MATURATION AND SPAWNING IN *POLYNEMUS HEPTADACTYLUS* CUV. AND VAL.[1]

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ABSTRACT

The maturity cycle of *Polynemus heptadactylus* has been described. The ripe ova measure 0.64 - 1.04 mm in diameter, and each ovum contains one to many oil globules. Size at first maturity is 133 mm in female and 128 mm in males, when the fish has completed its second year of life. Females dominated in number in almost all length groups. Males were totally absent in length groups above 203 mm. Spawning is prolonged, and the release of ova is in batches. Individual fish spawns twice with an interval of six months; but with slight diversities in their individual spawning periods, the spawning of the species appears to be throughout the year. All the maturity stages are obtained all through the year. There are two peak spawning seasons, March-June and August-November, and two recruitments every year. The spawning intensity seems greater in offshore waters. The fish appears to spend the juvenile stages in inshore waters.

INTRODUCTION

The works of Palekar and Karandikar (1952 a, 1952 b and 1953), Pradhan and Palekar (1956), Prabhu (1956), Krishnamoorthy (1958), Dharmamba (1959) and Qasim and Qayyum (1961) relate to the study on the maturity and spawning behaviour of some of the commercially important fishes of India. Studies by Mohamed (1955), Nayak (1959) and Karekar and Bal (1960) on the maturity and spawning behaviour of *Polydactylus indicus* and Karandikar and Palekar (1950) on the spawning periodicity of *Polynemus tetradactylus* (= *Eleutheronema tetradactylum*) are contributions of much significance in the comparative study on the maturation of different species of polynemids.

Since nothing so far is known about the maturity and breeding habits of *Polynemus heptadactylus* which has some commercial importance in Bombay-Saurashtra waters, the present investigation on the maturation, sex ratios, spawning periodicity, fecundity and ponderal index of this species, has been attempted.

MATERIAL AND METHODS

A total of 1,746 specimens of *P. heptadactylus* was studied in the period 1956-'59. Of these 520 specimens were examined from the inshore waters of

1. This paper formed part of the thesis for the award of Ph.D degree of the Bombay University.

Bombay (245 from Versova landing place during December 1956 — November 1958 and 275 from Govt. of India vessels during May 1956 — October 1958) and the remaining 1,226 from the off shore waters landed by the New India Fisheries Company's trawlers during May 1957 to October 1959.

Weekly collections from the inshore landings at Versova could be had regularly, but the trawl collections were obtained either weekly or biweekly or even fortnightly depending on the arrival of the trawlers at Sassoon Docks. Till June 1958 each sample consisted of 10 specimens, taken at random, but subsequently the number was increased to 25. Specimens below 75 mm in furcal length were not included in this study as sexes could not be differentiated in them.

In the laboratory the fish were measured for furcal length and grouped into 12 size groups with 15 mm intervals. The maturity stages were recorded and a few ovaries in the advanced stages of development were preserved in 10% formalin for further studies on the ova diameter measurements and fecundity.

MATURATION

The ovary and ova of *P. heptadactylus* in different stages of maturity are described below.

Immature ovary — The immature fish has a pair of small colourless thread-like ovaries, of varying thickness, extending to less than half the length of the body cavity. Ova are invisible to the naked eye.

Under the microscope immature ova are almost round, minute, yolkless and transparent, with a single central distinct nucleus in each and measure up to 0.32 mm in diameter.

Maturing ovary — Maturing ovaries extend from half the length of the body cavity to its full length.

The ova undergo a series of changes from being opaque and yellowish, due to the heavy deposition of yolk, to getting translucent in the penultimate stage when the oil globules begin to appear. At this stage when the yolk deposition increases, the cytoplasm becomes transparent around the periphery. The ova diameters range from 0.33 to 0.64 mm.

Mature ovary — Mature ovaries fill the body cavity and attain a creamy colour. Ova are transparent or translucent with one to many oil globules. The oil globules measured from 0.2 to 0.3 mm in diameter, the ova diameters from 0.65 to 1.04 mm.

