CONTRIBUTIONS TO THE BIOLOGY OF PENÆID PRAWNS OF THE SOUTH-WEST COAST OF INDIA

I. Sex Ratio and Movements

By M. Krishna Menon

(Prawn Research Unit of the Central Marine Fisheries Research Station, Ernakulam)

Introduction

The biology and fishery of Indian Penæid prawns of commercial importance particularly of the south-west coast, are being studied in detail by the Central Marine Fisheries Research Station and some of the results obtained so far have been already published (Menon 1951, 1953, 1954, 1955 and Panikkar and Menon, 1955). The present contribution deals with the sex ratio at successive stages of life in four species, namely, *Metapenæus dobsoni*, *Penæus indicus*, *Metapenæus affinis* and *Parapenæopsis stylifera*. Some observations on this aspect in relation to *M. dobsoni* have been included in the second of the two papers dealing with its biology (1955). The discovery of the wide disparity in the proportion of the sexes in the third year of life of this species provided the incentive for a more extensive study of the problem in the same species as well as in three other species also.

Thomas (1955) has described seasonal variations in the sex ratio in the lobster *Homarus vulgaris* M. Edw. and has drawn attention to the possible application of a study of the sex ratios in relation to mortality rates in other Crustacea. It should therefore be interesting to ascertain to what extent the two are interrelated among Penæids.

Material and Methods

Most of the data presented in the following pages have been obtained by the routine study of samples of commercial catches from the sea and backwaters at Narakkal during the years 1952–1955. The species in each sample were separated and the individuals belonging to each, sorted out into males, females and indeterminates, if any. Total length measurements were taken of all and the percentage values of each species (both sexes together) were determined, besides noting the state of maturity of the larger individuals and whether they were impregnated or not. The data collected at West Hill, Kozhikode, before the transfer of the Unit to Narakkal, could not be used in this study (except those of a few months in 1951), since the

prawns were measured before sorting them out according to their sex. Besides determining sex ratio, the average percentage contributed by each year class or size range of each sex to the annual fishery of each species at Narakkal has also been calculated so that the relationship between the two, if any, could be elucidated.

Metapenæus dobsoni

In the backwater catches the proportion of one sex is slightly higher in 1952–53 (48·8 : 51·2) and 1953–54 (51·1 : 48·9). But the difference disappears when both years are considered together, the ratio being 50·0 : 50·0. It is reasonable to expect, though figures are not available, that the ratio will not be different for the next two years also.

TABLE I

M. dobsoni—*Actual numbers of each sex examined*

Year	All Size		Over 80 mm.		Over 100 mm.	
	♂	♀	♂	♀	♂	♀
1952	701	786	146	197	61	147
1953	577	608	219	201	99	131
1954	773	650	439	344	96	260
1955	926	769	432	228	119	136

TABLE II

M. dobsoni—*Sex ratio and percentage in total of each group*

Year	All Size		Over 80 mm.				Over 100 mm.			
	Ratio		Ratio		Percentage in total		Ratio		Percentage in total	
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
1952	47·1	52·9	42·6	57·4	20·8	25·1	29·3	70·7	8·7	18·7
1953	48·7	51·3	52·1	47·9	38·0	33·1	43·0	57·0	17·2	21·5
1954	54·3	45·7	56·1	43·9	56·8	53·0	27·0	73·0	12·4	40·0
1955	54·6	45·4	65·5	34·5	46·6	30·0	46·6	53·4	12·8	17·7

TABLE III

M. dobsoni—*Sex ratio and percentages for all four years together*

	All Size		Over 80 mn..		Over 100 mn..	
	♂	♀	♂	♀	♂	♀
Number ..	2977	2813	1236	970	375	674
Ratio ..	51·4	48·6	56·0	44·0	35·7	64·3
Percentage in total ..	..	..	41·5	34·5	12·6	24·0

In regard to the marine catches for the first two years the ratio for all sizes together, separately for each year or for both years together, shows the females preponderating by a margin of 2·6–5·8%. In the following two years, however, the numerical relationship of the sexes is just the reverse, the males exceeding by a margin of 8·6–9·2%. When the ratio is worked out for all the years together the proportion of males is slightly higher (by 2·8%).

