RESULTS OF THE TAGGING EXPERIMENTS ON THE INDIAN SPINY LOBSTER, *PANULIRUS HOMARUS* (LINNAEUS)— MOVEMENT AND GROWTH[1]

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ABSTRACT

Mark-recovery experiments conducted with the help of suture tags on Indian spiny lobster *Panulirus homarus* (Linn.) showed that their movement in the fishing ground is of a very restricted nature. Long migratory movements were not observed. The species grows very fast and attains commercial size by the end of first year after the puerulus stage settles down to the bottom of the fishing ground. The growth rate slows down after the second year. Sizes attained at successive ages have been estimated with the help of von Bertalanffy's growth equation. The commercial fishery is largely supported by 1st and 2nd year animals.

INTRODUCTION

Recent developments in the frozen sea food industry have brought to limelight the relatively modest lobster fishery of the south-west coast of India. Prior to these developments the lobsters of this region supported only a subsistence fishery of diffused nature. Even at that time fair quantities of lobsters were landed at the southern portion of the west coast (Kanyakumari district), but accurate data on the yield were not available. Packing lobster tails for export commenced in late nineteen fifties and since then new lobster centres have been located and more efficient methods of capture introduced. At present, the average annual production of lobsters from Kanyakumari district alone is around 500,000 numbers. The value of the 80,800 kg of frozen lobster tails exported, chiefly to the U.S.A., in 1966 was around rupees 1.5 million.

Among the six species of spiny lobsters (Genus: *Panulirus*) recorded from India (George, 1967) *Panulirus homarus* is the most important commercial species particularly on the west coast of India. A detailed study of the biological and fishery aspects of the spiny lobsters of India has become an imperative need, as

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simultaneous with the developments in the export industry a fear of depletion of the stock has caught hold of the fishermen, exporters and administrators. Different aspects of the biology and fishery of the species are now being studied and some accounts have already been published (Miyamoto and Shariff, 1961; Balasubramanyam *et al.*, 1960 and 1961; Chacko and Nair 1963 and George, 1965). In this context a tagging programme was initiated at Muttom by the Central Marine Fisheries Research Institute in the 1964 fishing season and the present communication deals with the observations made on the movement and growth of these animals as seen from the recoveries of tagged lobsters.

TAGGING

A semi-internal suture tag made of PVA and nylon was used in the programme. The tag was made of two pieces of hard red PVA, one used as anchor and the other as tag, connected to each other by two strands of monofilament, colourless nylon strand (Fig. 1). Measurements of the tag are as follows:

	Length mm	Breadth mm	Thickness mm	Material
Tag	20.14	5.27	0.5	PVA
Anchor	14.04	3.12	0.5	PVA
Strands		0.3 mm in diameter		Nylon

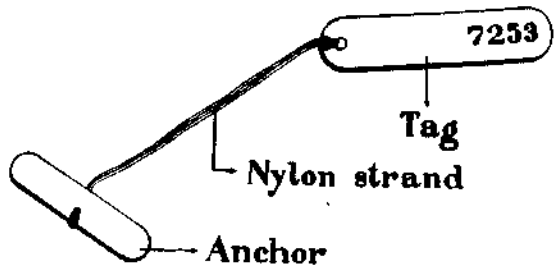


FIG. 1. Tag used on lobster *Panulirus homarus*.

Live lobsters caught in traps were collected from fishermen when they were still in the fishing grounds. The animals were carefully removed from the traps and transferred into the catamaran from which the tagging operations were carried out. The size[1], sex and other conditions of the lobster were recorded before the actual tagging. A small incision was made on the ligament between the cephalothorax and abdomen and the anchor portion of the tag was inserted deep into the dorsal thoraco-abdominal muscle on the left side of the lobster. A gentle pull

1. Both total length and carapace length of the animal were recorded. Length referred to in this paper is the total length measured from anterior median edge of carapace to tip of telson, when the animal is kept pressed on a horizontal plane.

at the tag got the anchor in position. The tags and the instruments were kept dipped in rectified spirit. Only at the time of making the incision the lobster reacted violently. After tagging the lobsters were left free inside the catamaran to move about in the sea water. All the lobsters tagged were apparently healthy and no symptom of exhaustion or severe injury was observed after the insertion of the tag. When all the lobsters were tagged they were taken a little out into the sea and released near the outer fringe of the fishing ground, after carefully noting the bearing in respect of the land marks and recording the depth and temperature of the water.