The mature ova of *P. heptadactylus* are of the nature of pelagic eggs as in the two other allied species, *E. tetradactylum* and *P. indicus*. Karandikar and Palekar (1950) observed oil globules ranging 0.25 - 0.30 mm in diameter in the mature ripe ova of 0.70 to 0.85 mm diameter in *E. tetradactylum*. However, the author had an

opportunity to observe the ripe ova of the same species ranging in diameter 0.70 - 1.00 mm. Nayak (1959) recorded in *P. indicus*, oil globules measuring between 0.26 mm and 0.40 mm in diameter in the ripe ova measuring 0.63 - 1.10 mm. Thus these three species of polynemids, though differing greatly in the maximum size to which they grow, appear to have ripe ova of almost the same size and also oil globules of the same number and nature.

Spent ovary—Spent ovaries are blood-shot in colour, shrunken, flaccid, empty and sac-like containing innumerable small immature yolkless ova along with a few degenerating residual ones in the process of resorption.

The maturity key for the females has been found to be parallel with that for the ovarian part of the ovotestis of the hermaphroditic individuals (Kagwade, 1971).

Different maturity stages could not be assigned for males because these stages were not distinct. The testes ripen early even when their full dimensions are not attained and continue to show ripe spermatoa all through thereafter.

Maturity Stages in Commercial Catches

A study of this aspect based on samples from the inshore and offshore catches would throw some light on the location of the probable spawning ground of the fish. The monthly percentage occurrence of different maturity stages of females has been

Table 1. *Monthly percentage occurrence of maturity stages of female* P. heptadactylus *in the inshore catch*

Month	Maturity stages I	II	III	IV	V	VI	VII
May 1956	—	39	13	30	—	—	18
October	43	4	3	37	13	—	—
November	22	—	7	71	—	—	—
December	42	—	—	25	33	—	—
January 1957	67	—	—	22	11	—	—
February	70	18	—	6	6	—	—
March	88	12	—	—	—	—	—
April	57	40	3	—	—	—	—
May	47	47	—	—	—	—	6
June	40	20	10	10	—	—	20
September	70	25	—	5	—	—	—
October	38	62	—	—	—	—	—
December	17	55	11	17	—	—	—
January 1958	19	25	25	31	—	—	—
February	28	10	24	24	4	10	—
March	21	13	4	21	8	29	4
October	30	23	4	2	27	7	7
November	44	34	—	3	8	8	3

given in Tables 1 and 2. From the tables it is observed that all the maturity stages appeared in almost all size groups, excepting those in which the fish had not attained the sexual maturity.

In the inshore catch, the immature stages and in the offshore catch, the advanced and spent stages, were noticed in high percentages throughout the year. Mature stage in the inshore catch was slightly more in March than in other months. In the offshore catch mature ones predominated in May and October 1957. Spent individuals occurred almost throughout the year but taking the inshore and offshore catches, this stage has been found to occur in high percentages during March-June and August-December.

Thus the presence of all stages all the year round indicates that the spawning may be throughout the year. As most of the stages show two periods of high percentages in their occurrence in a year, it appears that there are two peak spawning

TABLE 2. *Monthly percentage occurrence of maturity stages of female* P. heptadactylus *in the offshore catch*

Month	Maturity stages						
	I	II	III	IV	V	VI	VII
May 1957	—	—	—	20	—	40	40
June	—	—	—	6	—	—	94
July	—	24	16	20	16	20	4
August	—	—	—	29	50	21	—
September	—	—	14	52	29	5	—
October	—	—	—	—	50	50	—
November	—	—	13	50	—	37	—
January 1958	—	—	4	42	54	—	—
February	—	—	4	45	23	23	5
March	—	—	—	17	33	33	17
June	—	—	22	11	22	11	34
July	—	—	—	24	35	39	2
August	—	—	—	57	14	29	—
September	—	—	—	13	13	7	67
October	—	—	—	25	39	6	30
November	—	10	—	33	—	—	57
December	14	—	—	39	11	6	30
January 1959	—	4	—	34	50	8	4
February	—	—	—	67	8	5	20
March	—	—	—	51	—	9	40
April	—	—	—	66	6	11	17
May	—	—	—	50	—	—	50
June	—	38	—	8	4	—	50
July	—	—	—	70	13	—	17
August	—	—	—	43	3	—	54
September	—	—	—	60	5	—	35
October	—	4	—	40	4	—	52

