen from Table I that the food values of the fresh meat of chank compare favourably with that of the preserved form (chank chips) and are in general agreement with that of fish. The chank flesh is rich in protein and minerals, especially in protein, iron and copper. These latter two elements are effective in nutritional anaemia and they are in a form easily available for haemoglobin production. It may be of interest to point out here that the operculum is believed to cure some of the diseases of the children and this probably may be due to its high protein and mineral contents.

As can be inferred from Table II, the pearl oyster meat contains a fairly good quantity of protein and it is high in minerals and glycogen. The iodine contents of pearl oysters has not been worked out but from published literature it is learnt that pearl oyster meat contains about 200 parts per billion of iodine on fresh basis. As mentioned earlier, the oyster meat is not very popular with our people though in Japan this is considered a delicacy and after the search for pearls is over the meat is shucked, frozen, and sent or canned with suitable condiments. Gunasekara (1961) has also reported on the plain drying or salt curing of pearl oyster flesh and found the processed product to be a palatable food and a good source of protein. Table III gives the amino acid make up of the oyster meat protein and this compares favourably with the values for other foods of marine origin.

An investigation into the causes of formation of pearls in the pearl oysters was done earlier [Chari (1956)] when the meats from pearl bearing oysters and non-pearl bearing oysters were analysed chemically, with a view to find out whether any material difference exists in the course of nitrogen metabolism for stimulative secretion of the nacreous layers in the mantle. The results are given in Tables IV and V. It can be seen from both the tables that the general pattern of chemical composition of the two categories of oyster meat is almost the same excepting for the difference in the case of iron. The role played by iron in non-pearl bearing oysters is as yet not clearly understood. It may be concluded that the chemical constituents like protein, fat, ash, as well as the amino acid contents in the two categories fail to indicate the contributing factors responsible for the formation of pearls in the bivalves. However, the presence of iron as a trace element in greater quantities in non-pearl yielding oyster than pearl yielding oysters is a significant factor to be reckoned with and may require further detailed investigations.

COMPOSITION OF THE SHELLS

The chemical composition of the two shells shows about 94 to 96 per cent calcium carbonate with 2 to 3 per cent of organic matter and less than 1 per cent of sulphates and chlorides. Though the chemical characteristics of the shells are almost identical, yet the chank shell is white and very hard unlike the oyster shell which is rather brittle and whose mother of pearl layer is irridiscent.

CONCLUSIONS

Chank flesh is utilised by the fishermen divers as an article of food and the food values compare favourably like any other fish as could be inferred from the analytical values.

The oyster flesh is not quite so popular and is eaten only rarely. The chemical analysis shows this to be a good source of proteins, minerals and glycogen.

Chemical constituents like protein, fat, ash, phosphorus, calcium, in the flesh of the pearl yielding and non-pearl

yielding oyster as well as the amino acid composition of the protein of the above two categories fail to indicate the contributing factors responsible for formation of pearls in the bivalves. However, it is significant to note that the iron content in the case of non-pearl yielding oyster meat is greater than that in the pearl yielding oyster.

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TABLE I.

Food value of Chank flesh.

Particulars.	*Moisture.*	*H₂O Free Basis.* *Protein.*	*Fat.*	*Total mineral matter.*	*Ca.*	*P.*	*Iron mg.*	*Copper. mg.*	*Nacl.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	PER CENT	PER CENT	PER CENT.	PER CENT.	PER CENT	PER CENT	PER CENT	PER CENT	PERCENT
Chank flesh (raw) ..	67·50	76·43	2·52	5·66	0·39	0·29	8·34	1·32	1·08
Chank flesh (boiled and dried-chips).	13·04	80·50	0·53	5·86	0·27	0·37	3·62	1·09	1·47

TABLE II.

Chemical composition of the pearl oysters meat.

	PER CENT.
Moisture	77·71
Protein	14·42
Fat	0·82
Total mineral matter	3·36
Glycogen	2·69
P_2O_5	0·23
Cao	0·36
Iron	mg. 5·57

TABLE III.

Amino acid composition of the pearl oyster meat calculated to 16g. *of* N/100g.

Leucines	11·73
Pyenylalanine	2·56
Valine, Methionine	6·75
Glutamic Acid and Threonine	21·71
Glycine, Serine and Aspartic Acid ..	16·63
Arginine	5·92
Histidine	1·55
Lysine	6·25

TABLE IV.

Chemical composition of the meat from pearl bearing and non-pearl bearing oysters.

Particulars.	*Meat from oysters with pearl.*	*Meat from oysters without pearls.*
(1)	(2)	(3)
	(PER CENT.)	
Original moisture	75·30	74·49
Nitrogen	2·19	2·44
Fat	0·95	0·92
Ash	3·58	4·10
P_2O_5	0·23	0·21
CaO	0·36	0·21
Iron (mg.)	3·90	25·71

TABLE V.

Amino acid composition of the meat from pearl bearing and non-pearl bearing oysters, calculated to 16g. N/100g.

Particulars.	*Meat from pearl bearing oysters.*	*Meat from non-pearl bearing oysters.*
(1)	(2)	(3)
Leucines	10·76	11·32
Phenylalanine	2·98	2·88
Valine, Methionine	7·45	6·53
Tyrosine	1·88	3·81
Glutamic acid and Threonine.	22·32	20·82
Alanine	5·03	3·61
Glycine, Sarine and aspartic Acid.	21·59	20·39
Arginine	4·34	3·51
Histidine	6·44	4·91
Lysine	4·85	6·30

TOXICITY OF SOME ORGANIC AND INORGANIC SUBSTANCES TO FISH

BY

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The advances made in the application of various agricultural chemicals for crop and forest protection has posed a serious problem for fish and wild life administrators [Cottam (1960), Byrd (1960), Hoffman (1960)]. Some of these chemicals have also been used by Fishery workers for management of lakes and ponds [Fukano and Hooper. (1958), Lewis and Tarrant (1960)]. In India, the use of pesticides has not attained a stage to pose a problem for fish or wild life as it does in the U.S.A., and Japan. But great need is felt for a cheap, effective and manageable toxicant for eradication of unwanted fish from large pieces of water. With this object in view the toxicity to fish of a number of organic and inorganic chemicals has been tested.

EXPERIMENTAL

In general, the methods prescribed by Doudoroff *et. al.* (1951) were followed with some variations. The experimental fish were taken from cement tanks with natural food, viz., heavy blooms of plankton. They were starved in holding tanks of 600 litres capacity for 24 hours prior to start of experiments. The quality of the holding water and experimental water is furnished in Table I. The toxicants were dissolved in water or other appropriate solvants and added to the test water to obtain the requisite concentration. 10·0 L water in glass aquaria jars with fishes of size 5·0 to 7·5 cms. were used generally. *Barbus mahecola* and *Rasbora daniconious* were however of sizes 8·0—10·0 cms. ; eight to ten fishes were used in each jar. Initial concentration of oxygen was kept sufficiently high to leave at least 50 per cent saturation after 24 hours. Mortality of fish during 24 hours was noted, as also the reaction of fish. The results are presented as the concentration causing 100 per cent mortality in 24 hours (Tables II and III).