Although these spiny lobsters do remain alive for a considerable length of time out of water, special care was taken to select those of them in good condition and to keep them out of water for the minimum length of time. Injured and mutilated specimens were not used for tagging and for the same reason lobsters obtained by anchor hooks could not be made use of for this purpose. This has necessarily affected the total number of releases.

Tagging was carried out at Muttom during the 1965 and 1966 fishing seasons. In both years the fag end of the season was selected for the purpose due to the following reasons:

1. The tagged lobsters will not be subjected to fishing soon after release.
2. The effect of the monsoon on the movement or dispersal of the stock could be better understood if they are allowed to remain out in the sea throughout the monsoon which followed the fishing season. A total number of 88 lobsters (52 males and 36 females) were released in 1965 and another 47 (26 males and 21 females) in 1966.

The programme was given wide publicity in the lobster fishing centres and an amount of Rs 2/- was offered for every tagged lobster returned, in addition to the travelling expenses of the person who brought the lobster. This was publicised by hand-bills, posters etc. and also by announcements made at the local church congregations.

OBSERVATIONS

The first recovery of the tagged lobster was reported on the 16th day after release from generally the same locality. The specimen showed no growth. The wound caused by the insertion of the tag was quite dry and no sign of infection was apparent (Pl. 1). Thereafter tagged lobsters were recovered (see Table 1) at regular intervals and from more or less the same locality. The condition of the wound in the recovered lobsters and the high percentage of recovery indicate that tagging mortality was quite insignificant. In 1965 season 29 out of the 88 lobsters released were recovered (ca. 33%). Among the recoveries the proportion of male and female was more or less the same as of the lot released. In the second year the percentage

of recovery was low, being 13.0% and this is generally believed to be due to the unattractive nature of the reward offered. The longest period a tagged lobster was out in the sea was 615 days and this period covered two fishing seasons.

Among the lobsters tagged and released, two were carrying orange-coloured berry at the time of release. One of these (tag no. 5163, released on 9-3-1965 at size 210 mm, recovered on 3-4-1965 at size 212 mm) had shed the berry when recaptured after 25 days from the same locality. The other one (tag no. 5065, released on 11-3-1965 at size 230 mm, recovered on 11-1-1966 at size 260 mm) had berry on the pleopods when recaptured from the same locality after 306 days. It is obvious that the berry that was originally present at the time of release must have been shed within a month, as seen from the earlier recovery, and that the present berry has been acquired subsequently. It would therefore appear that at least two, if not more, spawnings take place within the period of 306 days during which time the lobster had grown from 230 mm to 260 mm. While stating that egg-laying in *P. longipes* occurs every second year Sheard (1949) suggested the necessity of confirmation of this point which is of vital importance to any conservation scheme. A more frequent periodicity of spawning is indicated by the present observations on *P. homarus* and it may as well be identical in all the species of the genus.

Movement

The movement of these lobsters (Fig. 2), as seen from the recoveries, is extremely limited and it is quite obvious that they seldom move out of the fishing ground. Practically all the lobsters recovered were caught by the fishermen of the same village within ¼ to 7 km from the spot of release. Only on one occasion a tagged lobster has been recaptured from Colachel, about 12 km north of Muttom, after 246 days. All the lobsters recovered including the one which covered the longest distance of 12 km showed shoreward and northward movements. The distance covered being very insignificant, the apparent northerly movement would have in all probability been the result of the tide or drift in existence at the time of release. Similarly the shoreward movement may be due to the effort of the animal to come into the natural habitat of the rocky sea bottom which is close to the shore. Dawson and Idyll (1951) and Smith (1958) observed that the American spiny lobster normally hides under rocks and seaweeds during day time and moves about very little during night in search of food. In general, according to them, the spiny lobster movements may be said to be random wanderings, usually over short distances. Isolated cases of long migrations were also noticed and they believed that such long migrations helped to mix the population over the entire area. Sheard (1962) observed that the Australian crayfish (*Panulirus longipes*) is relatively sedentary in nature and consequently the population is divided into more or less independent stocks, each of which is subjected to a different level of exploitation, depending on accessibility. The habit of restricted movements noticed in the case of these lobsters seems to hold good in the case of *Panulirus homarus* too. The present observations clearly indicate that the animal keeps itself within a restricted area and it is quite possible that

each of them or a group of them remains in a favourite hide-out. If that is the habit the relatively insignificant distance of ¼ to 7 km travelled by the recovered lobsters must have been covered within a few days of release, partly due to the tide and partly due to their search for a suitable hide-out, they having been released in the outskirts of the grounds where suitable hide-outs are not in existence.

