BIOLOGY OF THE THREADFIN BREAM, *NEMIPTERUS JAPONICUS* (BLOCH)

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ABSTRACT

Nemipterus japonicus attains an average length of 150 mm in the I year; 210 mm at the end of II year; and 240 mm at the end of III year. The fishery along the Andhra-Orissa coast is supported by fish which have completed one year. November marks the commencement of spawning and *N. japonicus* may spawn for the first time at 160-170 mm and for a second time, perhaps, at 220 mm. *N. japonicus* is undoubtedly a carnivore, feeds substantially on crustaceans, molluscs, annelids and echinoderms in that order of abundance and in one of the 1,726 stomachs examined over a three year period, vegetable matter was encountered. It is actively predaceous and possibly a sight-feeder. There was a certain degree of regurgitation, particularly during the spawning period from November to March. The feeding intensity did not increase with an increase in size, but the nature of food components was size-dependent. There was a significant increase in the feeding intensity as *N. japonicus* advanced to maturity. The peak catches in the fishery coincided or followed peaks in feeding intensity.

INTRODUCTION

Simultaneous with studies on the distribution and magnitude of abundance of *Nemipterus japonicus* off the Andhra-Orissa coast (Krishnamoorthi, 1968), an investigation, extending over a three-year period from August 1964 to July 1967, was carried out to study the growth, reproduction and food and feeding habits in *N. japonicus* and the results are dealt with in the present account.

MATERIAL AND METHODS

The material was largely drawn, as in an earlier study (Krishnamoorthi, 1968), from the catches of the Govt. of India trawlers M.T. *Ashok*, M.V. *Champa* and M.V. *Sea Horse*. Though M.T. *Ashok* operated a 15 m trawl and M.V. *Champa* and M.V. *Sea Horse* operated a 14 m trawl, the mesh size of the cod end of all the trawls was similar. Hence, biological data of *N. japonicus* collected in a month from all the vessels were pooled together. Samples were obtained at weekly intervals. Though large numbers (100 specimens on an average) of *N. japonicus* were measured every week for length, fewer numbers (as indicated in the sections concerned) were used for collection of other biological data. All measurements were, made on fresh specimens. A scale of only six stages of maturity, as followed by Prabhu (1955) for *Trichiurus haumela*, was adopted in the present studies. While Prabhu (1955) did not come across stage VI in *T. haumela*, I could, on many occasions, observe *N. japonicus* in an oozing stage which, along with fish in a stage slightly more advanced than stage V, were treated as belonging to stage VI.

AGE AND GROWTH

Length frequency

A total of 6,865 specimens of both males and females of *N. japonicus* was measured during the three-year period of this investigation (1964-65: 3,147; 1965-66: 1,288 and 1966-67: 2,430 specimens). The frequency polygons at size intervals of 10 mm for the three years are presented in Figs. 1 to 3.

1964-65. There were, during this year, principally 6 modes *a, b, c, d, e* and *f* (Fig. 1), whose progression could be followed. Modes *a* and *c* could be traced only from August to October. While the former progressed from 160 mm to 180 mm the latter progressed from 150 mm to 160 mm. In other words, mode *a* moved by 20 mm in 3 months at the rate of 6.66 mm per month, and mode *c* progressed by 10 mm in 4 months at the rate of 2.5 mm per month. The mode *b* progressed by 60 mm in 10 months, modes *d* and *e* by 60 mm in 7 months and mode *f* by 50 mm in 4 months at the respective rates of 6, 8.6 and 12.5 mm per month. Thus, the size group at mode *f* had the greatest rate of growth (12.5 mm per month) and the size group at mode *c* the least rate (2.5 mm per month). Both the size groups at modes *d* and *e* had a similar rate of growth (8.6 mm per month) and the size groups at modes *a* and *b* had more or less comparable rates of growth (6.66 and 6 mm per month). Since it is known that with increase in age the rate of growth tends to fall in fishes, it could be assumed based on the rates of growth presently obtained for the various modes, that the size group at mode *f* may represent the I year class, at modes *d* and *e* the II year class, and at modes *a* and *b* the III year class. In other words, *N. japonicus* attained a size of 150 mm at the end of the I year, 230 mm at the end of the II year and 260 mm at the end of III-IV year in 1964-65.

1965-66. This year there were principally only 4 modal groups, namely, *a* (*a* and a_1), *b* (*b*, b_1 and b_2), *c* (*c* and c_1) and *d* (Fig. 2). While the mode at *d* (220 mm) in November could not be traced in the succeeding months, the progression in the rest of the modes could be followed through the months from August to July. Thus, the modal group *a* (180 mm) of August progressed to 220 mm in May, i.e., a growth of 40 mm in 10 months or 4 mm per month. The group *b* which appeared in September at 150 mm progressed to 200 mm in July i.e., a growth of 50 mm in 11 months or 4.5 mm per month. The group *c* at 100 mm in September progressed to 170 mm in July and had a growth of 70 mm in 11 months or 6.4 mm per month. Extending the same arguments as for the modes of the previous year, the group *c* may be considered as the I year class because it had the highest

