BIOLOGY AND FISHERY OF THE PALK-BAY SQUID, *SEPIOTEUTHIS ARCTIPINNIS* GOULD

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CONTENTS

		Page
I.	Introduction	37
II.	Environment, Material and Methods of Study	38
III.	Taxonomy and External Morphology of *Sepioteuthis arctipinnis* Gould	39
IV.	Longevity and Growth of the Year Classes	44
V.	Length-Weight Relationships of Males and Females	51
VI.	Age and Size at Sexual Maturity	54
VII.	Food and Feeding Habits	55
VIII.	Spawning	57
IX.	Fishing Industry	58
X.	Summary	64
XI.	References	65

I. Introduction

The only account of the Palk-Bay Squid, which supports an ancient and locally well-known minor industry in the Ramnad District of the Madras State is that of Hornell (1917, 1922) who has described it as '*Loligo* sp.' The wide long fins extending almost the whole length of the mantle, as shown in his figures, indicate that the form dealt with is a member of the genus *Sepioteuthis* and not of *Loligo*. Hornell's (1950) posthumous publication, *Fishing in Many Waters*, contains references to squid fishing but these notes are based entirely on his earlier accounts. Apart from the general observations on the methods and seasons of fishing there is no published account of its true taxonomic status or biology. On the Indian cephalopods studies of a taxonomic nature have received some attention in the past; the papers of Goodrich (1896), Massy (1916) and Adam (1939 *a*) contain valuable information on preserved collections of the Indian Museum, Calcutta.

In several markets of the coastal towns and villages of the Ramnad District, Madras, squids find a ready sale, as the people here have developed a taste for them unlike those of most other regions of India. They are sold at even higher prices than good edible fish, bulk for bulk. Squids are in great

demand being excellent fish bait for long lines, and this demand is no less important than that for human food. The present investigation on the Palk-Bay squid, *Sepioteuthis arctipinnis* Gould, was undertaken with a view to understanding the fishery biology of the species in the hope that a fuller knowledge will be of some help in the development and conservation of this valuable fishery.

II. Environment, Material and Methods of Study

The observations were carried out at the Central Marine Fisheries Research Station near Mandapam (79°·9′ long.; 9°·16′ lat.) which is situated on the east coast of South India on a small peninsular extension of the mainland in line with the Rameswaram Island. To the north of the peninsula and the Island is the Palk Bay, and to the south is the Gulf of Mannar; the waters of the two are in communication with each other through the Pamban Pass (79°·12′ long.; 9°·17′ lat.) and Adam's Bridge. Squids are caught by fishermen from the Gulf of Mannar and the Palk Bay along the Rameswaram Island (79°·19′ long.; 9″·17′ lat.) as well as from several places on the mainland in the vicinity of Mandapam.

For a taxonomic study, specimens within a wide range of sizes from various fish markets and fish-landing places of Ramnad District were examined. The year classes were studied by the size-frequency method from random samples taken in fishermen's catches from Palk Bay off Rameswaram and Mandapam. During the height of the fishing season, complete hauls obtained in '*olai valai*,' a kind of net operated for squids, were analysed. The length of the dorsal mantle from the tip of the rostrum behind the region of the head to the posterior end of the animal was taken as a standard measure. Size-frequency tables and diagrams were constructed in the usual manner, representing the frequencies as percentages of the total observations for each month in size-groups of 10 mm. intervals. Growth of the different year classes was read from the shifting of the modes in the size-frequency diagrams of different months. As the fishing is seasonal and does not take place all the year round, there are gaps in the data for certain months. To confirm results obtained during one fishing season, it was found absolutely necessary to have data from a succeeding fishing season. With a view to studying the length-weight relationship, size at sexual maturity, period of spawning, and food habits, large numbers of squids were individually measured in length and weighed, and their sex and gonadic condition as well as their stomach contents were recorded. Bundles of twigs and branches of *Cassia* laid in the inshore waters of the Palk Bay were periodically examined to note the time of deposition of egg-capsules on them. The craft and tackle used in the squid fishery in this district were studied; and, from the weekly landings observed, an approximate estimate was made of the extent of the fishery in terms of catches obtained and money realised by the fishermen at Mandapam and Rameswaram. With a view to improving the quality of dried squid products now sold in the markets, different methods of curing were tried under laboratory conditions.

III. Taxonomy and External Morphology of *Sepioteuthis arctipinnis* Gould

Under the family Loliginidæ, the genus *Sepioteuthis* with the type species *S. sepiacea* de Blainville 1824 (*vide* Hoyle, 1886; Berry, 1912) is characterised by very elongate marginal fins bordering quite nearly the entire mantle length so that the outline of the animal is oval or elliptical. The species *Sepioteuthis arctipinnis* with which the present form is identical was described by Gould in 1852 (as cited by Berry, 1912) from specimens obtained from the Island of Maui, Sandwich Islands. Gould found it closely similar to *S. loliginiformis* D'Orb. from the Red Sea, a species with greater expansion of fins in the posterior part of the body, and shorter tentacular arms. *S. arctipinnis* was also subsequently recorded from Honolulu, and Bertrand Island of Papua. Specimens collected from the Andaman Islands and Singapore were described by Goodrich (1896) as *S. indica*, new to science, with *S. blainvilliana* Fer. and *S. mauritiana* Q.G., as its nearest allies, but differing from them in such doubtful and minute characters as the presence or absence of suckers on the buccal membrane, and greater or lesser number of teeth on the horny rings of suckers. Massy (1916) ascribed the specimens from Andamans and Moscos Island to *S. arctipinnis* Gould. Winckworth (1926) referred the most abundant myopsid of the Ceylon coast to *S. arctipinnis* Gould and assumed *S. indica* Goodrich to be identical with the former species. D'Orbigny and Ferussac (1848) referred specimens from Trincomali of Ceylon and of the coast of Malabar in South India to *S. lessoniana* Ferussac, a species which was originally described from Japan. Whether *S. arctipinnis* Gould is synonymous with *S. lessoniana* is doubtful. Berry's (1912) distinction between the two species seems to be valid. Sasaki (1929) however, held the view that the differences pointed out by Berry might be seen in specimens from different localities, yet tending to be marked by the presence of graduated series of intermediate forms, indicating absence of any specific distinction. Adams (1939) treated *S. lessoniana*, *S. indica* and *S. arctipinnis* as distinct species, and opined that proper researches were necessary to establish their identity. He assumed that they were closely allied, though not synonymous species.

As very little is known of the Palk-Bay squid, the following brief description may serve to identify the species. *Sepioteuthis arctipinnis* (Figs. 1, 2 and 3) is a myopsid, decapodan, dibranchiate cephalopod, the adults of which are of fairly large size, the males attaining a much bigger maximum size than the females. The mantle is elongate, conico-cylindrical, tapering to a blunt point behind. Antero-dorsally it extends over the nuchal region into a rounded point, the rostrum; and antero-ventrally below the funnel it bears a deep emargination, the edge of which on either side is produced into an acute prominent angle. Fins, which are attached on either side of almost the entire mantle length, are large, thick and muscular. They are narrow in front, gradually widened behind and broadest about the posterior

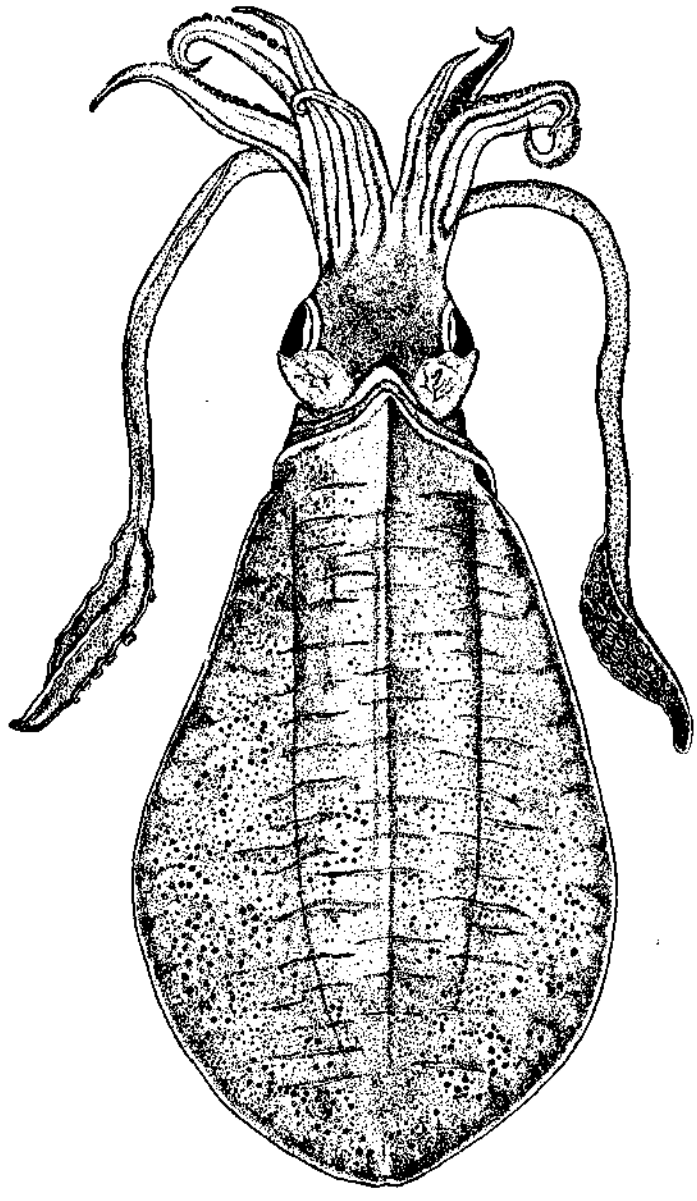

FIG. 1. Dorsal view of a medium sized Palk-Bay Squid, *Sepioteuthis arctipinnis* Gould. ¾ Natural Size.

third of the body, beyond which they again narrow down rapidly and meet each other at the posterior tip of the mantle.