RESULTS AND DISCUSSION

Experiments with chlorinated hydrocarbons show that endrin is the most toxic of all—the 24 hour lethal dose being 0·005 to 0·012 p.p.m. as the 20 per cent emulsifiable compound (or 1/5th of this as active ingredient). *Tilapia* and *gambusia affinis* were more resistant than carps. Anderson *et. al.* (1960) found endrin to be the most toxic known chemical. Katz and Chadwick (1961) determined the toxicity of endrin to six species of fish and found that the tolerance of these fishes differed. Matida *et. al.* (1957) and Iyatomi *et. al.* (1958) have furnished data on the toxicity of endrin to fish in Japan. Next to endrin, we found chlordane and aldrin to be most toxic. Cope *et. al.* (1947) however report that 30·0 p.p.m. of chlordane was required to kill rainbow trout in 24 hours. This appears to be rather too high. Applegate (1957) indicates that 0·1 p.p.m. of chlordane was lethal to trout but not to blue-gills. The results of Hatch (1957), however, closely agree with ours. Ginsburg (1945) found 0·2—1·0 p.p.m. chlordane toxic. The wide divergence in results may be due to lack of uniformity in the environmental conditions as well as in test fish. Toxaphene was found to be highly toxic next to chlordane and aldrin. Cope *et. al.* (1947) found toxaphene and chlordane equally lethal. Fukano and Hooper (1958) also recorded the high toxicity of toxaphene to fishes. However, there are conflicting opinions about the residual effect of toxaphene. Webb (1961), Handerson *et. al.* (1960) and Tarzwell (1959) found D.D.T. to be highly toxic—0·026 to 0·032 p.p.m. However Cope *et. al.* (1947), Dutt and Kundu (1960) found D.D.T. to be toxic only at higher levels as our results also indicate. Only 4·0 p.p.m. technical D.D.T. (5 per cent) was lethal to *Barbus* sp. and *Cirrhina* sp.

Phenol was found by us to be toxic to *E. maculatus* only at 30·0 p.p.m. Among others, Applegate *et. al.* (op. *cit*) found that 5.0 p.p.m. of phenol killed trout but did not affect Blue-gills. Pentachlorophenol emulsion was lethal at 10·0 p.p.m. to our minnows. It was reported to be lethal even at lower dose of 1·0 p.p.m. to trout Blue-gills, etc. [Applegate (1957)]. Paranitrophenol was more toxic than phenol but less so than pentachlorophenol. Bandt (1957) recorded that 5·0 mg./L of nitrophenols to be lethal to fish. Nicotine was lethal to some of our fishes at concentrations of 4 to 8 p.p.m. (or 20·0 to 40·0 p.p.m. as " Nicotox "). The TLm ranged from 17·0 to 25·0 p.p.m.

Chloramine-T (Sodium, P-toluenesulfonchloramide) was lethal to *Tilapia mossambica* at 28·0 p.p.m. The TLm was 25·0 p.p.m. Alpha-naphthylamine at 3·0—4·0 p.p.m. was lethal to *Barbus* sp. Saponin at 15·0 p.p.m. did not affect either *Gambusia affinis* or *Tilapia*. This is surprising since Tang (1961) reported that 100 per cent mortality was caused by 1·5 p.p.m. of Saponin to *Tilapia mossambica* under conditions similar to ours. We used pure B.D.H. saponin. Powder of the seed of *Abrus precatorius* (family *Papilionaceae*) was not at all toxic to *Tilapia mossambica* and *Barbus* sp. at concentrations up to 100 p.p.m.

Among inorganic chemicals, copper sulphate was lethal to four species of fish at 5·0 p.p.m. in 24 hours but to *Macrones vittatus* it was lethal in higher doses, viz., 10·0 p.p.m. in 72 hours or 15·0 p.p.m. in 48 hours. Toxicity was less in hard water. Kemp (1958) found 3·0 p.p.m. copper sulphate lethal to some fishes but Mackereth and Smyly (1951) found as low a conc. as 0·2 p.p.m. of Cu toxic. Tompkins (1958) used copper sulphate for capturing fishes ; from lakes. Calcium hypochlorite appears to be a cheap and efficient fish toxicant, killing *Barbus* sp. at 5·0 p.p.m. Panikker (1960) and Armstrong (1949) used it for management of ponds. We found that the lethal dose of Sodium arsenite was 50·0 to 60·0 p.p.m. well above the limits of concentration necessary to control submerged weeds. These results agree with the findings of Boschetti and Mc. Laughlin (1957) that, only 45·0 p.p.m. was toxic to fishes tested and that no mortality occurred at 15·0 p.p.m. Sodium hypochlorite was toxic only at high levels, viz. 200—400 p.p.m. to *Cyprinus carpio* (German strain) and at still higher doses only (1,500 p.p.m.) to *Tilapia mossambica*. Sodium sulphite was likewise lethal only at high conc. of 500—1,000 p.p.m. Tomiyama and Yamagawa (1950) likewise found no ill effects on fish with 268 mg/l of Sodium

sulphite. Grice (1961) also did not notice any distress of fish at 100—150 p.p.m. of sodium sulphite. Sodium cyanide was lethal for *Tilapia mossambica*, *murrels* and *Barbus* sp. at 0·4 p.p.m. in 24 hours.

Use of fish toxicants in fishery management is a problem engaging the attention of fishery interests. Derris root has been widely used for partial or selective killing of fish. "Killing and rearing of fish are quite compatiable procedures for obtaining the greatest fish toxicant to waters in such a way as to deliberately cause a partial or selective kill of the fish present....is the best method of fish management" [Byrd (1960)]. Toxaphene, a chlorinated comphene has come into use of late for large scale fish eradication [Tanner and Hayes (1955)].

Use of endrin in fishery management was mentioned by Prevost (1960) and Soong and Merican (1959). The latter used it successfully to eradicate fishes from mining pools. However, for the first time large scale use of endrin was made by us to eradicate *Gambusia affinis* from the 84 acre Ooty lake. This upland lake was mainly used for the culture of varieties of the German carp *Cyprinus carpio* and the crucian carp *Carassius vulgaris*. They were multiplying and growing well. This lake was the only source of fingerlings of these fishes. The inadvertant introduction of *Gambusia affinis* into the lake had the disastruous effect of preventing the breeding of these carps or of non-survival of spawn. (Sreenivasan, 1962). Initially Endrix 20 E.C. (20 percent Endrin) was applied at the rate of 0·015 p.p.m. in ponds of size 30m. $\times$ 15·5m $\times$ 1 m. Two applications were made during November 1959. A complete kill of *Gambusia* was obtained. After a lapse of a month, adult spawners of german carps (*Cyprinus carpio* var *specularis* and *C. carpio vulgaris*) were introduced. They spawned successfully, fry and fingerlings being obtained. This gave an indication that elimination of *Gambusia affinis* may facilitate the spawning of the carps and the survival of spawn. Following the successful example of Hayes and Livingstone (1955) poisoning of the shallow margin of the Ooty lake was undertaken during July 1960. *Gambusia* were invariably crowded along the surface of the shallow margins only, especially near weed beds, feeding on insect larvae. This species invariably inherits only the shallow areas and stays at the top few centimeters. Further, the lake is stratified and oxygen depletion occurs below 3·0 or 3·5 m. 4·5 litres of Endrix 20 E.C. (Shell chemicals) was sprayed along the lake margin. Roughly 90 per cent of the *Gambusia* had died as a result. Prior to the application of Endrin, with half an hour's effort two tins full of *Gambusia* were being obtained for feeding trout but after poisoning even a complete day's effort could not yield a tenth of this quantity. A known 200 number of adult *Cyprinus carpio* were also exterminated but a few were able to survive. After a month the water was tested for "residual toxicity" and found to be detoxified. In about ten weeks since spraying in September 1960, the German carps were seen playing about and had spawned successfully. Similarly in fish farms in Kodaikanal *Carassius auratus*, as well as *Cyprinus* carpio bred after years of failure when *Gambusia affinis* and *Barbus melanampyx* were exterminated, using endrin.

The cost for treating the 84·0 acres Ooty lake was just about Rs. 160·00. Since September, 1960 the Ooty lake has in fact become over-populated with the carps. There is no fear of affecting human beings or cattle. The lake is a polluted water not used by human beings for any purpose. Nor do cattle use the water. LD 50 for Endrin is reported to be 10-35 mg./kg. [Dutt and Kundu (1960)]. One has to consume 500 litres of water of 0·02 p.p.m. endrin residual to show symptoms of poisoning. Further endrin is more toxic than phosphorous insecticides to fish but less toxic than the latter for human beings [Dutt and Kundu (1960)].

In poisoning operations, it was noted that when a fine spray was directed into the water, the *Gambusia* revelled at the surface gulping the spray, whereas the carps do not come up. Though the *Gambusia* died off, the mirror carps were seen surfacing in distress only on the second day. These could be revived by transferring to non-toxic water. In a spraying programme in Chetput Fish Farm, it was observed that apart from fishes, frogs and water snakes also died. Zooplankton was eliminated. In this water, livecage experiments showed that the water remained toxic for over 45 days. This was a hard water with a hardness of 182·0 p.p.m. $CaCo^3$, a pH of 9·1 and alkalinity of 478·9 p.p.m. (HCO^3).