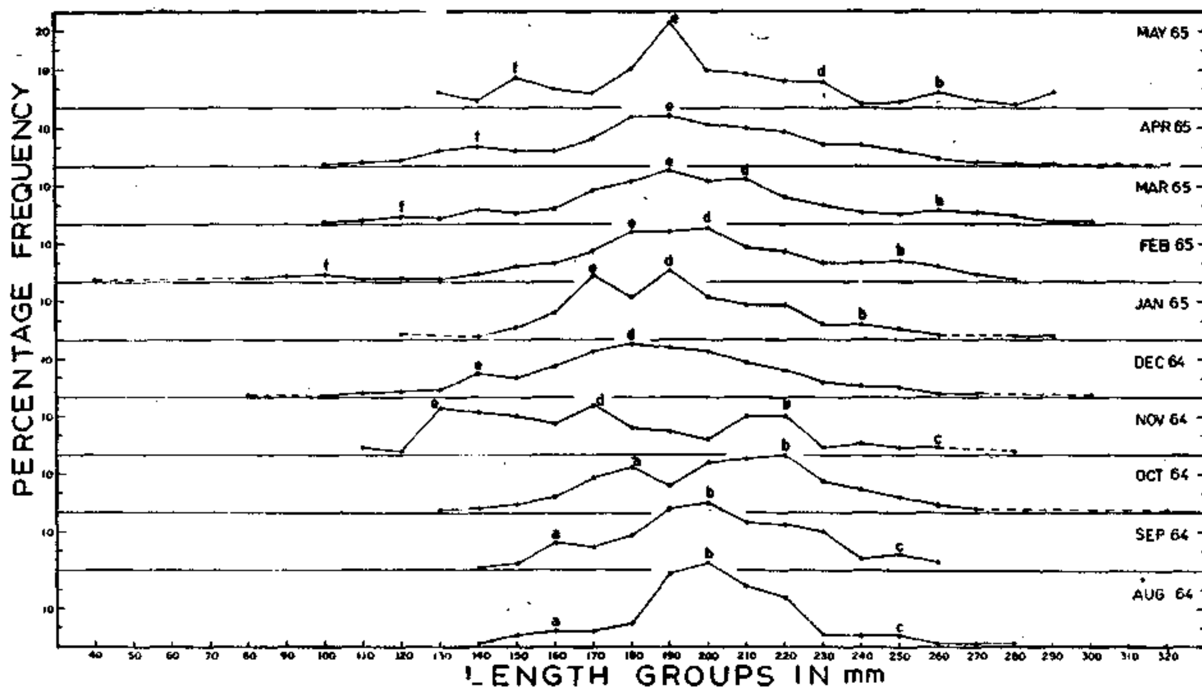

FIG. 1 Length frequency distribution in *N. japonicus* during the various months of the year 1964-65.