The head is a little narrower than the body, somewhat squarish, dorso-ventrally flattened, and rounded at the sides behind. Eyes are large and

prominent, with a distinct pore in front of each orbit. The skin behind the eye is raised into a prominent, bilobed olfactory crest, with distinct olfactory pit sheltered within the fold of the ventral lobe.

The funnel is very large, broad at the base and tapering bluntly to the valved aperture in front beneath the head.

Arms are of unequal length in the order $3 \rightleftharpoons 4 \cdot 2 \cdot 1$. They are outwardly keeled, with the keels rather faint in the first pair of arms, and very prominent in the second and third pairs. The keel on the third arm runs down bordering the ensheathing base of the tentacle, and is continued by that of the fourth arm. Bordering the sucker-bearing area there is a marginal membrane which is particularly well developed in the third pair of arms. Suckers are arranged in two alternating rows. The horny rings on the suckers are provided with teeth of which there are about 23 on the large suckers and about 20 on the smaller ones. The teeth on the distal margins of the suckers are sharp and conical with their tips incurved, whilst those on the proximal margins are blunt, short and somewhat squarish.

The left ventral arm (fourth) is hectocotylised; up to about 20 pairs the suckers are normal; then for about 6 pairs the pedicles become enlarged, and the cups smaller; thereafter up to the distal region, the cups are totally absent and the pedicles enlarged into flattened conical papillæ, of which those of the right row are slightly larger (Fig. 2 *c*).

Tentacles are elongate, rounded, but slightly laterally compressed, with a subcarinate ridge on both the upper and inner surfaces. The inner face near the club is flattened. The tentacular clubs are large and expanded and bordered by a wide membrane, which is crenulate on the margin and bears transverse trabeculæ. Suckers are in 4 rows, 2 on either side. Those of the medial rows are large, while those of the outer rows are the smallest and close-set. The arrangement of teeth on their horny rings is similar to that described in the arms.

The buccal membrane bears 7 acute lobes bending inwards, and their inner surfaces possess minute suckers with horny rings having about 25 blunt teeth (Fig. 3 *b*).

Pen (Fig. 2 *b*) or gladius which is chitinous, lanceolate, transparent and colourless in fresh specimens, has a strong median rachis and distinct submarginal thickenings. It is comparatively a little broader in the larger females than in males of corresponding size.

The funnel cartilages situated ventro-laterally on the funnel, one on either side, are lanceolate (Fig. 2 *g*). In a specimen of 145 mm. mantle length

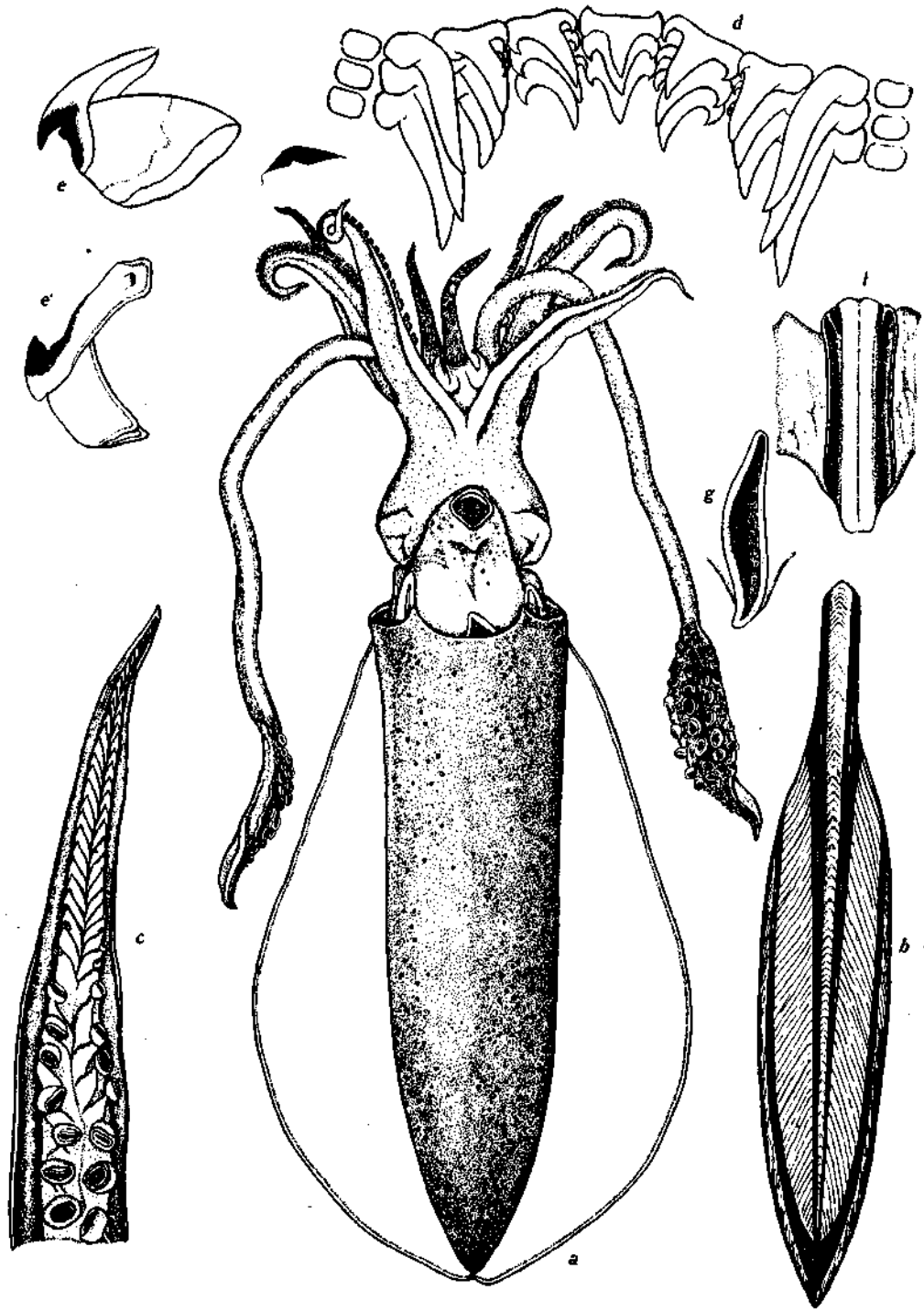

FIG. 2. *a*. Ventral view of the above, ¼ Nat. Size. *b*. Pen or Gladius, ¼ Nat. Size. *c*. Tip of hectocotylised arm magnified. × 4½. *d*. Radular Teeth. × 38. *e* & *e'*. Upper and lower jaws. × 1. *f*. Nuchal cartilage. × 1½. *g*. Funnel cartilage. × 1½.

each funnel cartilage is 23 mm. long and 5 mm. broad. The nuchal cartilage (Fig. 2*f*) situated dorsally behind the head is broad and rounded in front and narrow behind. Dorsally it bears a median ridge which fits into the shallow groove of the rachis of the gladius lying above.

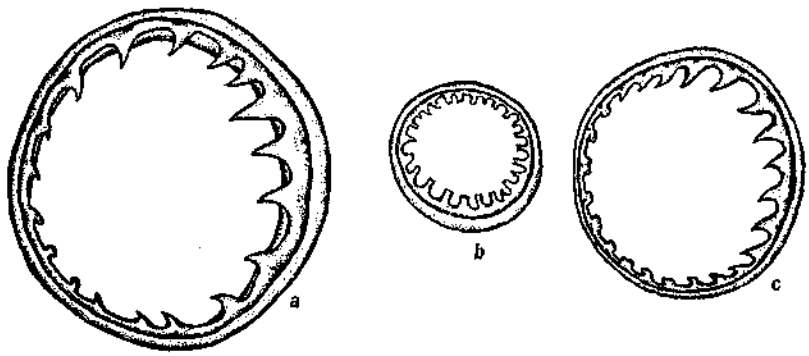

FIG. 3. Horny Rings with teeth belonging to (*a*) tentacular club, (*b*) the buccal membrane and (*c*) one of the arms.