Very judicious use of some of the modern insecticides especially chlorinated hydrocarbons could be made in fishery managements. Some of the inorganic chemicals especially calcium hypocholorite promises to be a cheap fish eradicant.

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TABLE I.

Quality of water used for conditioning and experiments.

Temperature	26·0—31·0°C
Free carbondioxide (p.p.m.)	0·0–1·0
Carbonate (CO_3) p.p.m.	0·0–7·8
Bicarbonate (HCO_3) p.p.m.	36·6—40·0
Oxygen mg/L	5·3—8·8
ph	7·0—7·5
Hardness (as $CaCO_3$) p.p.m.	36·0
Chloride (p.p.m.)	8·0—15·0

Table II.

Toxicity of Organic Chemicals to Fish.

(Figures indicate the 24-hour Lethal Dose to kill 100 per cent of fish.)

(Those in paranthesis are the 24 TLm values in p.p.m.)

Species.	*Endrix-20 E.C.*	*Dieldrix-18.*	*Aldrix-40 W.P.*	*Chlordane.*	*Toxaphene.*	*D.D.T. Technical 5%*
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1 *Tilepia mossambica*	0·012 (0·009)	0·06 (0·05)—0·08	0·05 (0·035)	0·07 (0·055)	0·05	..
2 *Barbus mehacola*	0·01—0·008	..	0·05 (0·03)	0·05	0·05—0·075	4·0
3 *Danio* sp.	0·009—0·006	..	0·07	0·06 (0·045)	0·07	..
4 *Cirrhina* sp.	0·01	0·08 (0·06)	..	0·06 (0·045)	..	4·0
5 *Labeo fimbriatus*	0·009	..	..	..	0·05—0·075	4·0
6 *Gambusia affinis*	0·01—0·012	..	..	..	..	..
7 *Channa* sp (murrels)	0·006 (0·005)	0·05 (0·04)	0·01	..	..	..
8 *Catla catla*	..	..	..	0·05 (0·04)	..	..
9 *Cyprinus carpio*	0·08—0·01	..	..	0·07 (0·06)	..	..
10 *Panchax panchax*	..	..	..	..	0·05—0·075	..
11 *Eutroplus Maculatus*	..	..	..	..	..	..

	Nicotox-20.	*Chloramine-T.*	*Sandotox.*	*Phenol.*	*p. nitrophenol.*	*Pentachloro phenol emulsion.*	*a-naphthyl amine.*
	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1 *Tilapia mossambica*	..	28·0 (25·0)	3·0	..	20·0	..	..
2 *Barbus mehacola*	25·0 (22·0)	..	..	30·0	15·0	10·0	3·0—4·0
3 *Danio* sp.	..	..	..	..	..	10·0	..
4 *Cirrhina* sp.	20·0 (17·0)	..	2·0	..	..	..	..
5 *Labeo fimbriatus*	..	..	..	..	..	..	..
6 *Gambusia affinis*	30·0—40·0 (20·0—25·0)	..	6·0—7·0	..	..	..	..
7 *Channa* sp. (*murrels*)	..	..	..	..	..	..	..
8 *Catla catla*	..	..	..	..	..	..	..
9 *Cyprinus carpio*	25·0	..	1·0	..	..	..	..
10 *Panchax panchax*	..	..	..	..	..	..	..
11 *Eutroplus Maculatus*	40·0	..	..	30·0	..	..	..

TABLE III.

Toxicity of inorganic chemicals.

Species.	*Copper Sulphate.*	*Sodium hypochlorite.*	*Sodium aresenite. (A.R.).*	*Calcium hypochlorite.*	*Sodium Sulphate.*	*Sodium cyanide.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1 *Tilapia mossambica*	5·0	400·0	60·0 (56·0)	4·0	1000	0·4
2 *Barbus mehacola* ..	5·0	..	50·0	4·5 (5·0)	500·0 (450·0)	0·4
3 *Danio sp.*	5·0	300·0	..	4·5	..	..
4 *Cirrhina sp.*	..	..	52·0 (48·0)	..	..	..
5 *Labeo fimbriatus* ..	..	..	52·0 (48·0)	..	..	..
6 *Channa sp.* (*murrels*)	..	..	..	..	..	0·04
7 *Cyprinus carpio* ..	..	200·0	52·0 (50·0)	..	..	..
8 *Etroplus maculatus*	5·0	..	..	..	..	..

VITAMIN 'A', COPPER AND IRON IN THE EAST COAST MARINE FISHES AVAILABLE AT TUTICORIN

BY

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The investigations on the nutritive value of important marine fishes of the West Coast of Madras for moisture, protein, fat, ash and mineral matters were already reported by Chari (1948). The nutritive value of marine fishes of Bombay province was studied by Setna *et. al.* (1944). Jeyachandran (unpublished data) has worked on the nutritive value of marine fishes found near Tuticorin. It was felt necessary to take up the estimations of Vitamin 'A' copper and iron contents, which are also vital nutrients to health, for the east coast marine fishes available in the Tuticorin area. About twenty fishes were analysed for the Vitamin 'A', copper and iron contents and the results are reported here.

METHODS

The study was taken only on the fresh fishes got from the landing place. Only the edible portion (i.e. after the removal of scales, fins, skin, gills, guts, head and tail portion) was taken up for analysis.

The methods of sampling followed were exactly the same as given by the Association of Official Agricultural Chemists (1945) and Association of Official Vitamin Chemists (1951). For medium sized fishes about 8 fishes were taken, with moderately big fishes, three to four were taken for analysis. The edible portion was minced well with a mechanical mincer and representative samples taken for analysis.

ESTIMATION OF VITAMIN 'A'

The representative minced sample was taken in a waring blender and added twice the amount of distilled water and blended well. Aliquots were withdrawn from the blended one and poured into an already weighed saponification flask. Reweighed. The difference in weight will give the weight of the sample for analysis. As described in the A.O.V.C. (1951) conducted saponification with 3 cc. of 1 : 1 potassium hydroxide and 30 cc. alcohol. The unsaponifiable matter was extracted with ether in successive quantities from the separating funnel. The last traces of moisture from the ether was removed by filtration through anhydrous sodium sulphate and then the last traces of the ether was evaporated in an inert medium. The unsaponifiable matter left behind was taken with cyclohexane and Vitamin 'A' estimated using Unicam spectrophotometer.

ESTIMATION OF COPPER AND IRON

The method for the estimation of copper was followed as given by Callen and Handerson (1929). Copper was estimated in the ash extract using sodium diethyldithio carbamate in the spectrophotometer. The iron content was estimated in the ash extract using xx dipyridyl in the spectrophotometer as per Andrews and Fett (1941).

Table I gives the vernacular (Tamil), common English name and scientific name of the fishes, and the estimations of vitamin 'A', copper and iron contents.

DISCUSSIONS

The presence of vitamin 'A', copper and iron is also an index of the nutritive value of the fish. In addition to protein, fat, calcium and phosphorus, these can also be considered to be the vital nutrients. There are wide variations in the contents of vitamin 'A', copper and iron contents in the fishes taken up for study.

Tarr (1954) has estimated the vitamin 'A' for some of the fishes like salmon, cod, haddock, mackerel, sword fish, etc. Almost all fishes contain less than 400 I.U. per 100 gm. of flesh in the wet basis. Hirao *et. al.* (1959) have examined 157 species of fish for vitamin 'A' in fish flesh. Eighty-five per cent of the species contained less than 200 I.U./100 gm. of fish muscle. In the fishes analysed in this laboratory, vitamin 'A' ranges from 27 I.U. to 325 I.U./100 gm. of the muscle.