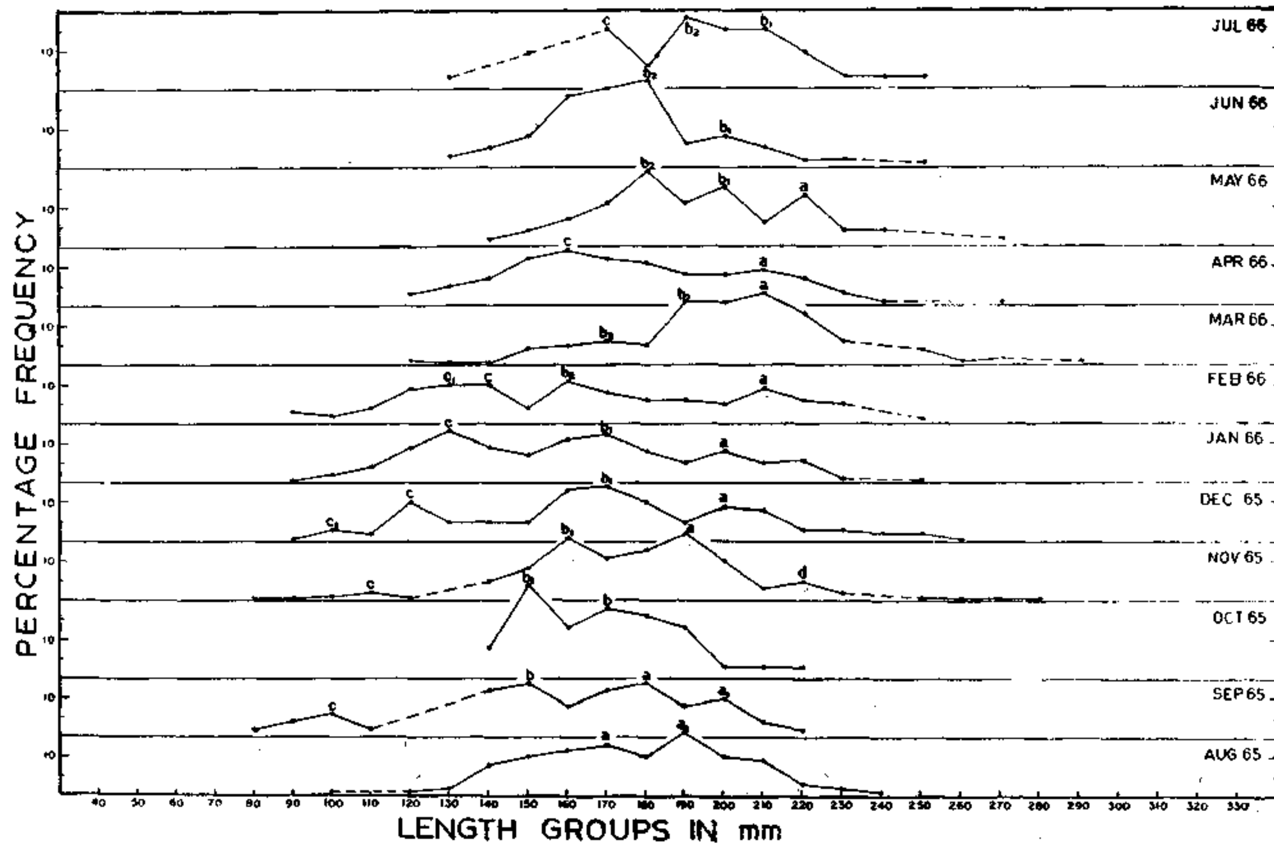

FIG. 2 Length frequency distribution in *N. japonicus* during the various months of the year 1965-66.

(6.4 mm per month) growth rate, the group *b* as the II year class which had a growth rate of 4.5 mm per month, and the group *a* as the III year class since it had the least rate of growth (4 mm per month). Compared to the previous year's, the rates of growth obtained in the present year were less.

1966-67. This year also there were principally 4 modal groups, viz., *a* (*a* and a_1), *b* (*b* and b_1) *c* and *d* (Fig. 3). While the progression of modal group *a* and *c* could be followed from August to May, the group *b* could be traced from August to June only. The mode *d* at 120 mm-fresh recruits to the fishery perhaps-appeared in February and progressed to 140 mm in May, i.e., a growth of 20 mm in 4 months at a rate of 5 mm per month. The growth rates of the other modal groups *a*, *b* and *c* respectively were 5, 3.3 and 3 mm per month; and based on these growth rates they respectively represent the I, II and III year classes in the fisheries for *N. japonicus.* The sizes reached at the end of I, II and III years, being 140, 220 and 250 mm, were comparable with those obtained during 1964-65.

Reviewing these studies, it may be said that *N. japonicus* attains an average size of 150 mm in its I year (140-170 mm), 210 mm (200-230 mm) at the end of its II year, and 240 mm (220-260 mm) at the end of its III year. Ben-Tuvia (1968) has reported a size of 130 mm for a fish of 'O' year class and 170 mm for one-year-old *N. japonicus* obtained in the trawl catches in the South Red Sea along the Ethiopian Coast. Sizes of 110-170 mm (mean: 140 mm) for 1 year old, 170-250 mm (mean: 230 mm) for 2 year old, and 290-300 mm for 3 year old males of *N. virgatus* from the South China Sea have been reported (Eggleston, 1970). Eggleston (1971) reports also the mean sizes of the males of *N. bathybus* as follows: 1 year - 120 mm., 2 year - 150 mm, and 3 year - 190 mm. The present results obtained for 1 and 2 year olds are more or less comparable with those reported for *N. virgatus*, though the average size presently obtained for the 3 year olds (240 mm) is much less than the range (290-300 mm) given by Eggleston (1970). From the studies of Ben-Tuvia (1968), it is not known which year class contributes most to the *N. japonicus* fishery along the Ethiopian Coast although the 'O' year class (13 cm) and 1 year class (17 cm) were represented in the catches. But the trawl catches for *N. virgatus* in the South China Sea are based mainly on fish in their second or third years of life (Eggleston, 1970). In the present studies, there is only one prominent mode each year (Fig. 3B), 180 mm in 1964-65, 170 mm in 1965-66, and 190 mm in 1966-67. Since *N. japonicus* may attain an average size of 150 mm in its I year, the *N. japonicus* fishery along the Andhra-Orissa coast appears to be supported by fish in their second year.

Growth parameters

The sizes attained at different ages (see previous section) by *N. japonicus* during each year of this study, were separately used and fitted, by the method of least squares, to Von Bertalanffy's (1938) growth equation:

$$L_{(t+1)} = L_{\alpha}(1-e^{-k}) + L_t e^{-k}.$$

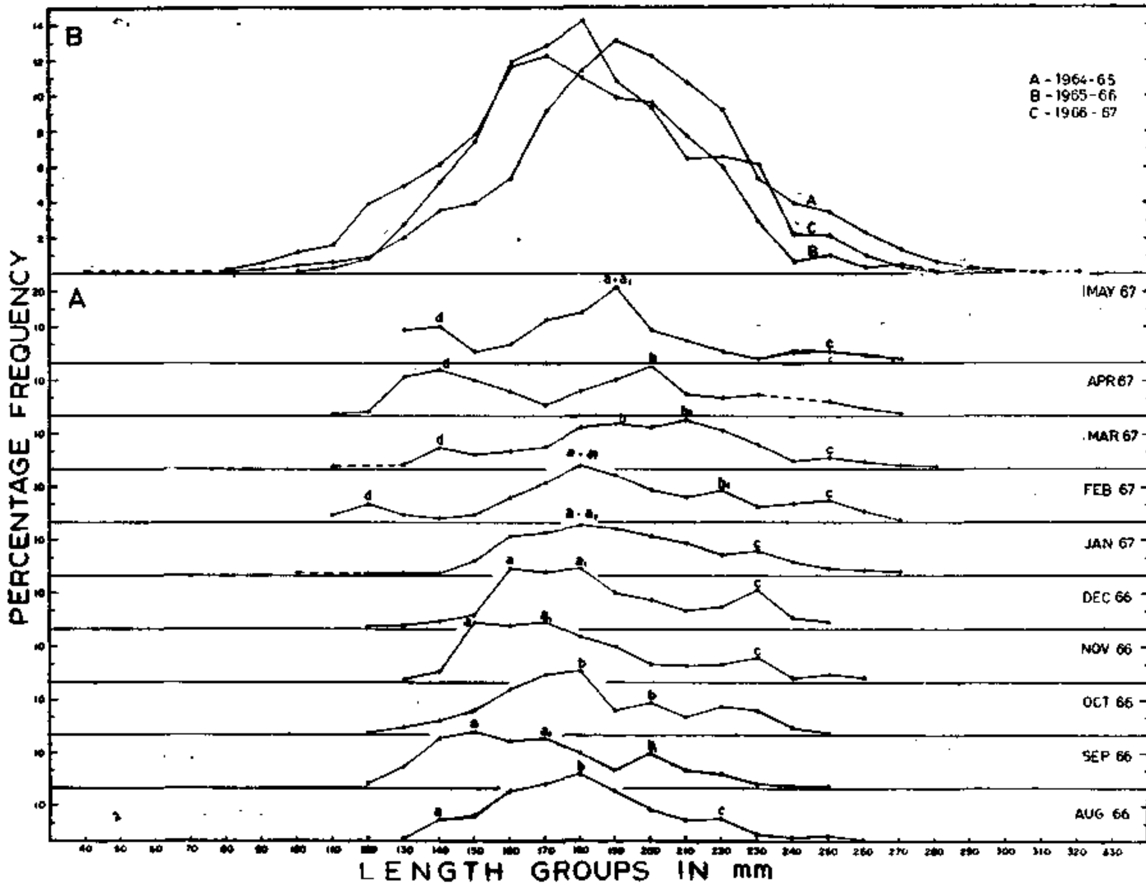

FIG. 3 Length frequency distribution in *N. japonicus* during the various months of the year 1966-67 (A) and for the three-year period (B).

which is of the form Y=a+bX. The *K* and $L\alpha$ values obtained during the different years of this study were as follows:

	1964-65	*1965-66*	*1966-67*
K	0.3141	0.6480	0.2941
$L\alpha$	305.43 mm	208.70 mm	302.63 mm

Excepting in 1965-66, the *K* values in the other years are comparable and may be the true values for *N. japonicus*, since samples of *N. japonicus* in sizes corresponding to estimated maximum attainable size (L_α) have been obtained in the trawler catches off Andhra-Orissa Coast. In fact stray specimens of *N. japonicus* measuring 350 mm* were recorded in 1964-65. The high *K* value in 1965-66 is a departure and needs to be explained. This year the demersal fisheries failed in general (Sekharan *et al.*, 1968); and, particularly, the fall in *N. japonicus* fishery, may have resulted from the extension into the seas around India of conditions of 'drought' that hit the peninsular India that year (Krishnamoorthi, 1968). Such environmental changes in turn may have brought about a departure in the *K* value. Since it is known that the higher the *K* value, the longer the time taken to reach the maximum attainable length (L_α), it may perhaps explain the low value of L_α (208.70 mm) obtained in 1965-66.

Based on the Bertalanffy's constants for 1964-65, the year when lengths at ages were maximum, 't_o' was calculated from the formula (Beverton and Holt, 1957 and Ricker, 1958):

$$l_t = L_\alpha (1 - e^{-k(t-t_o)})$$

which, rearranged, gives

$L_\alpha - l_t = L_\alpha e^{-k(t-t_o)}$, whose logarithmic transformation log $(L_\alpha - l_t) = (\log L_\alpha + kt_o) - kt$, is a linear equation, the regression having slope $-k$ and intercept $\log L_\alpha + kt_o$. A value of -1.1079 for 't_o' was obtained. The lengths at ages 1 to 3 calculated from these values are plotted in Fig. 4.