The general colouration is pinkish brown, with a greenish tinge in the region surrounding the eyes in fresh specimens. Chromatophores are present dorsally on all parts, and ventrally on the head, mantle and funnel. They are totally absent on the lower surfaces of the fins. Transverse grey streaks are found dorsally all over the body and fins. The round black dots described by Sasaki (1929) in *Sepioteuthis lessoniana* are not present in any of the numerous specimens examined in fresh as well as in the preserved condition.

The principal measurements of 10 specimens in millimetres are given below:

Sex	♂	♂	♂	♀	♂	♀	♀	♀	♂	♀
Dorsal mantle length ..	205	173	153	106	99	107	126	118	70	83
Ventral mantle length ..	185	157	139	96	91	98	115	107	54	74
Largest mantle breadth ..	65	60	54	40	36	38	41	42	30	35
Breadth of mantle opening	55	47	42	31	30	35	38	37	25	30
Largest breadth including fins	133	114	97	68	62	68	89	75	52	56
Largest mantle thickness	8·5	6	4·5	3·5	4	4	5	5	2·5	3·2
Length of head	39	35	35	23	24	24	28	26	21	21
Breadth of head ..	41	39	39	29	26	26	32	30	22	23
Thickness of head ..	26	20	21	14	17	16	17	17	11	14
Length of fin	184	159	146	98	88	98	117	110	67	74
Breadth of fin	33	31	26	16	19	16	25	21	12	12
Distance between fin base and mantle margin ..	6	4·5	4	3·5	3·5	5	4	3·5	2·5	3·5
First right arm	63	56	51	34	31	35	42	37	21	24

First left arm	62	55	52	34	31	33	42	38	22	28
Second right arm ..	83	74	68	46	42	44	58	50	35	50
Second left arm ..	83	76	71	47	43	46	57	54	33	41
Third right arm ..	91	83	81	52	55	60	72	64	45	50
Third left arm	95	85	85	50	59	58	70	69	44	52
Fourth right arm ..	89	83	78	56	55	59	69	68	39	52
Fourth left arm ..	98	88	79	55	60	60	69	68	38	51
Right tentacular arm ..	239	209	202	137	145	150	173	179	121	125
Left tentacular arm ..	230	210	205	132	145	148	175	177	118	127
Right tentacular club ..	80	64	60	36	41	38	50	49	35	35
Left tentacular club ..	75	63	62	34	42	40	54	47	36	35
Length of pen	203	172	154	106	94	104	125	116	69	81
Breadth of pen	36	32	28	26	19	20	29	28	15	17
Diameter of largest sucker of first arm	2·7	2·0	2·0	1·4	1·1	1·3	1·5	1·5	0·8	0·9
Diameter of largest sucker of second arm ..	2·8	2·8	2·4	1·6	1·4	1·5	1·7	1·6	0·8	1·0
Diameter of largest sucker of third arm ..	3·3	2·5	2·8	1·8	1·5	1·9	2·0	1·8	1·0	1·4
Diameter of largest sucker of fourth arm ..	2·7	2·0	2·4	1·2	1·3	1·3	0·6	1·5	1·0	1·2
Diameter of largest sucker of tentacular arm ..	4·7	3·6	3·7	1·8	2·1	1·8	2·5	2·3	1·5	1·8
Proportion of										
(i) Greatest breadth to length of pen 1:	5·5	5·4	5·5	4·8	4·9	5·2	4·3	4·1	4·6	4·7
(ii) Largest breadth to mantle length 1:	1·5	1·5	1·6	1·6	1·6	1·6	1·6	1·6	1·3	1·5

The upper and lower jaws (Fig. 2 *e* & *é*) are produced in the form of beaks with strong cutting edges. In the radula (Fig. 2) both the median and inner lateral teeth possess moderately long median denticles and short lateral ones. In the outer lateral tooth the median denticle is long, the inner lateral denticle is short and recurved, and the outer lateral denticle is suppressed. The outer tooth is long and tapering, with comparatively shorter basal piece. External to the outer teeth, are the oblong plates.

IV. Longevity and Growth of the Year Classes

The breeding season appears to be prolonged from the presence of the egg capsules from January to June on weeds and other objects in the waters of the Gulf of Mannar and the Palk Bay in the vicinity of the Central Marine Fisheries Research Station at Mandapam. Several broods therefore are liberated every year, and the young ones which are hatched out from the

eggs at the commencement of the season naturally vary greatly in size from those of later broods. Also there occur intermediate forms of all sizes. This greatly variable nature of age and size in the members of the same year classes makes the study of the growth rate of the populations extremely difficult from the size frequency diagrams for different months. Often two peaks are noticed representing the early brood and the late brood of one and the same year class, and at times the late brood of one year class merges with the early brood of the previous year class. Further the fishery being seasonal, it has not been found possible to obtain random samples for all the months. In spite of these difficulties, an attempt has been made to give a satisfactory interpretation to the shifting of the mode values of the year classes, read from the size-frequency diagrams for different months based on random samples obtained during a period of 13 months covering two fishing seasons.

In the frequency diagrams for the month of May 1951 (Fig. 4, and Tables I and II) there are two modes at 65 mm. and 45 mm. (*c.c'*). As peak occurrence of egg capsules with advanced embryos was noticed in January and March 1951, these modes presumably represent two broods of the 1951 year class, the former about 5 months old and the latter 3 months. Fresh broods continued to be liberated throughout May and early June 1951. A third mode in this month of 140 mm. is taken to represent the average length attained by the early brood of the 1950 year class (*b*) of about 1 year and 5 months old. With this have merged the late arrivals of the same year class (*b'*) on one side (left) and the late brood of the 1949 year class (*a'*) on the other (right). The early brood of the 1949 year class (*a*) is represented by a fourth mode at 195 mm., and is about 2 years and 5 months old.

In the month of June 1951, the new year class (*c*) assumes a little compactness, the two modes seen in the former month are now represented by a single one at 55 mm. Considerable numbers of this year class are grouped between 50 to 80 mm. There is a second mode at 125 mm. which is taken to represent the average growth of the late brood of the 1950 year class (1 year 4 months). Owing to the absence of a distinct mode for this group in the diagram for the month of May 1951, it was considered to have merged with the early brood of 1950 year class. The mode at 145 mm. represents the average growth of the early brood of the 1950 year class (*b*), which shows therefore an increase of 5 mm. as compared with the previous month. The early brood of the oldest year class, *i.e.*, the 1949 year class whose mode value showed at 195 mm. in the previous month is not represented by a mode now in the samples of this month because of the dwindling numbers. The late brood of the same year class (*a'*) shows a spread out of its members approximately between 160 and 180 mm.

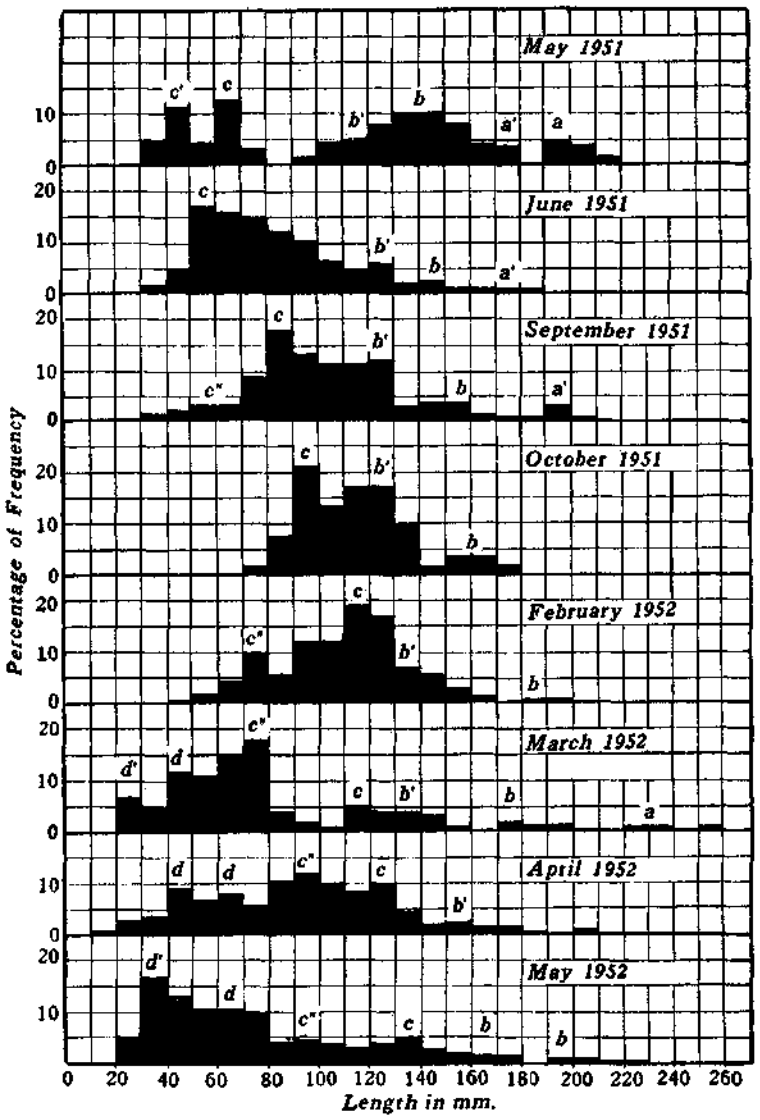

FIG. 4. Size-frequency diagrams of squids in different months. *a* & *a'*, representing the early and late broods of the 1949 year class; *b* & *b'* of the 1950 year class; *c* & *c'* of 1951 year class and *d* & *d'*, 1952 year class.