periods, *i.e.*, about March-June and August-November. The presence of mature and spent individuals in the inshore and offshore catches, indicates that the spawning may be in both the waters. From the differences noticed in the percentages of advanced and mature stages it may be inferred that the intensity of spawning is greater in the offshore waters than in the inshore, The occurrence of immature fish in very high percentages in the inshore catch seems to indicate a juvenile migration to shallower waters for more intensive feeding before they attain the adult size, after which the majority of them go back to the offshore waters for breeding.

Size at First Maturity

A total of 914 female *P. heptadactylus* from inshore and offshore catches was examined for determining the size at first maturity. All fish above stage III in which the ova are seen beginning to mature are considered to spawn during the season. Hickling (1930) and Clark (1934) have indicated that there is a possibility of some error in following this method because eggs in adolescent fish may start to mature, but may fail to reach the ripe stage and thus degenerate. However, it is observed that in *P. heptadactylus* maturing ova are noticed in most of the length groups through out the year.

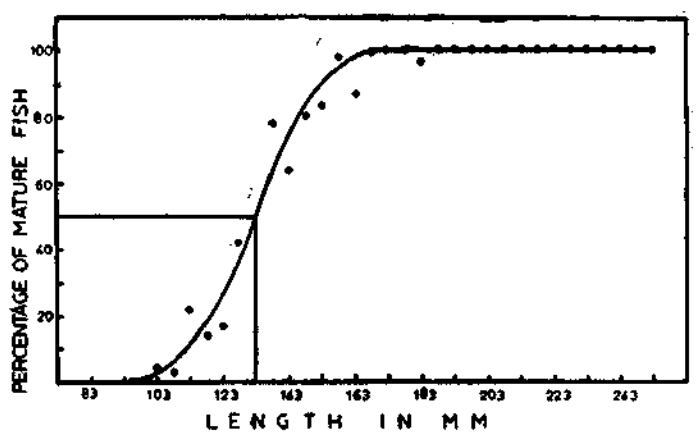

Fig. 1. Maturity curve for females of *Polynemus heptadactylus*.

In fish at 103 mm in length, 4% were mature, in those at 128 mm 42%, at 133 mm 48% and above 168 mm almost all were mature, as seen from Fig. 1 which also indicates that nearly 50% of the fish are mature when they attain the length of 133 mm. This is further supported by the study on the ponderal index in which the condition for the females was found to drop at a length of 133 mm and this may be attributed to the onset of sexual maturity. Thus it can be said that the female *P. heptadactylus* normally matures at 133 mm when it just completes its second year of life and enters the third year.

The condition factor which was found to drop at 128 mm was the only evidence of first maturity in the males at that size which is attained when the fish just completes its second year of life.

Sex Ratio

There are no external characters by means of which the sexes in *P. heptadactylus* can be differentiated. The sexes were, therefore, noted directly after opening the body cavity. Sex of the fish below 70 - 80 mm could not be recognised even with the aid of a microscope. Females were distinguishable beyond this length because of the presence of oocytes but males with distinct reproductive elements, occurred only after 90 mm length. However, hermaphrodite specimens were first noted in October 1958 and it was only after this they were treated separately. Superficial examination of the ovotestis reveals at first sight the well-developed ovarian part and not the less-developed testicular part, for which reason the gonad is often mistaken for an ovary. Fish in which sexes were indeterminate and which were available throughout the year were excluded from this study. A total of 1,601 fish, of which 503 were from the inshore catch and the remaining 1,098 from the offshore catch, was examined for this study.