GROWTH

Estimates of growth rate in different species of spiny lobsters have been made by different workers employing different methods such as length frequency distribution in the population, mark-recovery projects and even by holding them in

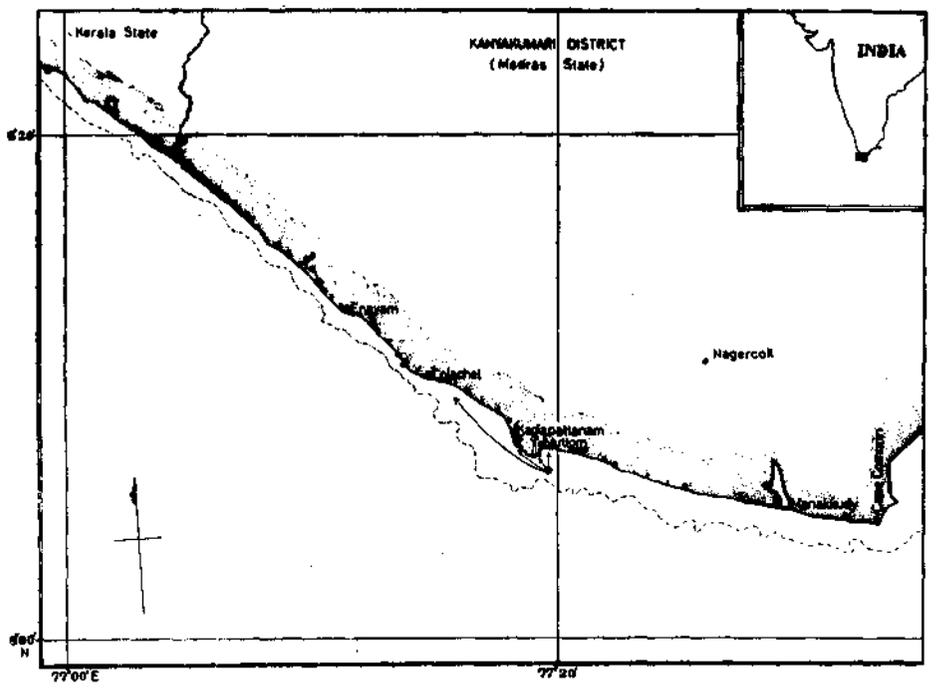


FIG. 2. Map showing movement of tagged lobsters and the lobster fishing villages of Kanyakumari district.

captivity. While each of these methods has its own limitations it is to be admitted that tagging would provide the most accurate direct evidence on this aspect if the recoveries are reasonably high. The growth increments gained by the recovered lobsters during the present experiments are shown in Table 2 and Fig. 3. With the exception of a few early recoveries within a short period of release all the other lobsters recovered showed varying increments of growth. Those recovered within the period of a month after release showed no appreciable growth, indicating that no moult has taken place within that period. Two female lobsters (168 mm