In the months of July and August 1951 there was no fishing of the squids either at Mandapam or at Rameswaram. Hence large numbers comprising a random sample could not be obtained. Stray specimens caught occasionally in the shore seines operated for food fishes were examined for their gonadic condition which is described elsewhere.

TABLE I

Showing Length Frequencies of Squids in Different Months

Size-groups in mm.	1951								1952							
	May		June		September		October		February		March		April		May	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
11— 20	..	..	..	..	..	..	..	..	..	..	..	..	1	0·2	..	..
21— 30	..	..	..	..	..	..	..	..	..	..	12	6·9	11	2·6	27	4·96
31— 40	9	4·7	5	1·4	2	1·5	..	..	..	..	8	4·6	16	3·8	92	16·90
41— 50	20	10·5	16	4·3	3	2·2	..	..	2	0·9	21	12·0	39	9·3	73	13·40
51— 60	10	5·2	62	16·9	4	2·9	..	..	4	1·8	19	10·9	27	6·4	56	10·30
61— 70	23	12·0	58	15·8	4	2·9	..	..	9	4·0	26	14·8	34	8·1	56	10·30
71— 80	6	3·1	53	14·5	12	8·8	1	1·9	21	9·5	32	18·3	25	6·0	54	9·90
81— 90	..	..	46	12·2	24	17·6	4	7·7	12	5·4	7	4·0	44	10·5	23	4·20
91—100	3	1·6	40	10·3	18	13·2	11	21·1	27	12·2	4	2·3	48	11·4	24	4·40
101—110	9	4·7	23	6·2	15	11·0	7	13·5	27	12·2	2	1·1	43	10·2	20	3·70
111—120	9	4·7	16	4·3	15	11·0	9	17·3	42	19·0	9	5·1	34	8·1	17	3·10
121—130	14	7·3	20	5·5	16	11·7	9	17·3	38	17·2	7	4·0	41	9·8	19	3·50
131—140	19	9·9	7	1·9	4	2·9	5	9·6	16	7·2	7	4·0	19	4·5	26	4·80
141—150	19	9·9	8	2·1	5	3·7	1	1·9	12	5·4	6	3·4	10	2·4	16	2·90
151—160	15	7·9	3	0·8	5	3·7	2	3·8	6	2·7	2	1·1	11	2·6	13	2·40
161—170	8	4·1	3	0·8	2	1·5	2	3·8	3	1·4	..	..	7	1·6	9	1·70
171—180	7	3·7	3	0·8	1	0·7	1	1·9	..	..	3	1·7	6	1·4	9	1·70
181—190	..	..	3	0·8	1	0·7	..	..	1	0·5	2	1·1	2	0·5	2	0·40
191—200	9	4·7	..	..	4	2·9	..	..	1	0·5	2	1·1	..	..	3	0·60
201—210	8	4·1	..	..	1	0·7	..	..	..	..	..	..	2	0·5	3	0·60
211—220	3	1·6	..	..	..	..	..	..	..	..	..	..	..	..	1	0·20
221—230	..	..	..	..	..	..	..	..	..	..	2	1·1	..	..	1	0·20
231—240	..	..	..	..	..	..	..	..	..	..	2	1·1	..	..	..	..
241—250	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
251—260	..	..	..	..	..	..	..	..	..	..	2	1·1	..	..	..	..
Total	191		366		136		52		221		175		420		544	

In September 1951 the mode value of the 1951 year class (*c*) is 85 mm. and is about 9 months old. A small percentage of its population (*c'*) possibly represented by the late arrivals of their class shows an average growth of 60 mm. The mode value of the late brood of the 1950 year class (*b'*) in this month also is 125 mm. as in June 1951. Apparently some of the members of the early brood of the 1951 year class have entered this group, and some of its own members passed on to the next group. As many members of the 1951 year class should have entered this group as had passed on to the next, with the result that the mode remains stationary. The early brood of the 1950 year class shows a mode value of 155 mm., there being thus an increase of 10 mm. over its value in June 1951. The late brood of 1949 year class now about 2 years and 5 months old shows a small mode at 195 mm.

In October 1951 there were moderate catches, and the number obtained in the random sample was very small. The 1951 year class (*c*) aged about 10 months shows a mode value of 95 mm. with an increase of 10 mm. over the value for the previous month. The merging of the late brood of the 1950 year class (*b*) with the early brood of 1951 year class is indicated as in the previous collection. The majority of the 1950 year class shows a mode value of 160 mm. indicating that they are approximately one year and 10 months old.

From November 1950 to January 1951 fishing was very poor, stray specimens alone being found in the fishermen's nets, and not adequate for population study.

In February 1952 there was fairly good fishing near Mandapam in the lagoons close to the Palk Bay. The size-frequency diagram for the month shows the average growth of the 1951 year class by the peak values of 115 mm. for its early brood (*c*), and at 75 mm. for its late brood (*c'*). The early brood of 1950 year class is sparsely represented by its members in the populations. If the size-frequency diagrams for September and October 1951 and February 1952 are followed, there is a clear indication of the merging of the late brood of 1950 year class (*b'*) and the early brood of 1951 year class (*c*). The 1952 year class has already appeared in this month as revealed by the presence of advanced stages of embryos in the egg capsules during this and the previous months. Recently liberated young were once obtained in the plankton collection from the Palk Bay in the last week of January 1951. In the random samples of the month the new year class is not represented, as its members are too small now to be hauled in the nets operated for catching squids.

In March 1952 the new year class, *i.e.*, of 1952 (*d.d'*) is represented in the sample showing two peaks at 25 mm. and 45 mm.; these broods are about

TABLE II

Showing Mode Values with Approximate Ages of the Different Year Classes in Different Months of Observation

Months of observation		Peak Values and the Approximate Ages of					
		1952 Year Class		1951 Year Class		1950 Year Class	1949 Year Class
May	1951 ..	..	..	45 mm. (3 months)	65 mm. (5 months)	140 mm. (1 year 5 months)	195 mm. (2 years 5 months)
June	„ ..	..	..	55 mm. (4–6 months)	..	145 mm. (1 year 6 months)	..
September	„ ..	..	..	60 mm. (5 months)	85 mm. (9 months)	155 mm. (1 year 9 months)	195 mm. (2 years 5 months)
October	„ ..	..	..	..	95 mm. (10 months)	160 mm. (1 year 10 months)	..
February	1952 ..	..	..	75 mm. (11 months)	115 mm. (1 year 2 months)	175 mm. (2 years 2 months)	..
March	„ ..	25 mm. (2 months)	45 mm. (3 months)	75 mm. (11 months)	115 mm. (1 year 3 months)	175 mm. (2 years 3 months)	230 mm. (3 years 3 months)
April	„ ..	45 mm. (3 months)	65 mm. (4 months)	95 mm. (12 months)	125 mm. (1 year 4 months)	..	..
May	„ ..	35 mm. (2–3 months)	65 mm. (5 months)	95 mm. (1 year 1 month)	135 mm. (1 year 5 months)	190 mm. (2 years 5 months)	..

2 and 3 months old respectively. The late brood of 1951 year class (*c'*), the early brood of 1951 year class (*c*), the early brood of 1950 year class (*b*), and the late brood of 1949 year class (*a*) have peak values of 75 mm., 115 mm., 175 mm. and 230 mm. respectively as in the previous month. Thus the population remains the same as in February 1952 but for the fresh arrivals of the 1952 year class.

In April 1952, the 1952 year class has two modes (*d* and *d'*) a prominent one at 45 mm. and a small one at 65 mm. The late brood (*c'*) and the early brood of the 1951 year class (*c*) have their mode values of 95 mm. and 125 mm. showing a definite increase in their average growth as compared with the previous month. There is no definite mode of the 1950 year class, and its members being sparse are spread out and do not form a compact group.