Riddel (1936) and Choudhury and Basu (1939) have estimated copper contents in the fish. Riddell (loc. *cit.*) found the copper content to vary from 0·03 to 0·12 mg./g. of ash. Saha (1941) estimated copper content of some fresh water species of fish and found that they contain less than 0·2 mg./100 gm. in wet basis. Table I shows that copper ranges from 0·02 mg./ per cent to 2·24 mg. per cent and iron ranges from 0·7 mg. to 9·0 mg. per cent in wet basis.

The fishes that contain more than 200 I.U./100 gm. of vitamin 'A' in the muscle have also been reported by Jeyachandran to be high in protein and fat content also indicating that they are highly nutritious.

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Table 1.

Amounts of Vitamin 'A', copper and iron in the marine fishes.

Local name (Tamil).	*Common name (English).*	*Scientific name.*	*Weight of average fish in Kg.*	*Average length in cm.*	*Edible portion percent.*	*Wet basis.*		
						Copper mg./100 gm.	*Iron mg./100 gm.*	*Vitamin · A I.U./100 gm.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1 Ullam	Shad	*Hilsa ilisha*	0·11	18·0	62·5	0·32	0·88	84·37
2 Kathalai	Jew fish	*Sciaena sp.*	0·17	8·5	66·6	0·72	4·26	36·24
3 Soorai	Tuna	*Euthinnus sp.*	0·70	38·3	68·0	0·14	1·42	129·80
4 Kuddippu	Big jawed jumper	*Lactarius sp.*	0·10	23·5	80·0	0·15	1·90	255·90
5 Parai	Horse mackerels	*Carnax sp.*	0·20	26·0	68·8	0·09	6·64	164·60
6 Vengadi	Torpedo fish	*Megalaspis cordyla*	0·28	24·0	63·6	0·15	2·90	298·00
7 Chenguli	Red soldier fish	*Holocentrus rubrum*	0·20	20·0	75·0	0·07	2·50	284·30
8 Panna	Silver banded jew fish ..	*Otolithus argenteus*	0·60	32·0	66·7	0·04	3·17	325·80
9 Sura	Shark	*Carcharius sp.*	1·00	41·00	82·5	0·10	2·87	30·46
10 Soodai	Sardines	*Sardinella gibbosa*	0·03	14·0	71·0	0·03	3·65	160·00
11 Vellai Vaval	White promfret	*Stromateus argenteus*	0·25	24·0	80·0	0·10	1·87	222.00
12 Keluthi	Cat-fish	*Arius jella*	0·25	26·0	66·7	1·19	9·02	98·70
13 Katta	Leather skin	*Chorinemus sp.*	0·33	28·3	60·0	2·10	1·08	202·10
14 Seela	Seer fish	*Cybium sp.*	0·60	42·3	75·0	1·80	2·00	107·30
15 Valai	Wolf herring	*Chirocentrus dorab*	0·90	52·0	77·7	0·28	1·10	70·90
16 Cheppili..	Golden Snapper	*Lutianus sp.*	0·50	26·0	70·0	2·24	0·70	46·00
17 Thamban	Vermilion Coral cod ..	*Serranus miniatus*	1·00	37·0	68·0	0·98	1·30	45·50
18 Kanankeluthi	Mackerel	*Rastrelliger sp.*	0·30	26·0	66·7	0·62	1·15	112·30
19 Salai	Sardines	*Sardinella fimbriata*	0·03	12·0	70·0	0·34	2·64	53·40
20 Keerimeensalai ..	Sardines	*Sardinella sirm*	0·04	18·0	66·7	1·07	0·70	63·51
21 Pambu Mural	Round tail alligator ..	*Tylosurus strongylurus* ..	0·017	21·0	70·6	0·40	0·31	27·54

TEMPERATURE ACCLIMATION AND OXYGEN CONSUMPTION IN FRESH WATER FISH

BY

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Temperature dependence of respiration in fishes is well understood [Krogh (1916)]. Oxygen consumption in poikilotherms increases with increasing temperature up to a particular limit. [Zeuthen (1947)] however points out that a cold-blooded animal when transferred to a lower temperature has its metabolic rate reduced immediately but after being kept for some days at this lower temperature, a higher rate of metabolism ensues. Wohlschlag (1960) has confirmed this " Cold adaptation " in poikilotherms. Scholander *et al.* (1953) found that oxygen consumption by tropical fishes is about five times the rate for Arctic species at 0°0 C and 30 to 40 times the hypothetical rate of tropical forms at 0° C—This statement has a bearing on reduction of metabolism of tropical fish and hence a few experiments were made to study the respiratory rate of thermally acclimated fish.

Fish (of sizes 6—12 cms.) were conditioned in small containers, one set acclimated to a higher tropical temperature of 28 to 30° C and another to a lower temperature of 18 to 20°C (with the test species used, viz., *Barbus sp.* and *Cirrhina reba*, still lower temperature could not be tried since these fishes died at 15°C. Even fry of *Tilapia mossambica* died of cold shock at 15° C). Oxygen consumption was studied for exactly half an hour. The following combinations were used:—

Oxygen consumption by ' warm ' fishes (those acclimated to 28 to 30°C) at ' warm temperature ' and at ' cold temperature ' ; Oxygen consumption by cold fishes (those acclimated to 18–20°C) at ' cold temperature ' and at ' Warm temperature'. The results are tabulated below: —

Experiment number.	*Acclimation temperature.* 30°C. *oxygen consumption in mg.*		*Acclimation temperature.* 20°C. *oxygen consumption in mg.*	
	30°C.	20°C.	30C.	20°C.
1. *Cirrhina reba* ..	2·48	0·32	2·0	0·72
2. *Cirrhina reba* ..	1·68	0·48	2·16	1·12
3. *Cyprinus carpio*	..	..	0·23	0·19
4. *Barbus sp.* ..	1·3	0·20	3·7	1·8

Note.—In the case of Barbus sp. the ' warm ' temperature was 28°C and ' cold ' temperature 18°C.

The results indicate that in the case of fish acclimated to a higher temperature, oxygen consumption falls very significantly when transferred to a lower temperature. What is striking is that this lowered rate of respiration is even far below that of the respiration of cold acclimated fish at the 'cold' temperature. Wells (1935) and Sumner and Wells (1942) also obtained similar results—They found that fishes acclimated to 30°C showed lower rate of oxygen consumption at 20°C than the ones kept acclimated at 20°C or the ones transferred from 10° to 20°C.

The effect of size on the relationship between thermal adoptation and respiration would be an interesting study.

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EXPERIMENTS ON THE USE OF COCONUT OIL IN CANNING PRAWNS (PENAEUS INDICUS)

BY

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INTRODUCTION

In India prawns contribute to a major fishery of economic importance especially on the West Coast. At present the bulk of the catches is sun-dried for export to Burma and South-East Asian countries. Of late, Indian prawns preserved by canning have established a good market in the United States and Western Europe, thus earning valuable foreign exchange for our development programmes. During 1960, export of prawns from India yielded foreign exchange worth Rupees thirty million.

There are vast potentialities of developing internal markets for prawns provided improved processing methods are employed, so that products appealing to the Indian consumers are made available at reasonable prices. Experiments conducted at the Fisheries Technological Sub-Station, Cape Comorin, have proved that a gravy made of chillies, and coconut oil yielded a very good medium for canning of prawns. The results of these investigations are presented in this paper.

MATERIAL AND METHODS

Marine prawns (*Penaeus indicus*) caught in boat seines from the inshore waters off Cape Comorin during July 1961 were used for these experiments. The prawns were processed immediately after landing when most of them were alive. These were washed in sea water and immersed in boiling 5 per cent brine for five minutes. While still hot the heads were severed, de-veined and the shells removed. The remaining flesh was packed in thirty cans, of size 301×206, 100 grams in each can. To each can was added 20 ml. of a gravy prepared as follows. 100 grams of dried chillies were finely powdered and heated with 500 ml. of fresh coconut oil for fifteen minutes. To this were added 50 grams of powdered common salt, 50 grams of cane sugar and another half a litre of coconut oil and heating continued for another 15 minutes with continuous stirring. The mixture was strained through cotton cloth and the resultant filtrate was used as gravy. After the addition of the gravy the cans were exhausted by placing them in boiling water immersed up to 1 cm. below the tops of the cans for ten minutes. The cans were then closed and sealed immediatey using a Metal Box domestic can sealer. The sealed cans were divided into three batches of ten each and sterilised in steam at 120°C (steam pressure=15 pounds per square inch) for 45, 60 and 75 minutes respectively followed by cooling in running cold water. The cans were stored at room temperature for a period of up to fourteen months and the contents periodically examined. Total volatile basic nitrogen and trimethylamine nitrogen were determined by the method of Conway (1947) using the press-juice prepared by grinding the prawns with solid trichloracetic acid. pH of the medium was determined using B.D.H. indicator paper strips. The organoleptic assessment of the products was carried out as suggested by Farber and Ferro (1956).