It has been shown (1951, 1955) that prawns of this species become mature at a length of 70–80 mm. The ratios among prawns of (1) over 80 mm. in length and (2) over 100 mm. in length have also therefore been determined (*see* Tables I and II). Except in the first year (1952) the proportion of females in the first group is markedly less. For all the four years together also the disparity is quite conspicuous (12·0%; *see* Table III). The ratio among those measuring up to 80 mm., when calculated, is found to be 48·6 : 51·4, females exceeding by 2·8%. The small excess of males of all sizes together (2·8%) seems therefore to be mainly the effect of the predominance of that sex among prawns of over 80 mm. in length.

The ratio among those of over 100 mm. in length, in contrast to that of the group considered previously, shows the females much in excess, particularly in 1952 and 1954. Even for the four years together the proportion of females is strikingly high. This higher proportion is reflected in the percentage values of the sex for each year separately and for all years together. When these males and females (measuring over 100 mm. in length) are excluded from the entire group exceeding 80 mm. the proportion of males in the remainder in each year is remarkably high. In 1954 and 1955 they are approximately 4 and 3½ times as much as the females. When the total

for all the four years is made up (861–296), then also the preponderance of males is equally prominent, the ratio being 74·4 : 25·5. The results so far obtained are summarised below for convenience of reference, taking only the figures for the four years together.

	♂	♀
(*a*) Sex ratio of backwater catches	50·0	50·0
(*b*) Sex ratio of all sizes from sea	51·4	48·6
(*c*) Sex ratio of prawns from sea up to 80 mm. in length (not much more than one year old)	48·6	51·4
(*d*) Sex ratio of prawns from sea between 80 mm. and 100 mm. in length (second year of life)	74·4	25·6
(*e*) Sex ratio of prawns from sea over 100 mm. (third year class)	37·5	67·4

Assuming that the data collected during the four years, when put together, should reflect approximately the size and age composition of the annual fishery of this species at Narakkal, the following average percentage values for each age-group of each sex have been calculated.

	♂	♀
(*a*) Up to 80 mm. (first year class mostly)	58·5–65·5	
(*b*) 80 mm. to 100 mm. (second year class)	28·9–10·5	
(*c*) Over 100 mm. (third year class)	12·6–24·0	

Further consideration of these data, particularly their bearing on the rate of survival and habits of these groups would be taken up later.

Penæus indicus

P. indicus is the other species, important both in the backwater and sea fisheries. The data collected so far are yet insufficient for drawing definite conclusions in regard to its growth, duration of life, etc. It is, however, almost certain that the vast majority captured from backwaters do not exceed 120 mm. in length. Similarly most of the mature individuals examined have measured 150 mm. and over. These two size limits have therefore been made use of for determining sex ratio, percentages, etc., of marine catches on the same lines as in *M. dobsoni* and are set forth in Tables IV–VII.

TABLE IV

P. indicus—*Backwater catches, Numbers and sex ratio for each year*

	1952		1953		1954		1955	
	♂	♀	♂	♀	♂	♀	♂	♀
No. ..	498	567	2239	2204	2703	2703	3496	3556
Ratio ..	46·8	53·2	50·4	49·6	50·0	50·0	49·6	50·4

TABLE V

P. indicus—*Marine catches. Actual numbers of each sex examined*

Year	All Size		Over 120 mm.		Over 150 mm.	
	♂	♀	♂	♀	♂	♀
1952	117	164	97	137	35	61
1953	366	381	116	135	16	30
1954	592	569	456	438	172	176
1955	505	531	276	281	38	57

TABLE VI

P. indicus—*Sex ratio and percentage in total of each group*

Year	All Size		Over 120 mm.				Over 150 mm.			
	Ratio		Ratio		Percentage in total		Ratio		Percentage in total	
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
1952	41·6	58·4	41·4	58·6	82·9	83·5	36·5	63·5	29·9	37·2
1953	49·0	51·0	46·2	53·8	31·7	35·4	34·8	65·2	4·4	8·0
1954	51·0	49·0	51·0	49·0	77·0	77·0	49·4	50·6	29·0	30·9
1955	48·7	51·3	49·5	50·5	54·6	52·9	40·0	60·0	7·5	10·7

In respect of backwater catches, though slight differences are noticeable in the ratio of certain years, it is roughly 50: 50 (actually 49·7: 50·3) as in the previous species, when reckoned for the entire four years period.