LENGTH-WEIGHT RELATIONSHIP

The data of lengths and weights (ungutted) of individual fish collected during 1964-65 only were utilised and fitted, by the method of least squares, to the formula $W = aL^b$, or $\log W = \log a + b \log L$, where W = weight, L = length and *a* and *b*

* This incidentally is the largest size recorded so far for *N. japonicus*. The largest specimen (male) reported from the South China Sea measured only 290 mm (Eggleston, 1971); the largest from the Ethiopian Coast was only 230 mm (Ben Tuvia, 1968).

are constants. The length-weight relationship for males and females were studied separately and they respectively were:

Males: $W = 0.001752L^{2.0769}$ or

$\log W = -2.7565 + 2.0769 \log L.$

Females: $W = 0.0000183L^{2.9423}$ or

$\log W = -4.7375 + 2.9423 \log L.$

The significance of the difference between the *b* values for males and females was tested by analysis of covariance (Snedecor, 1956). The differences were highly significant at 5% level (Table 1) and hence a single equation to describe the length-weight relationship for the males and females is not justified for *N. japonicus*. This is in conformity with the findings for *N. virgatus* (Eggleston, 1970).

TABLE 1. *Analysis of covariance*

Sex	Degrees of Freedom	Regression Coefficient (b)	d.f	Deviations from Sum of squares	Regression Mean square	'F' Value
Males	412	2.076902	411	1.1093		
Females	308	2.942303	307	0.5378		
Within			718	1.6471	0.00229441	
Diff. due to Reg. Coeff.			1	1.1748	1.1748	512*
Common	720		719	2.8219	0.00392526	
Adjusted Means			1	0.1525	0.1525	39*
Total	721		720	2.9744		

* Highly significant @ 5% level.

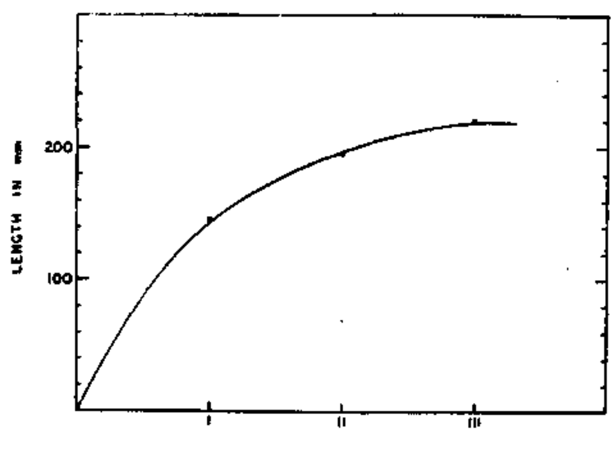

FIG. 4 Theoretical growth curve of *N. japonicus*.

Relative Condition Factor

The formula $K_n = W/\hat{W}.100$ where K_n = Relative condition factor, W = observed weight, and $\hat{W}$ = Weight calculated from the equation for length-weight relationship suggested by Le Cren (1951) has been used. In the present study only females have been considered and data for only one year (1964-65) presented. The average relative condition factor through the various months of the year are presented in Fig. 5 and in relation to size in Fig. 6. There was a building up of

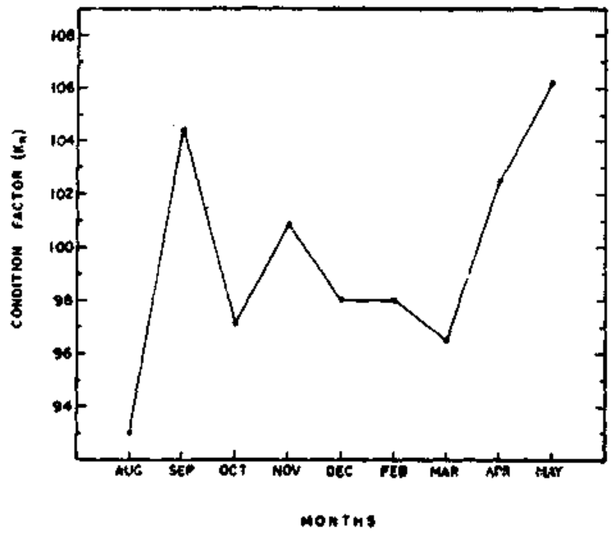

FIG. 5 Mean Kn values during various months.

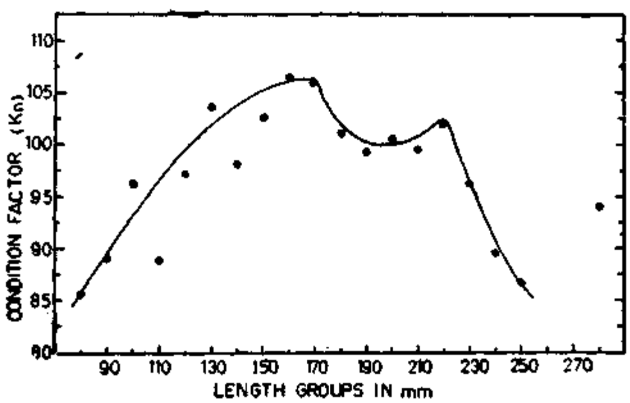

FIG. 6 Mean Kn values in relation to size.

fatness of the fish up to November followed by an abrupt and steep fall in the subsequent months (Fig. 5). Since such a fall is indicative of the onset of spawning, November may mark the commencement of spawning in *N. japonicus*. There was a building up of fatness up to a size of 160-170 mm and for a second time up to 220 mm, though the second peak was not as high as the first peak (Fig. 6). Extending the previous argument, it may be said that *N. japonicus* spawns for the first time at a length of 160-170 mm and perhaps for a second time at 220 mm.