TABLE 1. *Recoveries of tagged lobsters showing their movement*

Ser. No.	Date of tagging	Tag No.	Date of recovery	No. of days free in the sea	Distance travelled in km
		First Season, March 1965			
1	9.3.1965	5160	25.3.1965	16	¼
2	11.3.1965	5096	31.3.1965	20	2
3	9.3.1965	5163	3.4.1965	25	1
4	11.3.1965	5088	10.4.1965	30	1
5	9.3.1965	5165	9.4.1965	31	1
6	11.3.1965	5068	26.4.1965	46	½
7	11.3.1965	5080	26.4.1965	46	1
8	9.3.1965	5176	29.4.1965	51	¼
9	11.3.1965	5066	1.7.1965	112	1
10	11.3.1965	5075	9.11.1965	243	1½
11	9.3.1965	5170	9.11.1965	245	6
12	11.3.1965	5189	12.11.1965	246	12
13	11.3.1965	5087	12.11.1965	246	7
14	9.3.1965	5162	13.11.1965	249	¼
15	11.3.1965	5090	13.11.1965	247	¼
16	9.3.1965	5166	13.11.1965	249	¼
17	11.3.1965	5188	13.11.1965	247	5
18	11.3.1965	5078	15.11.1965	249	¼
19	9.3.1965	5171	16.11.1965	252	1½
20	11.3.1965	5190	16.11.1965	250	¼
21	11.3.1965	5061	17.11.1965	251	½
22	9.3.1965	5168	17.11.1965	253	6
23	11.3.1965	5091	19.11.1965	253	¼
24	9.3.1965	5161	20.11.1065	256	¼
25	11.3.1965	5079	27.11.1965	261	¼
26	11.3.1965	5098	1.12.1965	265	1
27	11.3.1965	5194	2.12.1965	266	¼
28	9.3.1965	5180	7.12.1965	273	1
29	11.3.1965	5065	11.1.1966	306	¼
		Second Season, March 1966			
1	28.3.1966	0118	4.4.1966	7	2
2	28.3.1966	0123	26.10.1966	212	1½
3	26.3.1966	0113	11.11.1966	230	2
4	29.3.1966	0136	9.1.1967	286	2
5	26.3.1966	0108	30.10.1967	584	8
6	26.3.1966	0112	30.11.1967	615	½

TABLE 2. *Size gained by the recovered lobsters and the growth rate*

Ser. No.	Size at tagging mm	Size at rocovery mm	Size gained mm	No. of days free in the sea	Growth/day mm
			Males — First season		
1	220	220	—	16	—
2	150	150	—	20	—
3	188	188	—	30	—
4	155	167	12	51	0.2353
5	155	179	24	112	0.2143
6	245	265	20	243	0.0823
7	130	215	85	245	0.3469
8	133	210	77	246	0.3130
9	145	213	68	249	0.2731
10	145	186	41	247	0.1659
11	140	216	76	249	0.3052
12	117	203	86	249	0.3454
13	132	200	68	250	0.2720
14	260	277	17	251	0.0677
15	135	210	75	253	0.2964
16	158	212	54	256	0.2109
17	225	242	17	261	0.0651
18	193	230	37	265	0.1396
19	134	215	81	266	0.3045
			Males—Second season		
1	215	215	—	7	—
2	164	220	56	212	0.2643
3	155	227	72	230	0.3131
4	134	230	96	286	0.3356
5	150	246	96	615	0.1561
			Females—First season		
1	210	212	2	25	0.0800
2	242	245	3	31	0.0968
3	168	170	2	46	0.0435
4	146	157	11	46	0.2391
5	150	216	66	246	0.2683
6	155	210	55	247	0.2227
7	125	194	69	252	0.2738
8	143	222	79	253	0.3123
9	122	198	76	273	0.2784
10	230	260	30	306	0.0980
			Females—Second season		
1	148	245	97	584	0.1661

and 146 mm in total length), both tagged on the same day, were recovered after 46 days. The larger one showed a very insignificant growth of 2 mm, while a growth increment of 11 mm was observed in the case of the other specimen. This 11 mm growth increment must have been achieved by a single moult and it would appear that the intermoult period of the larger lobster is more than 46 days. The insignificant growth increment of 2 mm in 46 days seen in the case of the larger specimen indicates the possibility of some intermoult growth also. The highest growth rate of 0.3469 mm per day was observed in a male specimen tagged and released on 9.3.1965 off Muttom fishing village. This lobster which was 130 mm at the time of release was caught after 245 days from Kadiapattinam, a fishing village situated only 6 km north of Muttom. The specimen measured 215 mm recording a growth of 85 mm