In the marine catches the ratio among prawns of all sizes for each year, except 1952, does not show as much disparity as in *M. dobsoni* and for all the years together the difference in the sexes is only 2%, though it is the females that are in excess. The ratio among those of over 120 mm. for all years again shows the females exceeding by a narrow margin of 1·4%. Similarly females outnumber males among prawns of over 150 mm. in length; but the margin has increased to 10·8%.

TABLE VII

P. indicus—*Sex ratio and percentages for all four years together*

	All Size		Over 120 mm.		Over 150 mm.	
	♂	♀	♂	♀	♂	♀
Number ..	1580	1645	945	991	261	324
Ratio ..	49·0	51·0	48·8	51·2	44·6	55·4
Percentage in total	..	..	59·8	60·2	16·5	19·7

The ratios for the various groups are therefore as follows:

	♂ : ♀
(*a*) Sex ratio of the backwater catches	50·0: 50·0
(*b*) Sex ratio of the sea catches up to 120 mm.	49·3: 50·7
(*c*) Sex ratio of the sea catches between 120 mm. and 150 mm.	50·6: 49·4
(*d*) Sex ratio of the sea catches over 150 mm.	44·6: 55·4
(*e*) Sex ratio of the sea catches of all sizes	49·0: 51·0

The following are the average percentages in the annual fishery of the species:

	♂ ♀
(*a*) Percentage of those of less than 120 mm. in length ..	40·2–39·7
(*b*) Percentage of those of between 120 mm. and 150 mm.	43·4–40·5
(*c*) Percentage of those of over 150 mm.	16·5–19·7

The ratios for the first two size-groups show the sexes nearly equally represented; but that of the third group, as already pointed out, reveals a considerable margin in favour of females, similar to, though not as large as, in *M. dobsoni.*

The percentages contributed to the annual fishery by the two lower groups show only small differences. Even in regard to the higher group, though considerably less than the former, the disparity between the sexes (3·2%) is not so conspicuous as in the former species.

Parapenæopsis stylifera

This is a non-migratory species and is hardly ever caught from backwaters. Ratios, percentages, etc., have been calculated for two length-groups, representing roughly first and second year classes (Menon, 1953), the available evidence being insufficient to establish the possibility of a third year of life for the species. Tables VIII, IX and X give the data for the same four years.

TABLE VIII

P. stylifera—*Actual numbers of each sex examined*

Year	All Size		Over 80 mm.		Over 100 mm.	
	♂	♀	♂	♀	♂	♀
1952	616	436	213	245	8	78
1953	800	719	427	433	5	107
1954	192	187	112	140	1	65
1955	607	411	177	179	3	77

TABLE IX

P. stylifera—*Sex ratio and percentage in total of each group*

Year	All Size		Over 80 mm.			Over 100 mm.			
	Ratio		Ratio		Percentage in total		Ratio		Percentage in total	
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
1952	58·6	41·4	46·5	53·5	34·6	56·2	9·3	90·7	1·3	18·0
1953	52·7	47·3	49·6	50·4	53·4	60·2	4·5	95·5	0·6	14·9
1954	50·7	49·3	44·4	55·6	58·3	74·9	1·5	98·5	0·5	34·5
1955	59·6	40·4	50·0	50·0	29·1	43·5	3·8	96·2	0·5	18·7

TABLE X

P. stylifera—*Sex ratio and percentages for all four years together*

	All Size		Over 80 mm.		Over 100 mm.	
	♂	♀	♂	♀	♂	♀
Number ..	2215	1753	929	997	17	327
Ratio ..	55·8	44·2	48·2	51·8	5·0	95·0
Percentage in total	..	..	41·9	56·9	0·8	18·7

The sex ratio among all sizes for each year, except 1954, shows males preponderating quite noticeably. In the total for all the years together also males exceed by 11·6%. The same is the case in regard to the departmental collection made at West Hill from January to June 1951 (♂:♀ : : 53·2 : 46·8). The ratio among those of over 80 mm. (the size at which sexual maturity is attained) can be seen from the table.