In May 1952, the new year class of 1952 has a high peak value of 35 mm. and a low one at 65 mm. It may be recalled that the corresponding values of this year class in the previous month were 45 mm. and 65 mm. The regression of the mode from 45 to 35 mm. is possibly due to a larger number of smaller individuals entering the population continuously during the season. The respective ages of the two broods represented by the two modes are approximately 3 and 5 months. The late brood of 1951 year class is 95 mm. The early brood of the 1951 year class has now increased to 135 mm. from 125 mm. observed in the previous month. The 1950 year class (*b*) has an average growth of 195 mm. and is about 2 years and 5 months old.

Average age at the end of first, second and third years of the life of squids.— (1) The late brood of 1951 year class which has commenced its life in May 1951 has attained a peak value of 95 mm. in April 1952 when exactly an year old.

(2) The early brood of 1950 year class being 160 mm. and 175 mm. in October 1951 and March 1952 at the ages of 1 year 10 months and 2 years 3 months respectively, the average growth per month during the interval of 5 months is 3·0 mm. The average growth attained at the end of the second year of their life is thus 166·0 mm.

(3) The average growth of 1949 year class being 230 mm. and 195 mm. at the respective ages of 3 years 3 months and 2 years 5 months, the growth rate is thus 3·5 mm. per month during the interval of 10 months, and the growth attained at the end of the third year of their lives is 219·5 mm.

The average growth rate is 95 mm. during their first year, 71·0 mm. in the second year and 53·5 mm. in the third year.

The maximum mantle length observed being 181 and 259 mm. respectively in the female and male squids, the former do not seem to live beyond the second year of their lives, whereas the latter live a year longer.

V. Length-Weight Relationships of Males and Females

Length-weight relationship of 872 squids of a wide range of sizes comprising 56 individuals without indication of sex, 432 males, and 384 females, was determined. Each specimen when fresh was weighed, its mantle length measured, and sex and gonadic conditions were noted. The total observations were arranged in size groups with class intervals of 5 mm. and the average weight in each group separately for males, females and those without signs of sex was found out. The observed group averages of the weights are indicated in the scatter diagram (Fig. 5), a glance at which shows that the course of the curve for males and females is the same till about 107·5 mm. of mantle length. Thereafter the curve for the females is distinct from that of the males, the former having higher average weights than the latter in the corresponding length groups. The differences in weights between males and females of the same size-groups are almost negligible before sexual maturity. The maximum length and maximum weight observed in male squids are very much higher than in females, as can be seen from the scatter diagram (Fig. 5 and Table III).

To the data on group averages of 432 males and 384 females the allometric growth formula of Huxley, *viz.*, $W = A L^a$ was fitted by the regresion method, and found to be

$$W = \cdot 00075885\, L^{2\cdot 4488}$$

or $$\log W = -3\cdot 1184 + 2\cdot 4488 \log L$$ for the males; and

$$W = \cdot 0003028\, L^{2\cdot 6588}$$

or $$\log W = -3\cdot 5189 + 2\cdot 6588 \log L$$ for females.

For the different lengths, the weights in each sex were calculated by the application of the respective formulæ above, and the calculated values of weights thus obtained are given in Table III.

In all the males and the smaller females, but not the larger females, there is a fair agreement between the weights of group averages observed and the weights obtained by the application of the formulæ. In general in all groups in both the sexes wide individual variations were noticed from their group averages; and these variations are due to variations in (1) the extent of development and condition of the gonads and other reproductive organs; (2) the amount of food in the digestive organs and (3) the general

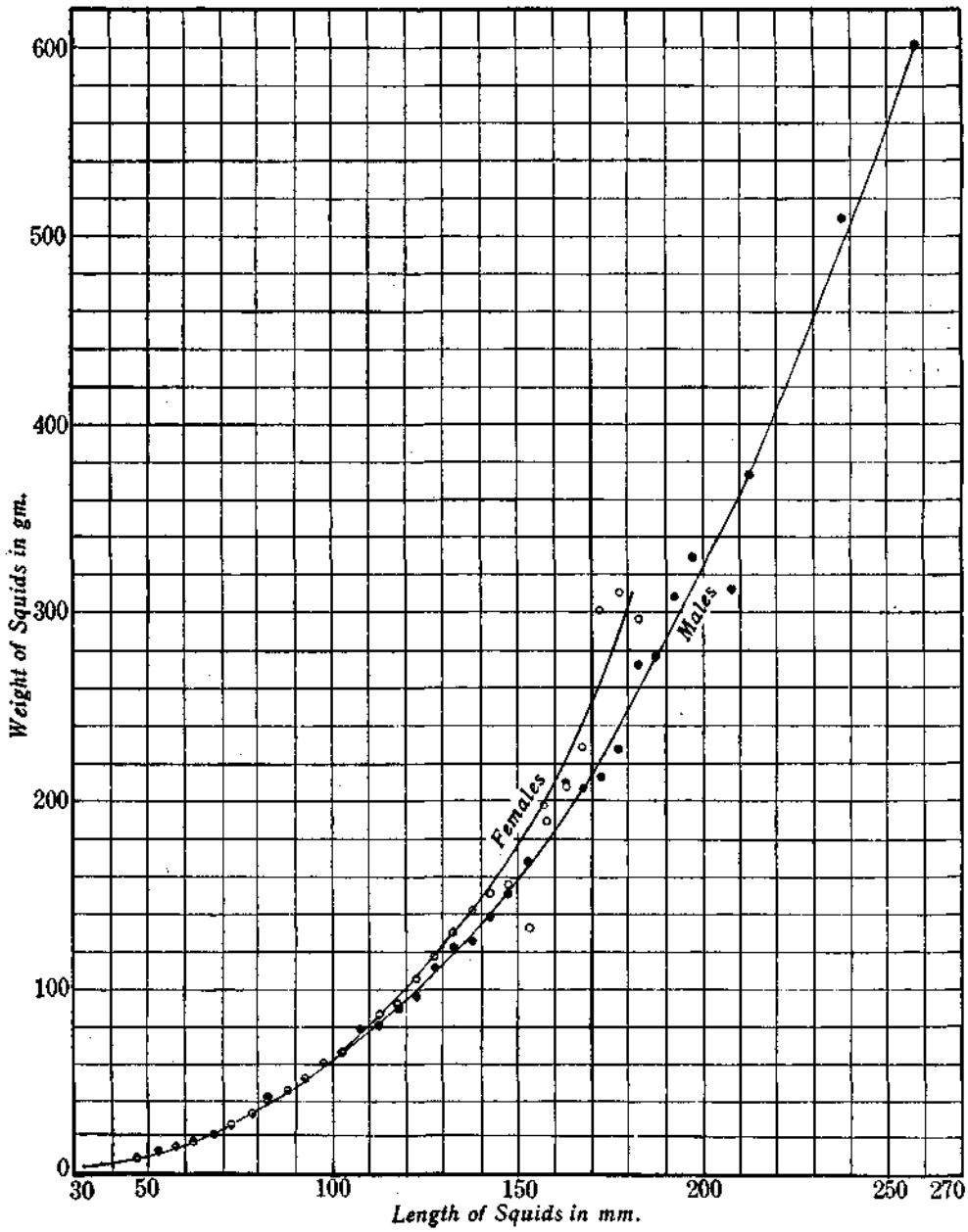

FIG. 5. Scatter diagram indicating length-weight relationship of a large number of male and female squids.

condition of the tissues, particularly of the mantle which forms the bulk of the weight of the squid. Owing to the large numbers of eggs that are extruded along with other materials for the formation of the capsules, the

TABLE III

Showing Observed Average Weights and Calculated Weights of Male and Female Squids

Length of size group in mm.	Observed average weights in grams		Calculated weights in grams	
	Males	Females	Males	Females
42·5	..	7·0	..	6·47
47·5	10·6	10·0	9·72	8·69
52·5	11·8	13·6	12·42	11·35
57·5	15·6	16·3	15·52	14·45
62·5	19·5	18·5	19·02	18·03
67·5	23·5	22·6	23·00	22·12
72·5	27·6	28·4	27·36	26·75
77·5	33·5	33·7	32·22	31·95
82·5	40·4	38·4	37·56	37·73
87·5	45·3	46·1	43·37	44·11
92·5	51·6	52·9	49·68	51·12
97·5	59·5	60·1	56·53	58·82
102·5	65·9	66·4	63·89	67·16
107·5	78·3	78·6	71·80	76·24
112·5	80·1	86·2	80·28	86·06
117·5	90·7	91·8	89·25	96·56
122·5	95·2	105·2	98·83	107·87
127·5	110·8	117·3	108·80	120·01
132·5	121·0	130·3	119·79	132·92
137·5	124·6	141·3	131·19	146·69
142·5	137·7	150·3	143·15	161·29
147·5	150·0	155·2	155·81	176·81
152·5	167·9	132·0	169·10	193·20
157·5	189·2	197·5	182·93	210·93
162·5	208·8	206·5	197·52	228·78
167·5	207·2	238·0	212·67	247·92
172·5	212·3	301·0	228·60	268·11
177·5	226·6	310·0	245·70	289·27
182·5	272·5	297·0	262·50	311·46
187·5	276·0	..	281·45	..
192·5	309·0	..	298·97	..
197·5	329·2	..	318·50	..
207·5	311·5	..	359·34	..
212·5	373·0	..	380·99	..
222·5	379·0	..	426·27	..
237·5	509·0	..	500·27	..
257·5	602·0	..	609·82	..

larger females suffer greater loss in weight after spawning than the larger males. The calculated weights of the larger females therefore show a greater degree of variation from the observed average weights of the respective groups.