TABLE 3. *Percentage occurrence of male and female* P. heptadactylus *in* 15 *mm length groups*

Size group mm	83	98	113	128	143	158	173	188	203	218	233	248
No. of fish	35	99	140	213	267	296	239	161	95	35	10	11
Male (%)	6	22	39	54	46	31	14	4	3	0	0	0
Female (%)	94	78	61	46	54	69	86	96	97	100	100	100

From Table 3 it is observed that the proportion in which the two sexes appeared in the commercial catches, varied greatly with the length of the fish. Excepting at the length 128 mm, the females dominated in all other length groups. Males were not encountered in the catches above the length of 203 mm. At no length did the males and females appear in 1 : 1 ratio in the catch.

In the inshore catch from May 1956 to November 1958 the females dominated (Table 4). However, a tendency for the males to increase was noticed in the months October, November and December 1956, March 1957 and October 1958 when they formed 43, 30, 37 and 34% respectively. Similarly in the offshore catches, too, from May 1957 to October 1959, the females were generally noted to predominate, though males exceeded the females in number in June (58%) and November 1957 (56%), November 1958 (54%) and May 1959 (65%). However, in June 1958 the sexes appeared in 1 : 1 ratio in the offshore catch.

TABLE 4. *Sex composition of* P. heptadactylus, *in the inshore and offshore catches during different months*

Month	Inshore catch		Offshore catch	
	Male(%)	Female(%)	Male (%)	Female (%)
May 1956	15	85	—	—
October	43	57	—	—
November	30	70	—	—
Decmeber	37	63	—	—
January 1957	0	100	—	—
February	11	89	—	—
March	33	67	—	—
April	12	88	—	—
May	15	85	17	83
June	29	71	58	42
July	—	—	37	63
August	—	—	30	70
September	13	87	30	70
October	7	93	40	60
November	—	—	56	44
December	6	94	—	—
January 1958	16	84	13	87
February	6	94	45	55
March	28	72	40	60
June	—	—	50	50
July	—	—	24	76
August	—	—	32	68
September	—	—	27	73
October	34	66	37	63
November	7	93	54	46
December	—	—	41	59
January 1959	—	—	38	62
February	—	—	15	85
March	—	—	5	95
April	—	—	19	81
May	—	—	65	35
June	—	—	32	68
July	—	—	4	96
August	—	—	17	83
September	—	—	10	90
October	—	—	7	93

SPAWNING

Ova diameter measurements of 7 ovaries in the penultimate and mature stages preserved in 10% formalin, were made use of for this study. In the preliminary observations no difference was found to exist in the diameter grouping of ova from the different regions of the ovary in this fish. Hence 500 ova, in a portion of the ovary from the middle region, were measured for their diameters in the seven individual fish. All the intra-ovarian eggs were measured in each sample, excepting those below the size of 0.08 mm which were always innumerable at any stage of maturity in an ovary.

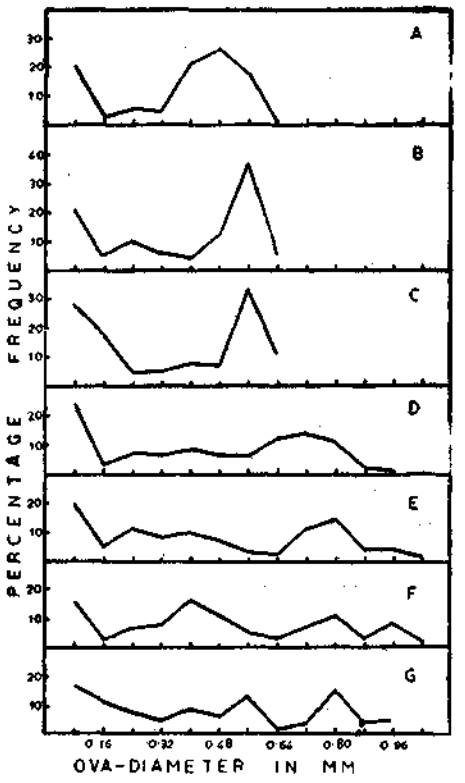

FIG. 2. Ova diameter measurements in *P. heptadactylus*.