The ratios among the three length groups can be summarised thus:

	♂	♀
(*a*) Ratio among prawns measuring up to 80 mm. ..	63·0	37·0
(*b*) Ratio among prawns measuring between 80 mm. and 100 mm. (mature, first year class)	57·6	42·4
(*c*) Ratio among prawns measuring over 100 mm. (second year class)	5·0	95·0

The average percentages contributed by these groups to the annual fishery are as follows:

(1) Percentage of group *a* .. .. .. 58·1–43·1

(2) Percentage of group *b* .. .. .. 41·2–38·2

(3) Percentage of group *c* .. .. .. 0·8–18·7

In regard to the two lower groups the males outnumber females by a fairly big margin, while in respect of the third, the proportion of males is quite insignificant. It is the first two groups, one year or less in age, that contribute to the bulk of the fishery.

Metapenæus affinis

The biology of this species has not yet been fully investigated. It has, however, been determined that sexual maturity is reached at a length of about 120 mm. and this has been made use of to calculate ratios and percentages of 2 groups, whose ages, however, are not definitely known. The data collected are set down in Tables XI–XIII.

TABLE XI

M. affinis—*Actual number of each sex examined*

Year	All Size		Over 120 mm.	
	♂	♀	♂	♀
1952	132	121	42	47
1953	259	255	20	22
1954	241	222	30	47
1955	208	263	23	29

TABLE XII

M. affinis—*Sex ratio and percentage in total of each group*

Year	All Size		Over 120 mm.			
	Ratio		Ratio		Percentage in total	
	♂	♀	♂	♀	♂	♀
1952	52·2	47·8	47·2	52·8	31·8	38·8
1953	50·4	49·6	47·6	52·4	8·0	8·6
1954	52·0	48·0	39·0	61·0	12·4	21·2
1955	44·2	55·8	44·2	55·8	11·0	11·0

TABLE XIII

M. affinis—*Sex ratio and percentages for all four years together*

	All Size		Over 120 mm.	
	♂	♀	♂	♀
Number	840	861	115	145
Ratio	49·3	50·7	44·2	55·8
Percentage in total ..	..	..	13·7	16·8

The ratio for each group for all years together is shown below:

	♂ ♀
(*a*) sex ratio among those measuring up to 120 mm. ..	50·4 : 49·6
(*b*) sex ratio among those measuring over 120 mm. ..	44·2 : 55·8

The average percentages contributed by these groups to the annual fishery are as follows:

	♂ ♀
(1) Percentage of group *a*	86·3–83·2
(2) Percentage of group *b*	13·7–16·8

In regard to this species also the bulk of the annual fishery is contributed by immature prawns.

DISCUSSION

Since the biology of *M. dobsoni* has been fairly fully elucidated it may be advantageous to review first the data presented in regard to this species. The sex ratio among the backwater population shows the two sexes evenly represented. The ratio in respect of all size-groups from the sea (for all years together) shows a slight preponderance of males (by 2·8%). But among the youngest of the three groups, *i.e.*, those measuring up to 80 mm. (mostly of the first year class) it is the females that are in excess by the same margin. It is quite likely that the vast majority of this group, as can be seen from the data on growth (1955), may have migrated into the sea form brackish water environments not long back and the small disparity may be an accidental result of this migration.

Among those measuring 80–100 mm. (in the second year of life) the proportion of males is almost thrice that of females. It is clear therefore that in the inshore area, up to about ten fathoms, exploited in the commercial fishery at Narakkal and elsewhere along this coast, there are almost three times as many males as females in this group. Is this disparity a result of mortality, natural or artificial by fishing? The percentages contributed by the three age-groups to the annual fishery show that females of the first year class exceed males by 7%. Only a small part of the disparity can therefore be attributed to fishing mortality. Since nothing is known of the occurrence of natural mortality its effects cannot be considered here.

It can however be explained, in part at least, by assuming that a good percentage of females of this age-group move out of this zone, probably into deeper waters, and reappear in the zone after about an year's sojourn outside. The sex ratio of, and the percentages contributed by, those of over 100 mm. (third year class) lend strong support to the correctness of this assumption. The ratio among the second and third year classes, caught in the commercial fishery, seems therefore significantly affected by their movements.