RESULTS AND CONCLUSION

The results of the periodic analysis are summarised in Table I. It was found that the products retained excellent keeping quality throughout the period of storage of fourteen months. There was no significant difference in the TMAN and TVBN values for the three sets of samples in spite of difference in the duration of sterilisation. Further it was found that sterilisation at 120°C for a period of 45 minutes was quite sufficient to ensure good keeping qualities for the product. The usual objection to the use of coconut oil as a medium for canning of fish is its relatively high solidification point of 22°C. But in a tropical country like India, there are very few regions outside the hill stations where atmospheric temperature falls below 22°C, that too only for a short period during the winter. The solidification point of coconut oil can be reduced to 10°C if so desired by incorporating 10 per cent of rice bran oil [Harsono Hardjohutomo (1958)]. The addition of rice bran oil to coconut oil will have a further advantage because of the presence of alphatocopherol a powerful antioxidant in rice bran oil. This will help inhibit the progress of spoilage by oxidative processes. The only reference so far about the use of coconut oil as a medium for canning fish is by Soejarwidodo (1958) who found it quite satisfactory for the species. *Clupea fimbriata* and *Caranx sexfasciatus* in Indonesia. With the availability of sufficient supplies of coconut oil at reasonable cost, the method of canning of prawns described is quite practicable and worth a trial by the Indian fish canning industry.

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TABLE I.

Result of storage studies on canned prawns.

Storage period.	*Batch.*	*A.*	*B.*	*C.*	*Remarks.*
Fifteen days ..	pH of medium	6·1	6·1	6·1	Batch-A. Sterilised for 45 minutes.
	TVBN (mgm/cent) ..	0·64	0·65	0·64	
	TMAN (mgm/cent) ..	0·062	0·071	0·071	
	Org. Score (Max-10) ..	10·0	10·0	10·0	
Thirty days ..	pH of medium	6·1	6·1	6·1	Batch-B. Sterilised for 60 minutes.
	TVBN	0·64	0·65	0·64	
	TMAN	0·062	0·071	0·071	
	Org. Score	10·0	10·0	10·0	
Forty-five days ..	pH of medium	6·2	6·2	6·2	Batch-C. Sterilised for 75 minutes.
	TVBN	0·64	0·65	0·64	
	TMAN	0·070	0·071	0·071	
	Org. Score	10·0	10·0	10·0	
Three months ..	pH of medium	6·2	6·2	6·2	
	TVBN	0·64	0·65	0·64	
	TMAN	0·070	0·070	0·071	
	Org. Score	10·0	10·0	10·0	
Four months ..	pH of medium	6·2	6·2	6·2	
	TVBN	0·65	0·66	0·66	
	TMAN	0·070	0·071	0·071	
	Org. Score	10·0	10·0	10·0	
Five months ..	pH of medium	6·2	6·2	6·2	
	TVBN	0·66	0·65	0·65	
	TMAN	0·071	0·070	0·072	
	Org. Score	10·0	10·0	10·0	
Six months.. ..	pH of medium	6·2	6·2	6·2	
	TVBN	0·66	0·66	0·66	
	TMAN	0·071	0·072	0·072	
	Org. Score	10·7	10·0	10·0	
Fourteen months ..	pH of medium	6·2	6·2	6·2	
	TVBN	0·66	0·66	0·66	
	TMAN	0·071	0·072	0·072	
	Org. Score	10·0	10·0	10·0	

A STUDY ON THE LOSS OF WEIGHT OF COMMON SALT DUE TO DRYAGE DURING STORAGE IN FISH-CURING YARDS

BY

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INTRODUCTION

The results of experiments conducted during the years 1960 and 1961 in assessing the loss of weight of common salt stored in fish-curing yard godowns in Madras State on prolonged storage in gunny bags are presented in this paper.

MATERIAL AND METHODS

Ordinary and alkathene lined gunny bags of two maunds (75 Kg.) capacity and common salt with a minimum of 96 per cent Nacl generally used for fish curing were used for these investigations. Ten ordinary gunnies and ten alkathene lined gunnies were packed with 75 Kgs. each of crushed common-salt and stacked in vertical rows of five bags each placed over wooden sleepers on the cemented floor in the salt godowns of the fish-curing yards. The experiments were carried out at Cape Comorin and Adiramapattinam. The initial gross weights of the individual bags were recorded on the day of packing. Subsequent weighments were made once every fortnight viz., on the first and fifteenth of every month to cover a total storage period of one year. The weights were recorded using standardised Avery platform weighing machines.

RESULTS AND CONCLUSIONS

The data recorded at Cape Comorin are given in Tables I and II respectively for salt stored in ordinary gunnies and alkathene lined gunnies. The net loss or gain in weight of the experimental bags are given in Table III. Corresponding data for Adiramapattinam are given in Tables IV, V and VI.

An analysis of the data collected at Cape Comorin shows that the average loss in weight of salt kept in alkathene lined gunnies due to dryage for a period of one year was 1·09 per cent or 0·82 kg. per bag. The loss of weight recorded during the same period in the salt stored in ordinary gunny bags was 3·8 per cent or 2·85 kg./bag. For the experiments conducted at Adiramapattinam the corresponding figures were 6·46 per cent (4·84 kg./bag) in the alkathene lined bag and 13·03 per cent (9·77 kg./bag) in the ordinary gunny bag. These figures have been arrived at assuming that the gain or loss, if any, in the weights of the material of the bags was negligible during the period of experiments. It was also observed that the bags kept at the bottom of the stacks recorded a slight increase in weight in the case of alkathene lined gunnies stored at Cape Comorin. In the corresponding ordinary gunnies the net loss of weight was the least among the latter, as was to be expected because of the proximity of the bags to the floor of the godown. No such observations were made at Adiramapattinam.

The data recorded clearly showed that with the use of alkathene lined gunnies for the storage of salt in fish-curing yards the wastage of salt due to dryage can be reduced considerably. But economically there is not much gain in using alkathene lined bags instead of ordinary gunny bags as the cost of one alkathene lined gunny bag is Rs. 2·20 as against the cost of Rs. 1·25 only for one ordinary bag and as the value of the contents, namely common salt is not much.

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Table I.

Showing the weights of ordinary gunnies with salt in the Cape Comorin Fish-curing Yard.

(weights in kilograms.)

Gunny number.	1	2	3	4	5	6	7	8	9	10
Gunny weight.	1·81	2·15	2·38	1·7	1·7	1·8	1·8	1·9	2·72	2·38
Date of record.										
1st October 1960	76·46	76·80	77·05	76·35	76·35	76·46	76·46	76·57	77·36	77·03
15th October 1960	77·0	78·13	75·98	75·75	75·3	76·09	75·86	75·86	75·56	76·09
1st November 1960	75·98	76·2	76·43	75·75	77·0	76·2	75·86	76·32	76·54	75·9
15th November 1960 ..	75·75	77·86	76·2	75·63	78·01	76·09	75·75	76·2	76·43	78·81
1st December 1960	75·18	75·30	75·52	75·18	75·56	75·18	75·3	75·75	76·09	78·58
15th December 1960 ..	74·61	74·84	75·07	74·96	75·68	75·3	75·3	75·75	76·2	78·47
1st January 1961	74·05	74·39	74·4	74·39	76·2	74·39	74·4	74·96	75·3	77·0
15th January 1961	74·16	74·4	74·73	74·4	76·32	74·16	74·62	74·95	75·3	76·89
1st February 1961	73·6	74·04	74·39	74·16	76·2	73·6	74·28	74·62	75·07	76·66

TABLE I—*cont.*

Showing the weights of ordinary gunnies with salt in the Cape Comorin Fish-curing Yard—cont.