SPAWNING

Minimum size at first maturity

For this study, too, only females were sampled and data for 1964-65 only considered. A sample of 100 to 150 specimens was examined every month and the number of maturing and mature (stages V and VI) specimens were noted in each 10 mm interval size group, and scaled down to percentages. The results are presented in Fig. 7. The rate of increase in the percentage of mature and maturing fish was high up to the size group of 220 mm (95% of the fish mature); above 220mm all were mature. The minimum size at first maturity (50% of the fish mature) was 165 mm which was corroborative of the earlier observation drawn from the studies on the relative condition factor in relation to size.

Period of spawning

As in the earlier studies, the data collected in 1964-65 only are presented here since observations in this year could be made in most months of the year. Also, only females have been considered. On an average 30 specimens were examined each month except in August and January when *N. japonicus* were poor in

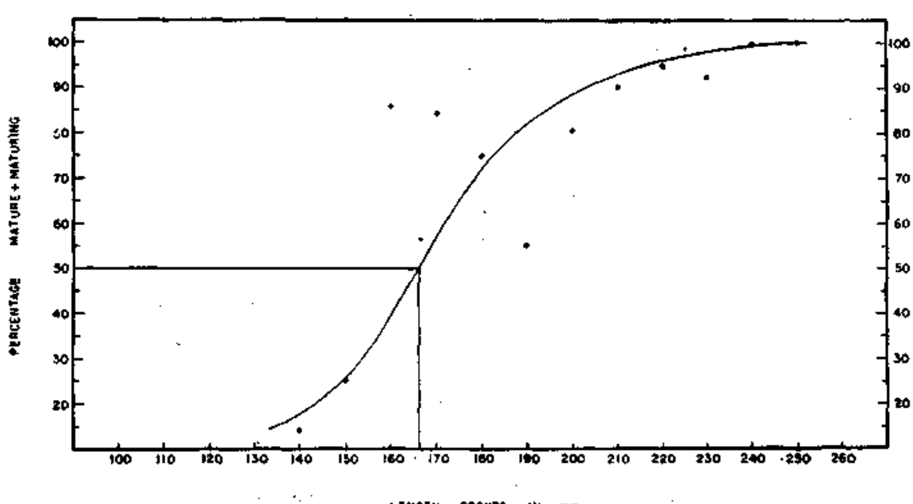

FIG. 7 Percentage frequency distribution of mature and maturing individuals in relation to size to show the minimum size at first maturity.

trawler catches. Specimens in stage VI were available from September to November only, and the occurrence of fish in stages IV to VI was high during the same period (Table 2). This indicates September-November as the probable period of spawning for *N. japonicus*. The peak relative condition factor noticed earlier in September is probably the result of the occurrence of *N. japonicus* in stage VI in high numbers during that month. While *N. japonicus* has an extended period of spawning from May to October in the South China Sea (Eggleston, 1971), in the tropical waters of India it is only for three months from September to November. Also the present finding confirms the earlier conclusion obtained from studies on the relative condition factor in relation to seasons.

TABLE 2. *The percentage frequency distribution of maturity stages in various months of the year 1964-65.*

Month	Total No. of fish examined	Maturity stages					
		I	II	III	IV	V	VI
Aug. 64	9	11.1	22.2	55.6	11.1		
Sep. 64	30			3.3	66.7	16.7	13.3
Oct. 64	33				72.7	24.3	3.0
Nov. 64	43		2.4	4.6	16.1	74.5	2.4
Dec. 64	32		6.2		25.0	68.8	
Jan. 65	7			14.3	85.7		
Feb. 65	32				62.5	37.5	
Mar. 65	35	2.9	11.4	71.4	14.3		
Apr. 65	42	11.9	45.2	42.9			
May 65	28	50.0	35.7	14.3			
June & July 65				No observations			

FOOD AND FEEDING

The results presented here are based on examination of samples collected from two contiguous latitude zones 17° 40' N and 18° 10'N off Visakhapatnam. The lengths (both standard* and total** length) in millimetres, the weight (with gut) in grams, sex and the stage of maturity were noted in the fresh specimens, then the stomachs were collected and preserved entire in 5% formaldehyde solution. A stomach was not examined until after a lapse of one month to allow for uniformity in preservation for it is known that formalin could bring about changes in biological material preserved in it (Parker, 1963).

* from the tip of the snout to the base of the Caudal fin.

** from the tip of the snout to the tip of the lower lobe of the caudal fin.

To evaluate the relative importance of the food items present the method followed was essentially similar to the points (volumetric) method (Hynes, 1950). The number of points gained by each item of food was summed up for each month and scaled down to percentages of the grand total of points gained by all the items of food. The relative abundance of each food item in the individual stomach was assessed by obtaining their volume instead of their weight although the latter could also be obtained easily since the food items were few in number and large enough for easy separation. The total volume alone is considered here and was obtained by the displacement method.

During the period extending over three years (August 64 to July 67) of this investigation, a total of 1,726 stomachs collected from fish ranging in size from 80 to 320 mm was examined.