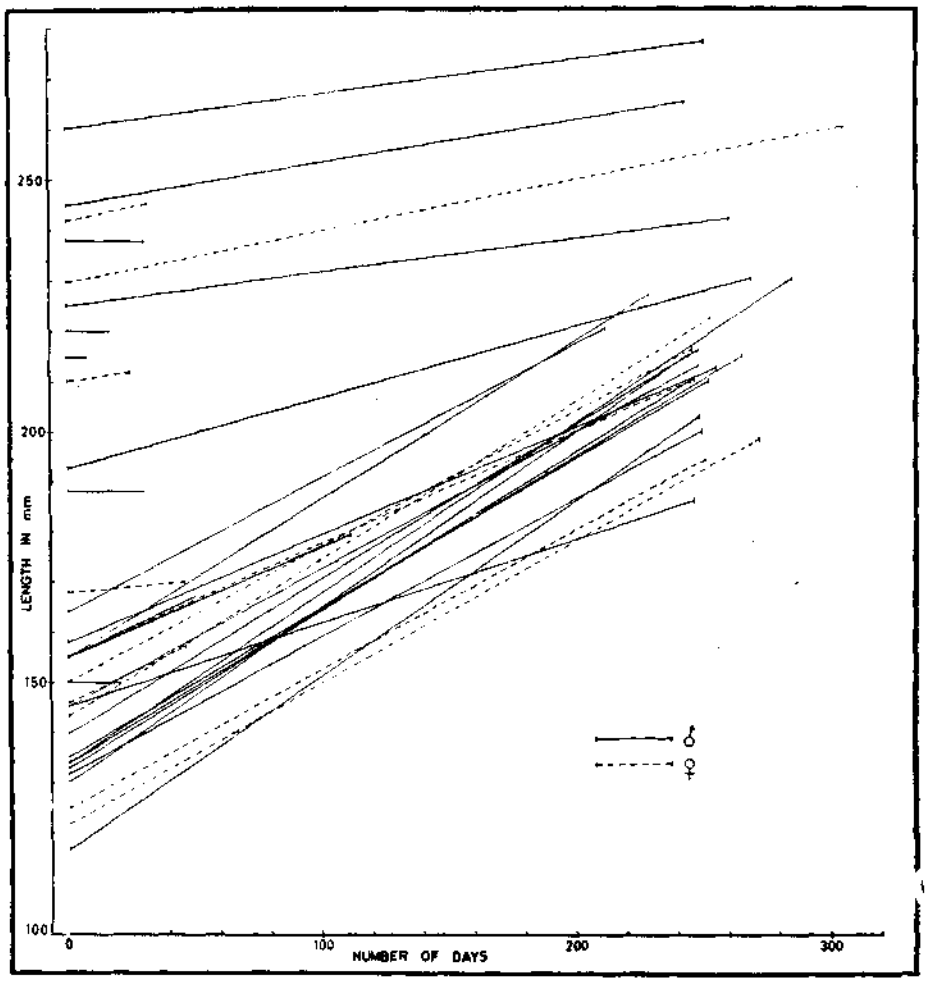


FIG. 3. Growth recorded by the recovered lobsters.

during the period. It so happens that the smallest and the largest lobsters tagged (both males) were released on the same day from the same spot (tag nos 5087 and 5061). Surprisingly they were both recovered from roughly the same locality after 249 and 251 days respectively. The rate of growth noticed in the younger lobster was 0.3454 mm per day, while the older one showed only a growth rate of 0.0677 mm per day. In general, the growth rate is seen to be much faster in the younger specimens than in the older ones. As the process of growth in these animals takes place by moulting which occurs at different periodic intervals, the calculated figures of growth per day as given in table may not indicate any absolute value. Nevertheless, it clearly brings out the trend as is manifested in the different stages of growth of the animal.

Using the data on growth increments noticed an attempt is made to fit von Bertalanffy growth equation,

$$l_t = l_\infty \left\{ 1 - e^{-K(t-t_0)} \right\}$$

where l_t is the size at age t, l_∞ is the asymptotic length, K is the growth coefficient whose estimate is to be obtained from the data at hand and t_0 is an adjustment in the time axis corresponding to the time when the fish was theoretically of size zero.

Since the fitting of the above equation requires data on size of lobster at equal intervals of time, this was not suitable for the type of data available at hand. The equaion was modified as

$$y = K\,(l_\infty - x)\frac{\tan k\,\frac{Ka}{2}}{\frac{Ka}{2}}$$

where K and l_∞ are the same parameters as in the original equation, y is the growth rate per unit of time, x the mid point between the sizes at release and recovery and a is the duration the animal was out in the sea. If Ka/2 is small the equation becomes

$$y = K(l_\infty - x)$$

From this linear equation the values of K and l_∞ are found out. For the purpose of applying the equation, a two-way table was formed with size at release (10 mm interval) on one side and the number of days elapsed before recovery (10 day interval) on the other side. x and y for each size interval was calculated from the mean of the values obtained from each cell of this two-way table. The least square estimation of K and l_∞ were obtained as follows:

Males: $K = 0.717$ and $l_\infty = 312.3711$ mm

Females: $K = 0.601$ and $l_\infty = 303.1656$ mm

From this it is seen that the growth rate was higher in males than in females. This explains the higher modal sizes of the males in the commercial catches. The value of l_∞ obtained for both males and females also seems to agree with the actual condition in existence as the largest sizes recorded in this fishery are about 315 mm and 300 mm in males and females respectively.