Fig. 2 represents the ova diameter measurements in the advanced stages of maturity for this species. The penultimate stage in each of the fishes 'A', 'B' and 'C' shows two peaks distinguishable from the general egg stock. Fish 'A' shows a mode at 0.24 mm of immature eggs in stage II with the percentage value of 26. In fish 'B', the eggs in stage II at 0.24 mm are 10% and those in maturing stage V at 0.56 mm are 37%. Fish 'C' does not show any mode at 0.24 mm but two modes of maturing eggs at 0.40 mm in stage III and at 0.56 mm in stage V with their percentage values of 8 and 32 respectively. This may be because the fish is a little more advanced

than the other two fishes in maturity. These observations indicate that when the maturing eggs attain further growth and are ready to spawn, a fresh batch of immature eggs from the general egg stock starts maturing.

The mature ovaries of fishes 'D', 'E', 'F' and 'G' showed more than two batches of ova. Fish 'D' had 7% of immature ova in stage II at 0.24 mm, 8% of maturing ova of stage III at 0.40 mm and 14% of mature ova at 0.72 mm. Fish 'E' showed 11% of stage II ova at 0.24 mm, 10% of stage III ova at 0.40 mm when the mature ova at 0.80 mm were only 14%. Fish 'F' did not show any mode for stage II; the maturing ova in stage III formed 16% while the mature ova were in two batches at 0.80 mm and 0.96 mm forming 11% and 8% respectively. Fish 'G' showed three batches of ova, the maturing ova in stages III and V at 0.40 mm and 0.56 mm forming 6% and 13% respectively and the mature ones at 0.80 mm forming 15%. Thus it is noticed that ripe ova above 0.64 mm in diameter are differentiated into one or two modes indicating thereby that the eggs are shed in batches and the spawning is not a short and restricted one but prolonged. Since the time interval between the shedding of the eggs in separate batches and also the number of batches in which all the ripe ova are expelled are not known, it is difficult to comment on the duration of spawning. But a mature ovary is noticed to contain a number of ripe ova dehisced from the ovarian follicles into the lumen and it may be inferred that the duration of spawning may not extent over a much prolonged period since the already dehisced ova may not take much time in getting expelled.

The two peaks of immature ova in stage II and the maturing ova in stage III noticed in the penultimate stage, are observed to persist in the mature stage of the ovary also, but the percentage difference in these two groups of eggs is small and they are not sharply distinguishable from each other. Hence, it is likely that the immature eggs may not take any long time to develop into maturing ones. At the same time, the percentage difference between these eggs and the mature or ripe eggs is also not marked. Thus it is inferred that this crop of eggs develops to maturity to contribute to a second spawning, a little later in the course of a few months.

A number of mature ovaries from which a greater part of ripe ova had already been shed, showed that maturing eggs in stage V at 0.56 mm were found to occur to the extent of 20 to 30%. It is unlilkely that such a great number of ova will go waste by way of resorption in the ovary. These eggs may be contributing to the second spawning mentioned above.

In the light of the above findings, it can be said that *P. heptadactylus* spawns more than once in a year and that the spawning is prolonged, the liberation of the ripe ova being in successive batches. The periodicity noticed in the spawning appears to pertain to each individual fish. When all the individuals with slight diversity in their spawning periods amongst themselves are taken together, the spawning in this species appears to be a very prolonged one and all the maturity stages have been found to occur throughout the year. But the appearance of these maturity stages in high

percentage twice a year, coinciding with the two major periods of recruitment in a year, as observed in the length frequency studies (Kagwade, unpublished), prove that the prolonged spawning has two peak periods of March-June and August-November, for this species.

Karandikar and Palekar (1950) have noticed two spawning seasons (January-April and July-September) in *P. tetradactylus*. Nayak (1959) has stated that in *P. indicus* the main spawning period (April - June) is followed by a supplementary one (October-December). Each of these periods being prolonged, breeding in the species appears to be continuous, as observed by Karekar and Bal (1960). It is of interest to note that in *Polydactylus opercularis* and *P. approximans* of eastern tropical Pacific Ocean, Klawe and Alverson (1964) have also observed that the species breed all round the year.