(WEIGHTS IN KILOGRAMS.)

Gunny number.	1	2	3	4	5	6	7	8	9	10
Gunny weight.	1·81	2·15	2·38	1·7	1·7	1·8	1·8	1·9	2·72	2·38
Date of record.										
15th January 1961	73·48	73·94	74·28	74·28	75·98	73·48	74·04	74·39	74·73	76·43
1st February 1961	73·6	74·04	74·39	74·16	76·2	73·6	74·28	74·62	75·07	76·66
15th February 1961	73·48	73·94	74·28	74·28	75·98	73·48	74·04	74·39	74·73	76·43
1st March 1961	73·03	73·6	73·82	73·6	75·52	72·92	73·6	74·39	74·39	76·2
1st April 1961	72·69	73·48	73·7	73·48	75·3	73·03	73·6	76·16	74·04	75·86
15th April 1961	73·14	73·6	73·82	73·6	75·52	72·92	73·48	73·94	73·94	76·2
1st May 1961	73·03	73·6	73·8	73·37	75·52	72·92	73·03	73·94	73·94	76·2
15th May 1961	72·92	73·48	73·6	73·14	74·41	72·9	72·92	73·82	73·82	76·2
1st June 1961	73·48	73·94	74·27	74·39	76·2	73·48	73·71	74·16	74·16	76·66
15th June 1961	73·26	73·94	74·38	74·38	76·43	73·71	73·94	74·62	74·71	75·56
1st July 1961	73·48	74·28	74·38	73·48	76·67	73·6	74·05	74·62	74·28	77·34
15th July 1961	73·48	74·16	74·39	73·48	76·43	73·48	73·94	74·62	74·16	77·11
1st August 1961	73·14	73·48	73·94	73·03	75·75	73·48	73·94	74·62	74·05	77·0
15th August 1961	73·03	73·26	73·71	73·26	75·75	73·39	73·94	74·39	74·16	76·66
1st September 1961	72·92	73·14	73·48	73·26	75·52	73·39	73·82	74·16	73·93	76·2
15th September 1961 ..	72·69	72·92	73·26	73·03	75·07	73·03	73·59	74·16	74·16	76·43

TABLE II.

Showing the weights of alkathene lined gunnies with salt in the Cape Comorin Fish-curing Yard.

(WEIGHTS IN KILOGRAMS.)

Gunny number :	1	2	3	4	5	6	7	8	9	10
Gunny weight :	1·13	1·25	1·25	1·25	1·13	1·25	1·25	1·25	1·25	1·25
Date of record.										
1st October 1960	75·78	75·89	75·89	75·89	75·78	75·89	75·89	75·89	75·89	75·89
15th October 1960	75·52	75·86	75·98	76·09	75·86	75·86	75·75	75·86	75·98	75·86
1st November 1960	75·64	75·86	75·86	75·18	75·86	76·09	75·98	75·86	75·98	75·98
15th November 1960 ..	75·64	75·86	75·98	76·09	75·92	75·98	75·86	75·75	76·2	75·98
1st December 1960	75·64	75·86	75·75	75·98	76·09	75·75	75·86	75·64	75·86	76·2
15th December 1960 ..	75·64	75·86	75·75	75·98	76·09	75·75	75·86	75·64	75·86	75·2
1st January 1961	75·64	75·75	75·64	75·98	76·09	75·75	75·75	75·64	75·86	75·2
15th January 1961	75·3	75·75	75·86	76·2	76·32	75·75	75·86	75·75	75·98	76·43
1st February 1961	74·96	75.52	75·64	75·86	75·86	75·52	75·75	75·52	75·75	76·09
15th February 1961	75·07	75·41	75·41	75·86	75·98	75·3	75·98	75·3	75·64	76·09
1st March 1961	74·84	75·41	75·52	75·64	75·86	75·18	75·41	75·18	75·41	75·86
15th March 1961	74·96	75·41	75·52	76·2	75·86	75·18	75·52	75·52	75·52	76·43
1st April 1961	74·84	75·52	75·86	76·43	76·43	75·3	75·52	75·52	75·52	75·98
15th April 1961	74·73	75·3	75·41	75·75	76·42	74·73	75·52	75·3	75·52	76·66
1st May 1961	74·62	75·07	75·07	75·64	76·09	74·39	75·3	75·3	75·41	76·2
15th May 1961	74·62	75·3	75·18	75·52	76·09	74·39	75·07	75·18	75·41	76·43
1st June 1961	75·07	75·41	75·41	75·75	76·88	75·52	75·3	75·18	75·3	76·55
15th June 1961	74·84	75·3	75·52	75·64	77·11	74·39	75·41	75·3	75·3	76·66
1st July 1961	75·07	75·52	75·52	75·75	77·11	74·39	75·18	75·41	75·41	77·0
15th July 1961	75·3	75·75	75·75	75·98	77·22	74·62	75·52	75·41	75·41	76·88
1st August 1961	75·3	75·75	75·41	75·75	76·88	74·50	75·41	75·31	75·41	76·66
15th August 1961	75·07	75·52	75·41	75·64	76·88	74·50	75·07	75·07	75·3	76·20
1st September 1961	75·07	75·3	75·07	75·3	76·32	74·28	74·96	75·96	75·07	76·43
15th September 1961 ..	74·4	74·96	74·84	75·07	76·09	74·82	74·62	74·73	74·73	76·20

TABLE III.

Showing the loss/gain in weight of the experimental salt bags for a storage period of one year in Cape Comorin Fish-curing Yard.

(WEIGHTS IN KILOGRAMS.)

Serial number.	*Alkathene lined gunnies.* Initial weight.	Final weight.	Difference.	Serial number.	*Ordinary gunnies.* Initial weight.	Final weight.	Difference.	*Remarks.*
1	75·78	74·40	— 1·38	1	76·46	72·69	— 3·77	Bags with serial numbers 5 and 10 were kept at the bottom of the stacks.
2	75·89	74·36	— 0·93	2	76·80	72·92	— 3·88	
3	75·89	74·84	— 1·05	3	77·05	73·26	— 3·79	
4	75·89	75·07	— 0·82	4	76·35	73·03	— 3·32	
5	75·78	76·09	+ 0·31	5	76·35	75·07	— 1·28	
6	75·89	74·82	— 1·07	6	76·46	73·03	— 3·43	
7	75·89	74·62	— 1·27	7	76·46	73·59	— 2·87	
8	75·89	74·73	— 1·16	8	76·57	74·16	— 2·41	
9	75·89	74·73	— 1·16	9	77·36	74·16	— 3·20	
10	75·89	76·20	+ 0·31	10	77·03	76·43	— 0·60	
	Total loss of weight ..		8·22				28·55	
	Average loss of weight. ..		·32				2·85	
	Average per cent of loss...		1·9				3·80	

TABLE IV.

Showing weights of ordinary gunnies with salt in the Adiramapattinam Fish-curing Yard.*

(WEIGHTS IN KILOGRAMS.)