Items of food

The food of *N. japonicus* is composed of 11 items excluding the 'digested matter' (Fig. 8), the invertebrates predominating. Among the invertebrate groups crustaceans formed the major item of diet with molluscs, annelids and echinoderms

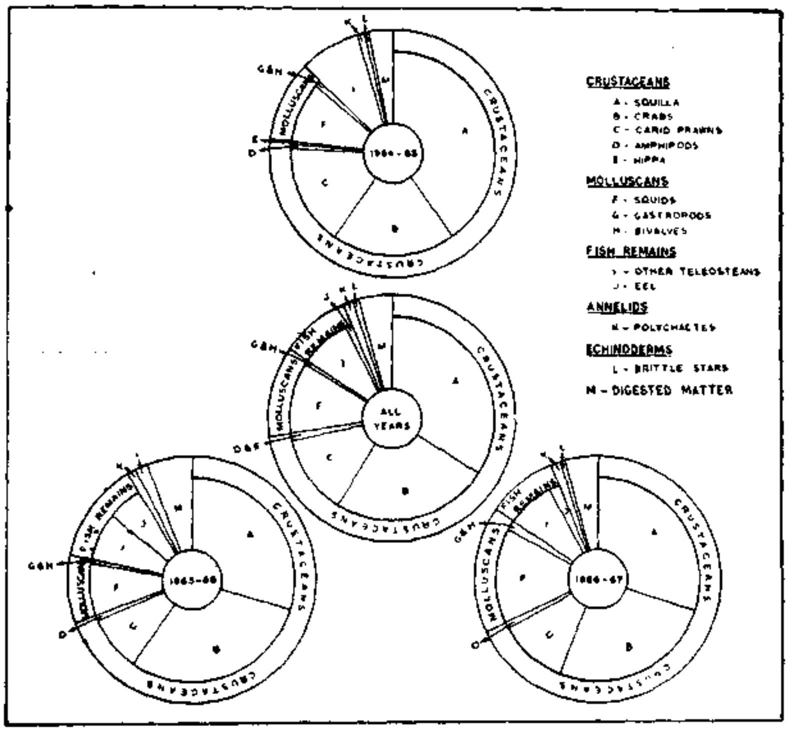

FIG. 8 Yearly percentage contribution of the various items of food during 1964-65, 1965-66, and 1966-67.

following in that order of abundance. Among the crustaceans, *Squilla*, crabs and carid prawns were the major components, amphipods and *Hippa* hardly contributing 1% each in any year. Among the molluscs contribution of the squids was by far greater than that of the gastropods or the bivalves. The 'other teleosteans' consistently took the fourth rank in all the years of this study. Young eels were encountered, but their contribution, like that of *Hippa* and the amphipods, was just 1.2% *N. japonicus* fed upon annelids (mostly polychaetes) and echinoderms (chiefly brittle-stars) also, but they hardly seemed of any importance as an item of food. Unidentifiable 'digested matter' was more considerable in the year 1966-67 than in the other years. Thus, it became apparent that the chief items of food of *N. japonicus* were *Squilla*, the crabs, the carid prawns, the squids and the 'other teleosteans' in that order of abundance and only these items of food are considered hereafter in detail. The rest of the items could at best be considered as occasional inclusions.

Seasonal variations

Squilla— This item had two major peaks, in August and March, and a minor peak in January, 1964-65 (Fig. 9A). In 1965-66 when *N. japonicus* could be obtained only from November to July, the trend was characterised by a peak in May and fall in April. During 1966-67, the trend of contribution of *Squilla* was in general similar to that observed in the year 1964-65. It may, thus, be concluded that *N. japonicus* fed regularly on *Squilla* all through the year and rather intensively during the summer months of March to August.

Crabs— In 1964-65, the crabs had two peak months of abundance, viz., December and April (Fig. 9B). The trends were in most respects similar in the following two years. When the trends of *Squilla* and the crabs are compared, it is apparent that those months marked by a fall in the contribution of the former were marked by an increase in the contribution of the latter.

Carid prawns— The seasonal variations of the carid prawns in the diet of *N. japonicus* are shown in Fig. 9C. In both 1964-65 and 1965-66, the carid prawns had two peak months of abundance, in 1966-67, there were three. When the trends of the contribution of the crabs and the carid prawns were compared, it became apparent that the months of good contribution of crabs were marked by low contribution of the carid prawns and *vice versa*.

Squids— Though the contribution of the squids to the diet of *N. japonicus* was as much as that of the carid prawns the trend of contribution of the squids was characterised, in any year, by a single peak of abundance (Fig. 9D). The two additional peaks noticed in August '66 and April '67 are perhaps departures peculiar to that period. The trends of the crabs and the squids appeared more or less similar in nature, but opposite to that of the *Squilla*.