FECUNDITY

Karekar and Bal (1960) and Nayak (1959) have studied the fecundity in *Polydactylus indicus* but there is no other published account on this aspect of study in respect of any other polynemid.

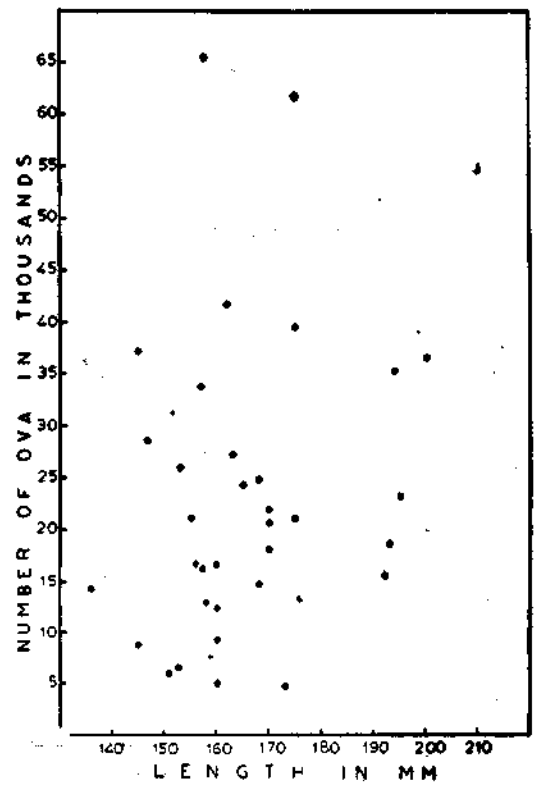

FIG. 3. Fecundity in relation to fish length in *P. heptadactylus*.

For this study, 38 specimens of *P. heptadactylus* ranging in size from 136 to 210 mm in the penultimate stage of maturity, were made use of. For each, the weight of the preserved ovaries (a pair) was recorded; a portion of the ovary was weighed separately and all yolky ova contained in the latter were counted, from which the total number of ova in the pair of ovaries was computed. The ova diameter studies have indicated that the ripe ova in this species are shed in batches but the frequency at which they are shed, as stated earlier, is not known. It is therefore difficult to estimate the correct number of ova destined to be spawned in a year by this method. However, it has not been possible to devise any other suitable alternative method of estimating fecundity in *P. heptadactylus*. Fairbridge (1951) in his work on *Neoplatycephalus macrodon* and Karekar and Bal (1960) in *P. indicus* have noticed similar instances in the fecundity studies of the respective species.

Fig. 3 shows that the number of ova destined to be spawned varied widely in a fish of the same length. The highest number of 65,423 ova was estimated in a fish of 150 mm. It will be interesting to note that another fish of the same length showed a fecundity value of 12,931 ova, which is roughly 1/5 of the earlier value. Such discrepancies in the estimated number of ova in varied proportions at different length of 145, 153, 157, 160, 170 and 175 mm, as noticed in the figure, seem to clearly indicate that the ova in this species are shed in several batches.

Ponderal Index

The condition factor or the ponderal index for 419 females ranging in size from 78 to 245 mm and 181 males ranging from 80 to 210 mm was calculated separately from the formula.

$K = 100W/L^3$, where W = weight, L = Length and K = condition factor.

The correlation is observed to increase with the length (Fig. 5). The value for K