VI. Age and Size at Sexual Maturity

All the individuals below the size group 42·5 mm. did not show any indication of sex. In the males differentiation of reproductive organs commenced in the group 47·5 mm. Up to and inclusive of the group 62·5 mm. all males were immature. The first indication of functional ripeness was noticed in a very small percentage in the size group 67·5 mm. As may be seen from the size-frequency studies this size is attained when the squids are over 6 months old. Gradually increasing numbers of mature specimens were obtained in groups 67·5 mm. to 112·5 mm. the majority, however, being mature at 82·5 mm. of mantle length, which is reached in about 10 months. All males were ripe in size group 117·5 mm. and above.

Table IV

Showing Size at Sexual Maturity of Male and Female Squids

Length of size-group in mm.	Without indication of sex No.	Males				Females				Total number examined
		Immature		Mature		Immature		Mature		
		No.	%	No.	%	No.	%	No.	%	
42·5	12	..	..	..	..	1	100·0	..	..	13
47·5	9	3	100·0	..	..	3	100·0	..	..	15
52·5	16	6	100·0	..	..	12	100·0	..	..	34
57·5	5	26	100·0	..	..	13	100·0	..	..	44
62·5	4	20	100·0	..	..	22	100·0	..	..	46
67·5	2	21	80·7	5	19·2	22	100·0	..	..	50
72·5	..	17	73·9	6	26·0	29	100·0	..	..	52
77·5	..	13	54·1	11	45·8	18	100·0	..	..	42
82·5	..	3	11·5	23	88·4	15	100·0	..	..	41
87·5	..	8	32·0	17	68·0	21	100·0	..	..	46
92·5	..	9	28·1	23	54·7	18	100·0	..	..	50
97·5	..	10	27·7	26	72·2	16	100·0	..	..	52
102·5	..	2	12·5	14	87·5	20	90·9	2	9·0	38
107·5	..	4	21·0	15	78·8	11	73·3	4	26·6	34
112·5	..	..	..	23	100·0	7	29·1	17	70·8	47
117·5	..	..	..	15	100·0	5	25·0	15	75·0	35
122·5	..	..	..	17	100·0	4	14·8	23	85·1	44
127·5	..	..	..	15	100·0	2	7·1	26	92·8	43
132·5	..	..	..	8	100·0	..	..	12	100·0	20

In the females sexual differentiation was first seen in group 42·5 mm. Individuals up to the size group 97·5 mm. were all immature. In the group 102·5 mm., *i.e.*, when they had completed 1 year of their life, a small percentage was sexually mature. The majority were mature at 112·5 mm. when they are about 1 year and 2 months old. The immature females, then decreased till they reached the size-group 127·5 mm. In the group 132·5 mm. and above, all females were sexually mature.

VII. Food and Feeding Habits

During the entire period of observations a total of 629 squids from different random samples in different months were examined for their stomach contents. 485 of them showed varying amounts of food and in the rest the stomachs were empty. Bony fish comprise the chief item of food of the squids, but prawns and crabs also form part of their food to some extent. A good number was cannibalistic. In 356 the stomach contents consisted wholly of macerated parts of bony fish, in 108 arms and other parts of the squid's body, and in 21 crushed portions and appendages of crustaceans. The food organisms in the stomach were never observed whole, as they were always crushed and broken into bits or reduced to a pulp making their specific identity impossible to determine. An attempt has therefore been made to study the species of fish amidst which shoals of squids occur.

During the summer months, commencing from about the middle of March and extending to June or July, large shoals of fingerlings, locally called 'Choodai meen' and consisting mostly of *Sardinella gibbosa*, *Sardinella albella*, *Sardinella fimbriata*, *Atherina forskali*, *Leiognathus* spp., *Anchoviella* spp., and *Hilsa kanagurtha* enter the shallow warm waters of the Palk-Bay in the vicinity of Mandapam and Rameswaram Island. Squids are always found associated with them. The 'Choodai meen' fishery is of considerable magnitude, and its peak season coincides every year with that of the squid fishery. It is therefore presumed that squids enter the shallower zones from their deeper recesses in the Palk-Bay and the Gulf of Mannar to chase their prey. The intensive period of spawning is over by about February, but spawning is continued to a small extent up to June. Hence squids obtained during the height of the fishing season comprise mostly feeding schools and small numbers of spawning individuals. Squids are known to cause much destruction to fingerlings, for they speedily chase and catch them with their suckered tentacles and arms, inflicting with their powerful jaws fatal injuries on the back behind the head crushing the spine. In the '*olai valai*' operated for squids a small number of a mixed collection of species of fish, *viz.*, *Therapon puta*, *Pelates quadrilineatus*, *Gerres*

pœti, Gerres sp., *Upeneus vittatus, Atherina forskali, Sardinella* sp., *Pteroscirtes* sp., *Teuthis* sp., *Monacanthus* sp., and *Syngnathoides biaculeatus* was obtained, some of which bore injuries on their backs, indicating that the squids feed on them also.

Table V will show that mature starving individuals of both sexes are met with in varying numbers from February to June. In the collections

TABLE V

Showing Number of Squids With and Without Gut-Contents in Different Months

Months	Number of squids without food			Number of squids with food			Total
	Immature males and females	Mature		Immature males and females	Mature		
		Males	Females		Males	Females	
May 1951 ..	2	1	4	12	17	4	40
June „ ..	2	6	5	86	12	15	126
September „ ..	1	..	..	31	21	6	59
October „ ..	3	1	..	18	8	13	43
February 1952 ..	17	12	22	44	10	3	108
March „ ..	8	5	14	61	8	2	98
April „ ..	5	..	8	20	11	2	46
May „ ..	9	12	12	52	18	6	109
Total ..		144			485		629

for September and October almost all the mature ones are obtained with food in their stomachs. As the spawning season extends from January to June, the empty guts in the said months denote that the spawners do not in general feed during the period of breeding. In February large numbers of egg capsules (Pl. I, Fig. 7) were observed in the Palk-Bay lagoons and in squids that were collected thereof, there were more mature females than mature males with empty stomachs. In the succeeding months, up to June, as the breeding intensity slackens, the percentage of mature females without food among the mature females gradually decreases. It is probable that all mature females do not feed during their breeding period. Though during the height of the breeding period mature males without food are not uncommon, the relatively small number of them which occurs presumably feed even during breeding.

VIII. Spawning

The period of spawning was determined from the nature of the reproductive organs and other tissues of the samples of squids examined in different months, and from the occurrence of the egg capsules deposited in the waters. Prior to spawning the mantle and the fins in the female are in perfect condition, and the ovary with numerous ripe eggs occupies a large space in the posterior part of the mantle cavity; the nidamental glands are full and glossy white, and the accessory nidamental glands orange-red. Females after copulation have spermatophores on their buccal membranes. After spawning, the mantle becomes flaccid, the fins are generally torn or injured, the ovary has very few eggs with exploded spermatophores in the oviduct, the nidamental glands thinner and less glossy, and the accessory nidamental glands turned pinkish. The spawned females weigh therefore considerably less than the gravid ones of corresponding length.

Spermatophores are found in sexually mature male squids in smaller or larger numbers throughout the year. The changes in the male reproductive organs at the spawning period are less marked than in the females. Before spawning the testis is glossy with the spermatophore sac bulging with spermatophores. After spawning, the testis becomes flaccid and the spermatophore sac shrunk with a few spermatophores only. The mantle and the fins show similar changes after spawning as in females already described.

The reproductive organs were observed to be full, partially or wholly exhausted in the months of May and June 1951; wholly exhausted in July and August 1951; flaccid and exhausted in September and October 1951; in a state of fulness from December 1951 to February 1952; and partially or wholly exhausted in June and July 1952. Thus from the nature of the gonadic condition the spawning period may be inferred to be from January to June or July.