Gunny number.	1	2	3	4	5	6	7	8	9	10
	Gunny weight 0·93.									
Date of record.										
1st July 1960	75·0	75·0	75·0	75·0	75·0	75·0	75·0	75·0	75·0	75·0
15th July 1960	75·0	75·0	75·0	75·0	75·0	75·0	75·0	75·0	75·0	75·0
1st August 1960	73·39	73·39	75·0	73·86	73·86	73·86	73·86	73·86	73·39	75·0
15th August 1960	73·39	73·39	73·86	73·86	73·86	73·86	73·86	73·86	73·86	73·86
1st September 1960	73·39	73·39	73·86	73·86	73·86	73·86	73·86	73·86	73·86	73·86
15th September 1960 ..	72·92	72·92	73·39	73·39	73·39	73·39	73·39	73·39	72·46	72·92
1st October 1960	72·46	72·46	72·46	72·46	72·46	72·92	72·92	72·46	72·46	72·46
15th October 1960	72·46	71·99	72·46	71·99	71·99	72·46	72·46	71·99	71·53	71·99
1st November 1960	71·99	71·99	71·99	71·53	71·53	71·99	71·99	71·53	71·53	71·53
15th November 1960 ..	71·99	71·53	71·53	71·53	71·53	71·99	71·53	71·53	71·53	71·53
1st December 1960	..	..	..	..	..	..	..	..	..	..
15th December 1960.. ..	71·06	71·53	71·53	71·06	71·53	71·99	71·53	71·53	71·53	70·13
1st January 1961	70·13	70·59	70·59	70·13	70·59	71·06	71·06	71·59	71·59	69·19
15th January 1961	69·66	69·66	69·66	69·66	70·59	70·59	70·59	70·13	70·13	68·73
1st February 1961	69·19	69·19	69·19	69·19	69·66	70·13	70·59	70·13	70·13	68·73
15th February 1961	68·26	68·26	68·73	68·26	68·73	69·19	69·19	69·66	69·19	67·79
1st March 1961	67·79	68·26	68·73	68·26	69·19	69·19	69·19	69·19	69·19	67·79
15th March 1961	67·79	67·79	67·79	69·79	67·79	68·73	69·66	68·73	68·73	67·33
1st April 1961	66·86	67·33	67·33	67·33	67·33	68·26	68·73	67·79	67·79	66·86
15th April 1961	66·86	67·33	67·33	66·86	66·86	68·26	68·73	67·79	67·79	66·86
1st May 1961	66·86	67·33	67·33	66·86	66·39	68·26	67·79	67·33	67·33	65·93
15th May 1961	65·93	66·86	66·86	66·39	66·39	68·26	67·79	67·33	67·33	65·93
1st June 1961	65·36	66·39	66·39	64·99	65·93	66·86	66·86	66·39	65·93	65·46
15th June 1961	64·99	65·53	64·99	64·53	65·46	66·39	65·93	65·46	64·99	64·99
1st July 1961	64·53	65·46	64·99	64·53	64·99	65·93	65·93	65·93	65·46	64·53

* Weights exclusive of the gunny.

TABLE V.

Showing the weights of alkathene lined gunnies with salt in the Adiramapattinam Fish-curing Yard.*

(WEIGHTS IN KILOGRAMS.)

Gunny number.	1	2	3	4	5	6	7	8	9	10
Date of record.	*Gunny weight 0·93 kg.*									
1st July 1960	75·0	75·0	75·0	75·0	75·0	75·0	75·0	75·0	75·0	75·0
15th July 1960	75·0	75·0	75·0	75·0	75·0	75·0	75·0	75·0	75·0	75·0
1st August 1960	75·0	75·0	75·0	75·0	75·0	75·0	75·0	75·0	75·0	75·0
15th August 1960	75·0	75·0	75·0	75·0	75·0	75·0	75·0	75·0	75·0	75·0
1st September 1960	75·0	75·0	75·0	75·0	75·0	75·0	75·0	75·0	75·0	75·0
15th September 1960 ..	75·0	75·0	75·0	75·0	75·0	75·0	75·0	75·0	75·0	75·0
1st October 1960	75·0	75·0	75·0	75·0	75·0	75·0	75·0	75·0	75·0	75·0
15th October 1960	75·0	75·0	75·0	75·0	75·0	75·0	75·0	75·0	75·0	75·0
1st November 1960	75·0	75·0	75·0	75·0	75·0	75·0	75·0	75·0	75·0	73·86
15th November 1960 ..	75·0	75·0	73·86	75·0	75·0	75·0	75·0	75·0	75·0	73·86
1st December 1960	..	..	..	..	..	..	..	..	..	..
15th December 1960.. ..	75·0	75·0	72·92	75·0	73·86	75·0	75·0	75·0	73·86	72·92
1st January 1961	73·86	75·0	72·92	75·0	72·92	75·0	75·0	75·0	73·39	72·46
15th January 1961	73·39	73·86	72·46	75·0	72·46	75·0	73·39	73·86	72·92	71·8
1st February 1961	73·39	73·86	72·46	75·0	72·46	75·0	73·39	73·86	72·92	71·8
15th February 1961	72·46	72·92	71·99	75·0	71·53	75·0	72·46	73·39	71·99	71·53
1st March 1961	72·46	72·92	71·99	75·0	71·53	75·0	72·46	73·39	71·99	71·53
15th March 1961	72·46	72·92	71·99	75·0	71·53	75·0	72·46	72·92	71·53	71·06
1st April 1961	71·53	71·99	71·06	75·0	71·06	73·86	71·99	72·46	71·06	71·06
15th April 1961	71·53	71·99	71·06	71·86	71·06	73·86	71·99	72·46	71·06	71·06
1st May 1961	71·53	71·99	71·06	73·86	71·06	73·86	71·99	71·99	71·06	71·06
15th May 1961	71·06	71·53	70·59	73·39	70·13	73·39	71·53	71·99	70·59	70·59
1st June 1961	70·59	71·06	70·13	72·46	69·19	72·92	71·06	71·52	70·63	70·13
15th June 1961	70·13	70·59	69·66	71·53	69·19	72·46	71·06	71·06	69·66	69·66
1st July 1961	69·56	70·13	69·19	71·06	69·19	72·46	71·06	70·54	69·19	69·19

* Weights exclusive of the gunny.

TABLE VI.

Showing the loss/gain in weight of the experimental salt bags for a storage period of one year in the Adiramapattinam Fish-curing Yard.

(WEIGHTS IN KILOGRAMS.)

Serial number.	*Alkathene lined gunnies.*			*Serial number.*	*Ordinary gunnies.*			*Remarks.*
	Initial weight.	*Final weight.*	*Difference.*		*Initial weight.*	*Final weight.*	*Difference.*	
1	75·0	69·56	— 5·44	1	75·0	64·53	— 10·47	
2	75·0	70·13	— 4·87	2	75·0	65·46	— 9·54	
3	75·0	69·19	— 5·81	3	75·0	64·99	— 10·01	
4	75·0	71·06	— 3·94	4	75·0	64·53	— 10·47	
5	75·0	69·19	— 5·81	5	75·0	64·99	— 10·01	
6	75·0	72·46	— 2·54	6	75·0	65·93	— 9·07	
7	75·0	71·06	— 3·94	7	75·0	65·93	— 9·07	
8	75·0	70·54	— 4·46	8	75·0	65·93	— 9·07	
9	75·0	69·19	— 5·81	9	75·0	65·46	— 9·54	
10	75·0	69·19	— 5·81	10	75·0	64·53	— 10·47	
Total loss of weight ..			48·43				97·72	
Average loss of weight ..			4·84				9·77	
Average per cent of loss ..			6·46				13·03	

A NOTE ON THE UNSUITABILITY OF THE PHILIPPINE METHOD OF BRINE-CURING OF FISH FOR INDIAN CONDITIONS

BY

JOSEPH, K. C. AND SRINIVASAN, R.

INTRODUCTION

Salt-curing continues to be the most widely employed method of fish preservation in India, the chief methods being dry-salting, pit-curing and brine-curing. Even though the basic principles involved in the various methods are sound, the finished products are often unsatisfactory and of poor storage quality, partly because of the insanitary conditions under which the processing operations are conducted in our coastal villages and partly because of lack of standard techniques of preparation for the various products. The need for fixing quality standards for the various salt-cured, and dried fish products to promote their trade in the export and internal markets has been felt for a long time and work has recently been taken up by the Indian Standards Institution in this direction in colloboration with the various Fisheries Technological Laboratories all over the country.

In the meanwhile some investigations, were taken up at the Fisheries Technological Station, Tuticorin, for improving the current methods of fish-curing in Madras State. One of the methods tried was to adopt the Philippine method of brine-curing for Indian conditions. The results of this study are presented in this paper.