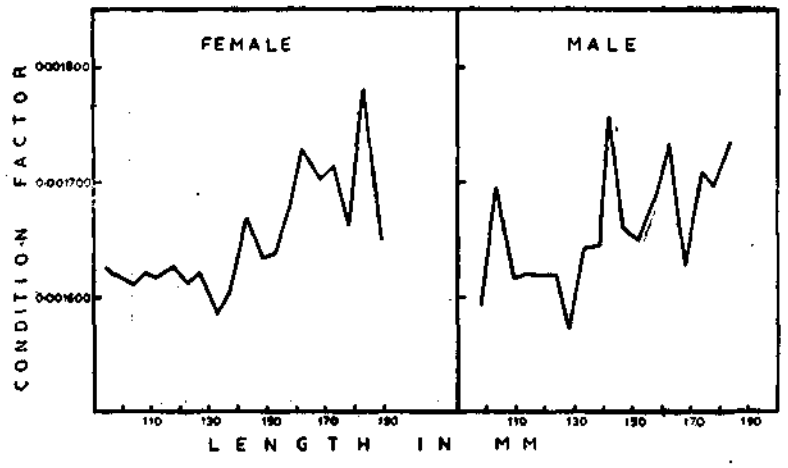

Fig. 4. Condition factor in male and female *P. heptadactylus* in relation to fish length.

in *P. heptadactylus* is found to fall first at the length of 133 mm in females and at 128 mm in males. According to Hart (1946) this fall in the condition is due to the onset of maturity and he states "The point of inflexion, on a curve showing this diminution of 'K' with increasing length is thus a good approximate indication of the length at which the sexual maturity is attained". Thus the condition falling at 133 mm in female *P. heptadactylus* and at a slightly smaller length of 128 mm in males may be attributed to the onset of first maturity in them. The result obtained earlier by the maturity curve for females supports this observation. The fluctuations noticed thereafter in the condition at different lengths in both the sexes are due to the cyclic spawning, recovery and maturation of the gonads.

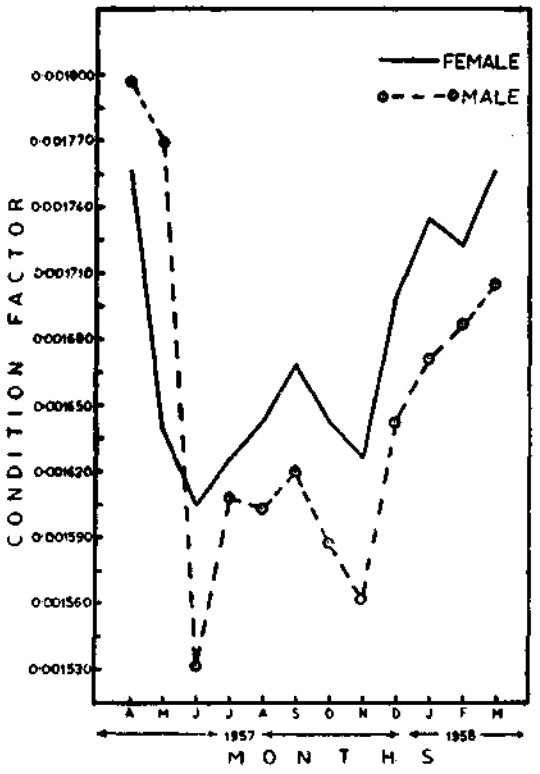

FIG. 5. Monthly average condition factor for male and female *P. heptadactylus* during 1957-'58.

The monthly average condition factor from April 1957 to March 1958 are plotted separately for females and males in Fig. 5. It is seen that in females the condition with a high value of 0.001757 in April falls to 0.001604 in June. After this, a steady gain to the value of 0.001668 in the month of September is noticed. The K value drops again to 0.001626 in November and then begins to increase steadily to 0.001764 in March. The pattern in which the condition varies during different months is the same for males as for the females. The drop in the condition factor

from 0.001797 in April to the value of 0.001531 in June, the increase from this to 0.001619 in September, the fall again to 0.001562 in November followed by a rise to 0.001705 in March is parallel to that found in females.

The condition starts falling in both the sexes during spawning and thereafter it begins to increase, suggesting the recovery of the gonads.

Acknowledgements

It gives me great pleasure to express my gratitude to Dr. D.V. Bal, former Director, Institute of Science, Bombay, for the guidance received in this study. I am grateful to Dr. S. Jones, Director of this Institute, for encouragement given to me when the work was in progress. I am thankful to Shri K. Virabhadra Rao for going through the manuscript and suggesting improvements.

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