As the presence of freshly laid capsules on floating or fixed sea weeds in the waters appears to provide a certain indication of spawning, bundles of twigs and branches of plants were weighted to rest at the bottom in the shallow inshore waters of the Bay and the Gulf for the eggs to be attached to them, and were constantly examined to ascertain the period of spawning. Capsules on algæ drifting from the offshore waters and occasionally caught in the shore seines were also examined. Since the freshly laid eggs take about 3 weeks to undergo complete development within the capsules, the exact time of deposition can roughly be ascertained from the degree of development of embryos within the capsules. In the first week of February 1952 large massive clusters of capsules with advanced embryos nearly 3 weeks

old were obtained in the shore seines. In the same month freshly deposited capsules were observed in the Palk-Bay lagoons on *Cassia* branches placed in the waters by the fishermen to serve as lures as described elsewhere. From March to June 1952 also egg clusters in varying stages of development were met with. Capsules obtained in May and June 1951 and 1952 showed mostly advanced embryos which were, however, rare in the early capsules of February. Spawning may therefore be inferred to commence in the offshore waters about January, followed by shoreward migration of the squids into shallow inshore waters and adjacent lagoons from February to June or July. The fulness of the reproductive organs, the healthy condition of the mantle and other body tissues, and the general absence of food material in the gut of the squids obtained in February are indications that these squids are members of the principal spawning schools. Those obtained from March to June in the inshore waters of the Bay comprise mixed populations of spawning and feeding individuals. The reasons for the shoreward migration of squids can only be conjectured at present. During March to June the occurrence in the inshore waters of small fry and fingerlings of a variety of fishes which form the food of the squids seems to be the chief inducement for their mass migration. The abundant presence of gravid squids and of egg capsules on floating objects is suggestive of a spawning migration to comparatively calm inshore waters which are better suited for the purpose of breeding than the disturbed offshore waters. Even though the data for the latter are meagre, the occasional presence of massive clusters of capsules in the seines makes it clear that they are not altogether unsuitable for spawning.

IX. Fishing Industry

Seasons and methods of fishing.—Squids are fished for food and fish bait, both from the Palk Bay and the Gulf of Mannar. The regular fishery in the Palk Bay brings in large landings of squids in certain special types of nets which are exclusively operated for them during the fishing season, whereas the Gulf of Mannar shore seine fishery being occasional and operated for a variety of food fishes, brings in only a few squids.

In the Palk Bay off Mandapam, the *olai valai* (*olai*, palm leaf and *valai*, net) squid-fishing season is from April to June, the peak catch being obtained in May. The net consists of a large rectangular bag about 27 feet long, 12 feet broad, of thick $\frac{1}{4}$ inch cotton mesh, and the rest of wider coir mesh, the cotton and coir portions measuring about 12 feet and 25 feet respectively. The wing ropes, each 900 feet in length, bear strips of palm-leaf in 3 to 4 close-set rows near the wings, and in a double or single row for the rest of the length. The head rope over the mouth of the bag and the wings

is provided with floats of light wood and coconut-palm husks and the foot rope below with sinkers. The net is loaded in a small canoe for casting. On reaching the desired spot one end of the rope is dropped in the water not far from the shore, and as the canoe is rowed to make a semi-circle with the shore, the entire length of the rope and the net is let into the waters. One of the fishermen swims up to the bag in the direction in which the wing rope is cast to make sure that the net is properly spread. The palm-leaf strips act as scares driving the squids into the bag of the net. The two ropes are then collected; from one end it is loaded into the canoe, and from the other dragged to the shore. Throughout April, *i.e.*, in the beginning of the fishing season at Mandapam, two nets are operated each landing two hauls every morning, but in May when peak catches are obtained they are fished both morning and evening. The hauls consist mostly of squids along with a few small fishes. When small schools are in sight fishermen occasionally cast their '*veechi valai*', the familar cast net and capture a few squids.

Two months ahead of the actual fishing season, *i.e.*, in February, squids are caught on a very small scale in the shallow water lagoons off Mandapam Camp. The lagoons being in communication with the waters of the adjoining Bay, squids enter them at high tides, and seek shelter in little heaps of *Cassia* branches tied togetner and placed in the waters by the fishermen to serve as lures. The foot rope is pressed with the foot of the person holding the net at either end. The squids seeking shelter are disturbed and driven into the net, the foot rope is then released, and the net hauled. In this way about a hundred squids are caught from a dozen or so of such lures in 3 hours. This kind of fishing does not usually last long, for about March the lagoons are cut off from the Bay and their waters dry up.

In Palk Bay off Rameswaram the major fishing season is from March to June, followed by a minor one during September and October. As in Mandapam the *olai valai* is the chief net used here also. Squids are caught in several other places too in the vicinity of both Rameswaram and Mandapam employing the very same methods of fishing. Off Ariyakundu near Rameswaram, fishing by keeping watch from specially erected forked poles in shallow waters called 'Machans' used to be practised widely as reported by Hornell (1917, 1922), but the method has now become obsolete. Along the coastline of the Gulf of Mannar, in the shore seines operated for food fishes at Dhanushkodi, Rameswaram and Pamban on the Rameswaram Island, and at Mandapam, Pudumadam, Muthupettai and Periapatnam on the mainland, squids are caught in small numbers only, throughout the year, except in February and March when the landings are in large numbers and occasionally enormous.

The landings from the different places on the Island are marketed chiefly at Rameswaram and Pamban, but a portion of them is sent by train to Mandapam. Those caught at Mandapam are sold entirely in the local market. Squids from Muthupettai and Periapatnam are sent along with food fishes by boats to Kilakarai market where there is a high demand for them. Most of the catch from Pudumadam is locally sold, but some of it goes to the Uchipulli market.

Composition of the market catch.—The size frequency diagrams in Fig. 4 indicate that a large number of young and immature squids are hauled in by nets operated for fishing. To ascertain the extent to which the immature ones are fished, and whether the continuance of the existing methods would lead to possible depletion and destruction of the natural stocks, the composition of the market catch was examined. For this purpose 9 random samples comprising 890 squids obtained from May 1951 to February 1952 were studied. Of these 75 showed no indication of sex, 431 were males and 384 females.

The frequencies of males and females in 10 mm. range of mantle as percentages of the total number of each sex, are graphically represented in Fig. 6. It may be seen that the majority of the males falls between 51 and 130 mm. range comprising 80·72% of the total number of their sex. Only 0·69% are below and 18·5% above the majority size range. The largest number of individuals in a 10 mm. range falls within 91–100 mm.

Among the females the majority size range is between 51 and 140 mm. comprising 91·7% of its population. Those below and above this range comprise 1·0% and 7·2% respectively. The largest number in a 10 mm. range falls between 121–30 mm.

The two sexes are represented in more or less equal numbers, *i.e.*, 52·8% males and 47·1% females, the former slightly exceeding the latter in numbers. Of the total number of males examined, 58·4% were mature and among the females 32·4% were mature. Thus it may be seen that more immature females than immature males are fished, owing to the fact that the males attain sexual maturity at an earlier age and at a smaller size than the females. Mature individuals in the total numbers of both sexes comprise 41·1%. The very young individuals in which the sex is not yet developed and those that are immature constitute as much as 58·8% of the total catch examined. At present the potential resource being pretty high, and the exploitation not extensive in this locality, there is no great danger to the fishery, but when intensive fishing is carried out, it is evident that the elimination of such high percentage of immature squids would lead to depletion of stocks.

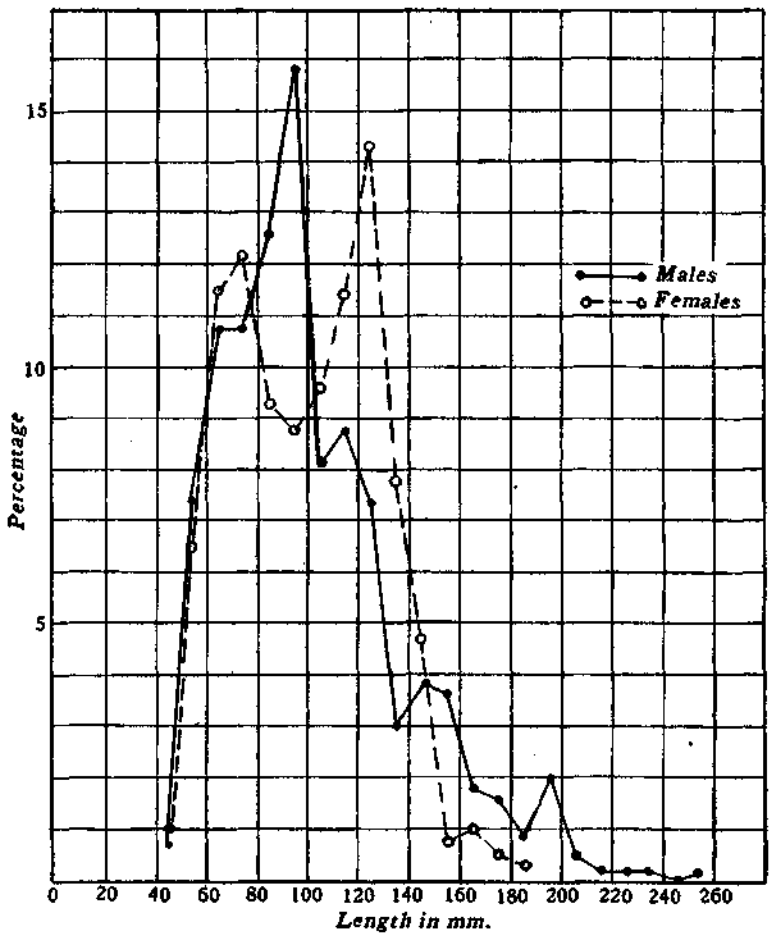

FIG. 6. Diagram showing size frequency distribution of male and female squids of a collection of 9 random samples of market catch.