MATERIAL AND METHODS

Sulit and Laron (1958) reported the excellent appearance, taste and keeping qualities of dried split-salted fishery products known as '*daeng*' in the Philippines prepared by curing the scaled, split and eviscerated fish in concentrated brine for not less than 12 hours, soaking the cured fish in fresh water for 90—120 minutes and drying the product in the sun for at least 16 hours. The present studies were conducted following the processing method described above with the seaperch, *Lethrinus sp.* (local name: Vilameen). The specimens used were, purchased fresh from the local hooks and line catches and immediately scaled, split, eviscerated and cleaned well by washing. These were kept in saturated brine for 18 hours. The brine was prepared from Tuticorin solar salt. The samples were then removed from the brine and divided into three lots. One was soaked in plenty of fresh water for 30 minutes and the second similarly for 120 minutes. The rest was dried in the sun without soaking in fresh water so as to serve as the control sample. After the soaking in the fresh water the other samples also were dried in the sun for three consecutive days, the total time of exposure to the sun being 18 hours each. The products were kept in storage in deal wood cases lined inside with paper and examined periodically for their keeping qualities. Moisture, sodium chloride total volatile basic nitrogen and trimethyl amine nitrogen of the products were assessed periodically for a storage period of three months. In addition the samples were assessed organoleptically for their appearance, texture, odour, flavour, surface moisture and fungal attack. Moisture and Nacl were estimated as per A.O.A.C. methods, (1955). TVBN and TMAN were estimated from the fish muscle extract prepared by grinding with 20 per cent trichlor-acetic acid according to the microdiffusion technique of Conway (1957).

RESULTS

The analytical data gathered from the periodic analyses are given in Table I.

The moisture content was only 27·86 per cent in the control sample as against 32·11 per cent in the sample soaked in fresh water for 30 minutes and 33·80 per cent in the sample soaked in fresh water for 120 minutes. The moisture content was thus found to progressively increase with the duration of soaking in fresh water. However, in all the cases, the moisture content was found to be below the range of 35 to 40 per cent normally found in salt cured fish. On storage up to 120 days, there was only very slight reduction in the moisture content ranging from 0·15 per cent to 0·71 per cent in all the samples.

The sodium chloride which was 23·17 per cent in the control sample, was decreased to 22·06 per cent by soaking for 30 minutes in fresh water and to 19·28 percent by soaking for 120 minutes. There was no appreciable change in the Nacl content in all the samples on storage.

The TVBN was the highest at 350 mg./100 gm. in the control sample and progressively decreased with the increase in time of soaking in fresh water. In sample BI, it was 308·5 mg./100 gm. and in sample B II it was 295·5 mg. 100 gm. In all the cases, it increased gradually on storage, the increase being progressively faster with the increase in the time of soaking. On storage for 120 days the increase was 61·00 mg./100 gm. in the control sample, as against increase of 78·00 mg./100 gm. in sample BI and increase of 98·5 mg./100 gm. in sample B II.

TMAN was 110 mg./100 gm. in the control sample and 112·5 mg./100 gm. in sample B I, but it was comparatively low at 98·0 mg./ 100 gm. in the sample B II. It increased gradually in all the cases on storage.

In appearence the control sample was whitish and attractive but with blisters till about 60 days when it began to assume a light brown colour. In samples B I and B II, though there were no blisters, the products were light brown in colour even to start with and the colour gradually deepened on storage.

In texture, the control sample was firm initially and became soft after 30 days ; whereas the samples B I and B II were soft even to start with and became very soft on storage for 120 days and 30 days respectively. The control sample was found to be better in flavour and odour than the other two samples initially and at all stages of storage all the samples developed marked pungent and ammoniacall odour after 60 days' storage and had fungal attack after 120 days, the attack being more marked in the case of the samples soaked in fresh water.

DISCUSSION

Sulit and Laron (loc. cit) found over-salting as a common defect in Philippines in the preparation of all dried split-salted fishery products which were consequently susceptible to the attack of molds due to the hygroscopic nature of the solar salt impurities, especially magnesium chloride (Lafant, 1952). As magnesium chloride is more soluble than sodium chloride, they attempted to eliminate the magnesium chloride and salt impurities together with some salt by soaking the cured fish after brining, in fresh water upto 120 minutes before drying in the sun for 16 hours. They found that the cured fish soaked in fresh water from 90 to 120 minutes were ideal in physical appearance, taste and storage qualities. In our experiments also, soaking in fresh water dissolved out the magnesium chloride and salt impurities and improved appearance of the product which was light brown in colour and was free from " blisters " characteristic of the cured fish prepared with solar salt. The T.V.B. (N) and T.M.A. (N) which are the normal indices of soilage were also found to be comparatively lower in the products prepared by soaking in fresh water than the ordinary brine-cured fish. As against these apparent advantages, the product prepared by soaking in fresh water was however found to be much inferior to the ordinary brine cured fish in flavour, texture and storage qualities. The product was soft even to start with and the fresh cured flavour was lost within the first four week and the product developed pungent odour after thirty days The higher moisture content and low sodium chloride are probably responsible for earlier deterioration and fungal attack of the product soaked in water than the ordinary brine-cured fish. It is therefore concluded that the Philippine method of soaking in water after brine-curing of fish is not helpful in improving the quality of the cured fish but on the other hand it is found to lower the texture, flavour and storage qualities of the product and so the method is not found suitable under Indian conditions.

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TABLE I.

Showing the results of periodical analysis of brine-cured fish (Lethrinus sp.).

Storage period in days.	*Sample.*	*A.*	*B I.*	*B II.*
	Moisture (per cent)	27.86	32·11	33·80
	Nacl (per cent)	24·17	22·06	19·28
	TVBN (mgm/cent)	550·0	308·5	295·5
	TMAN (mgm/cent)	110·0	112·5	98·0
Initial ..	Appearance	Whitish with 'blisters.'	Light brown, no blister.	Light brown, no blister
	Texture	Medium hard.	Soft.	Soft.
	Flavour	Good.	Fair.	Fair.
	Odour	Fresh cured.	Fresh cured.	Fresh cured.
	Surface moisture	Nil.	Nil.	Nil.
	Fungal attack	Nil.	Nil.	Nil.
30	Moisture (per cent)	27·82	31·90	33·21
	Nacl (per cent)	24·17	22·03	19·07
	TVBN (mgm/cent)	377·5	311·0	312·5
	TMAN (mgm/cent)	122·5	116·0	99·5
	Appearance	Whitish.	Light brown.	Light brown.
	Texture	Soft.	Soft.	Very soft.
	Flavour	Fair.	Poor.	Poor.
	Odour	Slightly pungent.	Slightly pungent.	Slightly pungent.
	Surface moistrue	Nil.	Nil.	Nil.
	Fungal attack	Nil.	Nil.	Nil.
60	Moisture (per cent)	28·18	31·52	33·24
	Nacl (per cent)	24·25	20·98	18·94
	TVBN (mgm/cent)	400·5	374·5	373·0
	TMAN (mgm/cent)	125·5	116·5	115·5
	Appearance	Light brown.	Brown.	Brown.
	Texture	Soft.	Soft.	Very soft.
	Flavour	Poor.	Poor.	Poor.
	Odour	Pungent.	Pungent.	Pungent.
	Surface moisture	Nil.	Nil.	Nil.
	Fungal attack	Nil.	Nil.	Nil.
90	Moisture (per cent)	27·42	31·96	33·09
	Nacl (per cent)	23·85	22·14	18·83
	TVBN (mgm/cent)	411·0	386·5	394·0
	TMAN (mgm/cent)	157·0	136·0	130·0
	Appearance	Brownish	Deep brown.	Dark brown.
	Texture	Soft.	Soft.	Very soft.
	Flavour	Poor.	Poor.	Very poor (off).
	Odour	Ammoniacal.	Ammoniacal.	Ammoniacal.
	Surface moisture	Nil.	Nil.	Nil.
	Fungal attack	Nil.	Nil.	Nil.

Remarks—
A—Control sample.
B I—Soaked in fresh water for 30 minutes before drying.
B II—Soaked in fresh water for 120 minutes before drying.

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