P. indicus.—The ratios among the somewhat arbitrarily fixed size ranges do not show such striking differences as in the previous species, though in the oldest group (measuring over 150 mm.) the females exceed by a margin of 10·8%. While the average percentages contributed to the fishery by the two sexes in the first group are approximately the same, in the second group males contribute 2·9% more and in regard to the third group the share of females is 3·2% higher. Thus the disparity in the ratio among the oldest group is not fully reflected in the percentage contribution of that group and may probably be due to the larger proportion of females (2%) in the total of all sizes examined. Is this discrepancy also brought about in part or in whole, by their movements? Further work on the problem seems to be necessary before a solution can be found.

P. stylifera.—Among prawns of all sizes the proportion of males is higher by 11·6%. So also in the two groups measuring up to 80 mm. and between 80 mm. and 100 mm. In both of them the difference is considerable. This may be either due to natural mortality at some stage of growth or due to a significant proportion of females wandering beyond the zone of fishing operations. Natural mortality by the activity of predatory fishes may not be inconsiderable among small prawns; the gut contents of such fish, which the author had opportunities to examine at West Hill, have proved it. But how it could affect one sex so heavily is difficult to imagine. It has been

established (1953) that this species moves away from the shore during the monsoon months, when salinity of the inshore waters goes down considerably, to reappear near the shore in October-November. It is likely that a good number of females do not return to the coastal waters soon after the rains have stopped; but only after varying periods of time, extending perhaps even to an year. The males, however, do not seem to share this habit of staying longer; they return and practically all are caught. This would explain the insignificantly low proportion of males among those of over 100 mm. (second year class). This is also reflected in the very low percentage (0·8) contributed by such males to the annual fishery.

M. affinis.—Of the two groups whose ratios and percentages have been determined, in the younger (up to 120 mm.), composed mostly of immature prawns, the sexes are almost evenly represented. Among older prawns, however, there is considerable disparity, females outnumbering by a margin of 11·6%. Since all of the latter may not belong to the same year class, it is possible that the predominance of females is limited to, or is more prominent in, a particular class. Before ascertaining the position in this regard the likelihood of a relationship between sex ratio and the habits of the species could not be reasonably established.

Summary

1. The sex ratio at different periods in the life of 4 species of Penæid prawns for each year from 1952–55 and for all the 4 years together has been determined.

2. In regard to 2 species, *viz.*, *Metapenæus dobsoni* and *Parapenæopsis stylifera*, whose growth and life span have been estimated, the ratios have been calculated with reference to each year class.

3. In respect of the other 2 species somewhat arbitrary size ranges, not necessarily reflecting yearly growth, have been adopted for reckoning sex ratio.

4. Great disparity in the proportion of the sexes among older prawns of *M. dobsoni* and among all but the youngest of *P. stylifera* has been noted.

5. It is suggested that movements, inshore and offshore, might partly explain how such disparity could arise.

6. Further information on growth, etc., may be required to ascertain whether the same explanation would hold good in regard to the other 2 species also.

7. The average percentages contributed by each year class or size range of each sex to the annual fishery of each species at Narakkal (each sex separately) have also been determined.

REFERENCES

Menon, M. K. 1951 .. The life-history and bionomics of an Indian prawn *Metapenæus dobsoni* Miers. *Proc. Indo-Pac. Fish. Coun.*, Section II, 80–83.

———. 1953 .. Notes on the bionomics and fishery of the prawn *Parapenæopsis stylifera* (M. Edw.) on the Malabar Coast. *J. zool. Soc., India*, 5 (1), 153–62.

———. 1954 .. On the paddy field prawn fishery of Travancore-Cochin and an experiment in prawn culture. *Proc. Indo-Pac. Fish. Coun.*, Section II.

———. 1955 .. Notes on the bionomics and fishery of the prawn *Metapenæus dobsoni* Miers, on the south-west coast of India. *Indian J. Fish.*, 2, 41–56.

Panikker, N. K. & Menon, M. K. 1955 Prawn fisheries of India. Presented at the symposium held under the auspices of Indo-Pacific Fish. Council.

Thomas, H. J. 1954–55 .. Observations on the sex ratio and mortality rates in the Lobster (*Homarus vulgaris* M. Edw.). *J. du Conseil*, **20**, 295–305.