For the purpose of estimation of t_0 the special characteristics of the protracted pelagic larval history of the animal has been taken into consideration. The fact that the animal on an average attains a size of about 20 mm at the time of settlement to the substratum has been utilized in the estimation of t_0. This is estimated to be

$t_0 = -0.094$ years for males and $t_0 = -0.117$ years for females.

Using the above estimates of K, l_∞ and t_0 in the Bertalanffy equation the sizes of the animal were calculated at successive ages and are given in Table 3. It may be explained here that the growth and life span of the lobster have been reckoned from the time of settlement of the puerulus stage in the fishing ground.

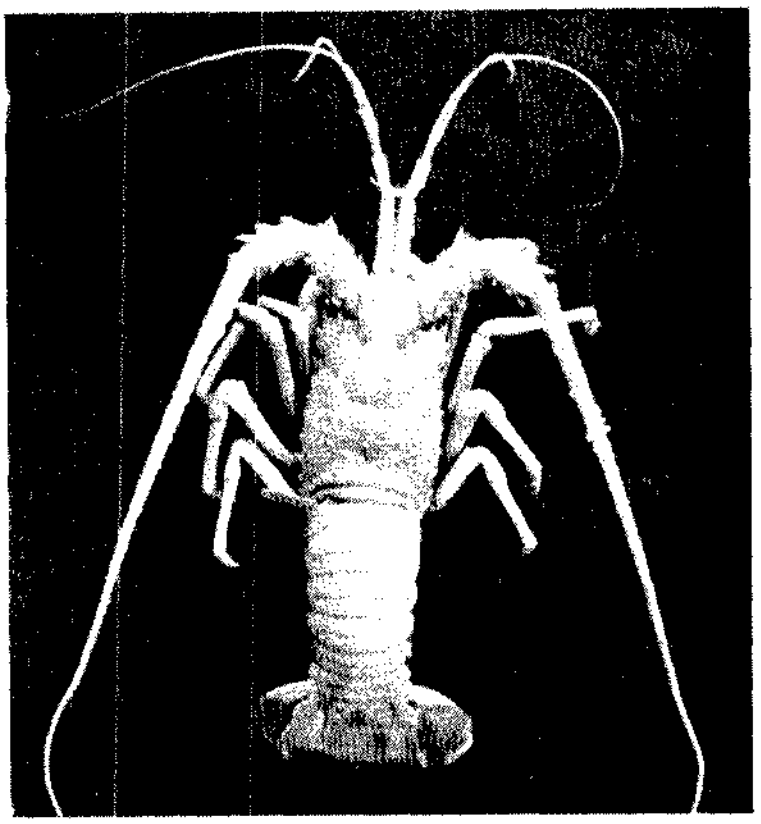
TABLE 3. *Sizes of lobsters at successive ages*

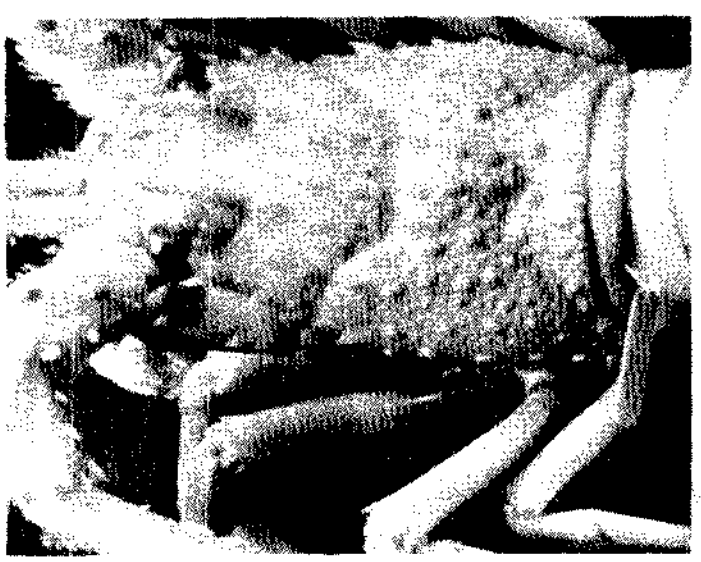
Age	Size in mm at successive ages	
	Male	Female
1	170.1	147.8
2	242.4	217.9
3	278.3	256.4
4	295.8	277.5
5	304.4	289.1
6	308.4	295.4
7	310.4	298.9
8	311.4	300.8
9	311.9	301.9
10	312.1	302.5