Extent of fishing.—Even when shoals of fish are abundant in the coastal waters of the Palk Bay, as in the months of April to June, fishermen are satisfied with catches sufficient for local needs. As the squid fishing season comes off at a time when the ' Choodai meen ' fishery is at its peak, fishermen concentrate their efforts on the latter fishery which brings in a substantial income, with the result that the squid fishing is relegated to the background. In the season, only 2 nets at Rameswaram, and 1 at Mandapam are regularly used for squid fishing. In most fishing centres of the district, the industry depends on uncertain catches obtained in shore-seines. At present squid-fishing is only a minor industry in this district, but if more nets are used the yield is bound to increase.

Tables VI and VII show the estimated catches at Rameswaram and Mandapam during the period of observations. The estimates are based on weekly observations of the landings, supplemented by information furnished by the fishermen on the number of fishing days and the number of hauls per day using the '*olai valai*'. It may be seen that during April to June

TABLE VI

Showing Estimated Landings of Squids at Mandapam during 1951–52

(Monthly values are estimates in places of production)

Months			Number of fishing days	Average catch per day in lb.	Total monthly catch in lb.	Monthly value in Rs.
April	1951	..	4	40·0	160	32–0
May	,,	..	20	89·1	1,782	356–6
June	,,	..	20	37·5	751	150–3
February	1952	..	7	19·0	133	26–9
April	,,	..	15	43·3	650	150–0
May	,,	..	8	60·0	480	96–0

TABLE VII

Showing Estimated Landings of Squids at Rameswaram during 1951–52

(Monthly values are estimates in places of production)

Months			Number of fishing days	Average catch per day in lb.	Total monthly catch in lb.	Monthly value in Rs.
March	1951	..	10	70·0	700	140
April	,,	..	24	72·5	1,740	348
May	,,	..	24	100·0	2,400	480
June	,,	..	8	35·0	280	56
July	,,	..	5	10·0	50	10
September	,,	..	14	30·0	420	84
October	,,	..	15	15·0	225	45
March	1952	..	12	43·3	520	104
April	,,	..	22	60·0	1,200	260
May	,,	..	18	91·6	1,650	290
June	,,	..	4	25·0	100	20
July	,,	..	4	50·0	200	40

in 1951 the total catch at Mandapam weighed 2,700 lb. valued at Rs. 540 and from March to October at Rameswaram it weighed almost double (5,800 lb.) valued at Rs. 1,150. Owing to the great irregularity in the catches obtained at other places, it was not possible to make similar estimates of the extent to which they are fished in the entire district. Dhanushkodi, Rameswaram Road and Pamban on the Island and Theedai, Uchipulli, Pudumadam, Periapatnam and Muthupettai on the mainland, each contributes roughly about the same catch as at Mandapam. On this basis the approximate landings in the district comprise 30,000 lb. valued at Rs. 6,000 (at production centres) a year.

Preparation of the catch for the market.—As the nets are hauled, the squids are collected usually in palm leaf baskets but occasionally the larger ones are sorted out and strung on to a piece of rope, after piercing through the region between the mantle and the fin. At Pudumadam, Periapatnam and Muthupettai squids are split open on being caught, and their ink-sacs removed before they are packed in palm leaf baskets along with food fishes. This precaution is taken to avoid the fish being tainted with squid ink. In the markets, the larger ones are sorted according to their size and sold in lots of 2, 4 or more, and smaller ones in lots of a dozen or so. In the estimate of landings given in Tables VI and VII the value is calculated at 5 lb. per rupee which is the wholesale price, but in the markets they are sold at 4 to 6 annas per pound. Part of the catch when landed is sold to line-fishermen for use as bait and the rest marketed as food.

Squids are sold mostly in the fresh condition, but at Rameswaram, small numbers are cured when catches are heavy. They are split with a median ventral cut, and left on the sands to dry without being cleaned. The crude resulting product is consumed only by the poorer classes of people.

The viscera may be exposed and removed, and with a second delicate superficial dorsal cut the shell or pen may be removed. When the outer pigmented skin is peeled off and washed in sea water, the spotless white flesh is ready for cooking, canning or sun-drying. In California, the squid fishery of the Monterey Bay area (Field, 1950) is one of the major fisheries of the world, and brings a substantial annual income to the fishermen. In 1946 it was estimated at $ 1,214,091 (Field, 1950). A small portion of the catch is used in fresh or frozen condition and the rest either canned and exported to Greece or sun-dried and shipped to China.

As the dried squids as sold in the markets of the Ramnad District are not a popular item of food, experimental curing has been tried. When well-

dressed squids were sun-dried in separate lots with and without the pigmented skin, the latter gave a more presentable product. A fairly good product was obtained when the flesh was simply washed in sea water and dried in the sun for 3 or 4 days, but treatment with a little salt before drying not only made it softer but also improved its keeping qualities. After dressing, some were dried whole and others were cut into slices and dried. The cured product packed into bottles after oven-drying at 70° C. for about an hour kept better than the untreated. Some of the dried preparations are shown in Pl. I, Fig. 6.

X. Summary

1. The Palk-Bay squid which supports a minor fishing industry in the Ramnad District of Madras State has been referred to a widely distributed myopsid, dibranchiate cephalopod, *Sepioteuthis arctipinnis* Gould.

2. From the size-frequency distributions, it has been concluded that the squids attain an average mantle length of 95 mm., 166 mm. and 219·5 mm. at the end of the first, second and third years of their lives. The growth rate in the first, second and third years is 95 mm., 71 mm. and 53 mm. of mantle length respectively. While the females do not seem to live beyond the second year of their lives, the males live a year longer.

3. The length weight relationship of a large number of squids of both the sexes was determined, and by the application of regression method the formulæ were derived separately for the two sexes. The weights of the males and females of the same size groups are almost the same before sexual maturity. After sexual maturity the females weigh more than the males. The calculated weights of the larger females vary widely from the respective group average weights, probably owing to spawning.

4. The males attain sexual maturity within a length range of 67·5 mm. to 112·5 mm. when they are from 6 to 14 months of age, and the females within 102·5 mm. to 112·5 mm. when they are between 12 and 14 months old.

5. The smaller fish and crustaceans form the principal food of the squids. Cannibalism is quite common. Females during their breeding period do not seem to take food.

6. Spawning commences by about January and is continued till the end of June. Squids migrate into shallow inshore waters and adjacent lagoons from the offshore waters by about February and deposit their egg capsules in abundance till about June.

7. Squid fishery in the Palk Bay off Mandapam and Rameswaram is regular and seasonal from February or March to June, and the type of net

chiefly used is the '*olai valai*'. The fishery in the Gulf of Mannar depends upon occasional catches obtained in the shore seines. Random samples of the market catch showed nearly 60% of the young and immature individuals. The fishery seems to be capable of further development as the present fishing activities are only on a very small scale.

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EXPLANATION OF PLATE

1. The '*olai valai*' the chief net used in catching the squids at Mandapam and Rameswaram.
2. & 3. The *chippi valai* in operation in Palk Bay lagoons in the vicinity of Mandapam.
4. One lot of a single haul obtained in '*olai valai*' for study.
5. One of the usual random samples arranged for size frequency study.
6. A few dried preparations of squids made in the laboratory.
7. A bundle of *Cassia* twigs with numerous egg capsules.

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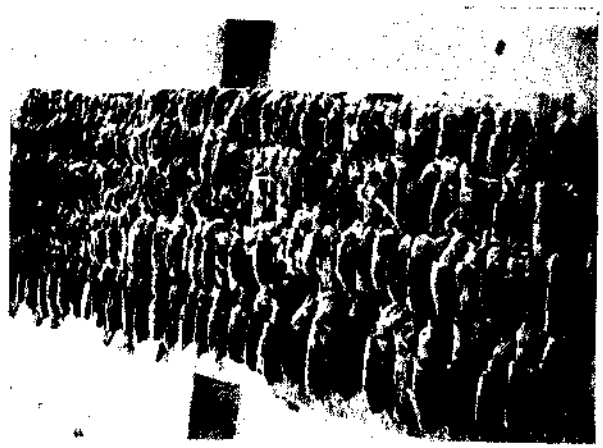

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