The species seems to grow very fast in the first year of life and thereafter the growth slows down considerably; the increment of growth gained in each year decreasing as the years advance. By about 5 years both males and females attain the largest size group observed in the fishery as a mode. Growth beyond this point is too slow to be of any practical significance for fisheries management. George (1965) recorded that the modal size groups of lobsters in this fishery were between 131-140 mm and 291-300 mm in different months of the season. Among these size groups the most predominant groups were 171-180, 181-190, 191-200 and 201-210 mm. The fishery is therefore largely supported by lobsters of 1 and 2 year groups.

DISCUSSION

The higher percentage of recovery of the tagged lobsters and the relatively insignificant movement exhibited by these make it clear that the concerned fishery





Recovered lobster with the tag on.

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is of a very restricted and localised nature. Although tagged lobsters were released towards the fag end of the 1964-1965 season, 27.6% of the recoveries were made during that season itself within 51 days before the season closed by end of April. The majority of the recoveries (51.7%) were obtained within 10 days of the re-opening of the season during the second week of November 1965. The same trend of recovery was noticed in the second season also While the selection of the fag end of the season has helped to allow the lobsters maximum free time in the sea in order to understand their growth rate for long durations, it has partly obliterated the details of growth process such as moulting and its frequency. Such details can be studied if tagging is carried out in small batches at regular intervals throughout the season.

That these lobsters do not move about very much is clear from the foregoing account, in most cases the distance travelled being more or less equal to the distance to which they were taken out and released. This obviously poses the question of the source of replenishment of the stock in the fishing ground. The recruitment must be taking place in very early stage, probably at the time of larval settlement to the bottom. The phyllosoma larva of the species is widely distributed and planktonic (Prasad and Tampi, 1959). The larvae settle to the bottom only when they finally metamorphose into the puerulus stage and this may take place at any locality. The survival of these settling juveniles may largely depend on the suitability of the substratum and the ecological conditions. It is therefore clear that the more or less continuous rocky reefs extending throughout the close inshore areas of the Kanyakumari district provide such environment for the successful settlement and survival of the juveniles.

From the direct evidence provided by these mark-recovery experiments it is clear that the Indian spiny lobster, *P. homarus*, has a rapid rate of growth in the early years of their life and thereafter the process slows down considerably. It is also clear that males have a relatively faster growth rate in conformity with the general growth rate observed in the respective years. By following the size frequency in commercial catches, George (*op.cit.*) observed 9 year classes of the species in the same fishery and concluded that lobsters measuring 300-310 mm are 10 year olds. This observation is substantially correct but his estimates of growth rate especially in the earlier years needs revision in the light of the statistical computations made from the present data.

In the Florida spiny lobster *P. argus*, Dawson and Idyll (1951) and Smith (1958) recorded an annual growth of 1 inch (25.4 mm) to 1½ inches (38.1 mm) in specimens of commercial size 9 inches (228 mm). Backus (1960) observed a growth rate of 20 mm in female and 17 mm in male *P. interruptus* measuring between 270 mm and 400 mm total length. While these growth rates observed at the particular sizes of the animal agree with what is observed in *P. homarus*, the same recorded in the Australian spiny lobster *P.longipes* by Sheard (1962), namely, 0.31 inch (7.8 mm) in females and 0.44 inches (10.07 mm) in males, are decidedly low. Most of these

data on growth related to animals above 200 mm in size and those already in mature adulthood. The extremely rapid growth rate of the Indian spiny lobster in first and second year of life is of vital significance from the standpoint of conservation of this restricted fishery.

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