'Other Teleosteans'— The share of this item in the diet of *N. japonicus* (7.7%) was poor compared to others (Fig. 9E). While there were two peaks of abundance

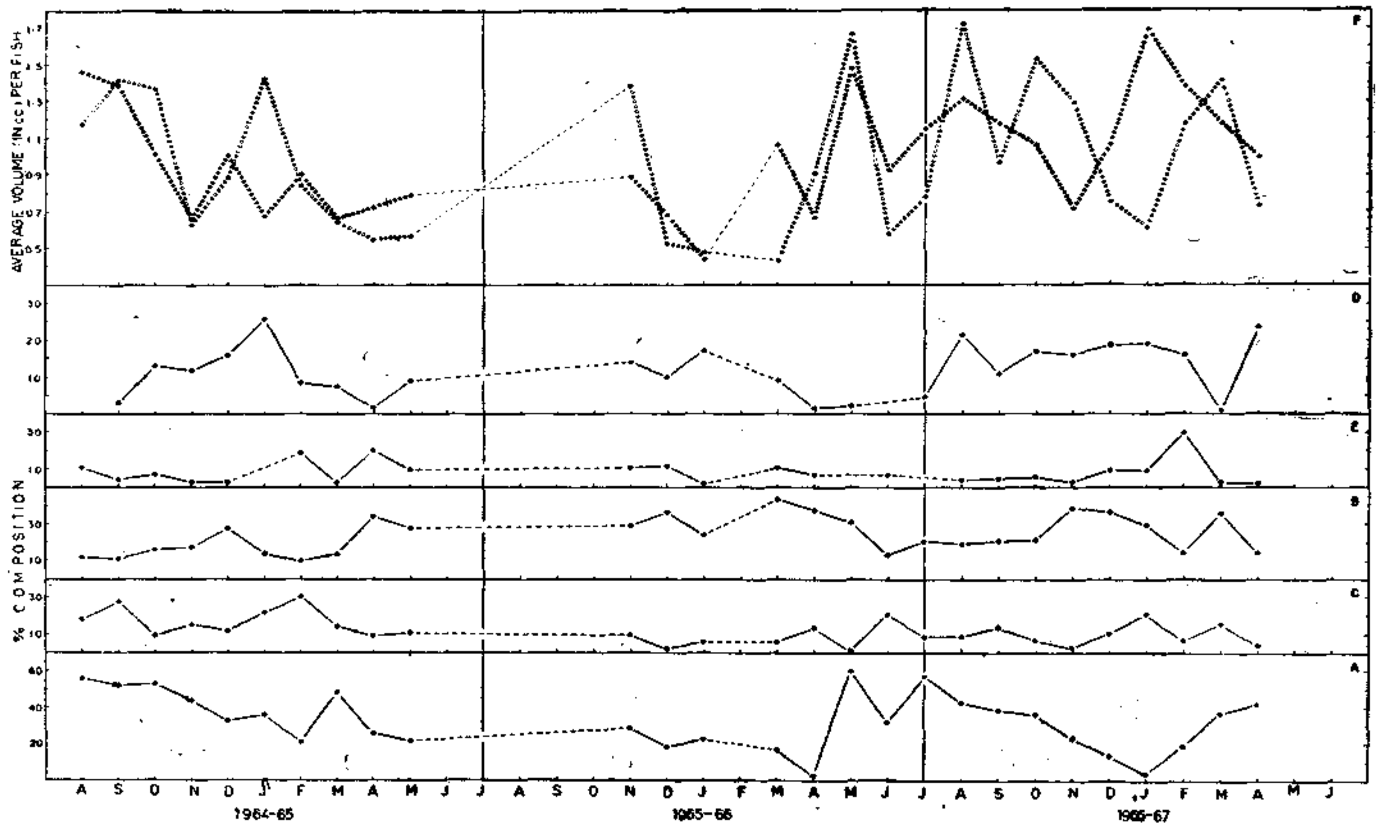

FIG. 9 Seasonal variations in terms of percentage contribution of the more important food items viz., *Squilla* (A); Crabs (B); Carid Prawns (C); Squids (D); and Fish Remains (E); of the feeding intensity (F); in males (solid circles) and females (open circles) during the years 1964-65, 1965-66 and 1966-67. Broken lines indicate discontinuity in the data.

in 1964-65 and one in 1966-67 no appreciable peak period of abundance was discernible in 1965-66.

Feeding intensity

Both sexes— The annual average feeding intensity ranged from the lowest (0.86 ml per stomach) recorded in 1964-65 to the highest (1.13 ml) observed in 1966-67, the year 1965-66 with a feeding intensity of 0.87 ml per stomch ranked between the two. In an annual cycle, the monthly average ranged from 0.64 ml (November) to 1.40 ml (September) in 1964-65, from 0.47 ml (January) to 1.49 ml (May) in 1965-66, and from 0.89 ml (April) to 1.41 ml (August) in 1966-67. Thus, the feeding intensity in *N. japonicus* was lowest during the winter months, followed by an increase in the succeeding months to reach the highest value during the summer months (Fig. 10B).

Males— The average monthly feeding intensities ranged from 0.65 ml (November) to 1.46 ml (August) in 1964-65 and from 0.44 ml (January) to 1.48 ml (May) in 1965-66 (Fig. 9F). In 1966-67 however, the values were higher, ranging 0.71 ml (November) - 1.69 ml (January).

Females— The average monthly feeding intensities (Fig. 9F) ranged from 0.55 ml (April) to 1.42 ml (September) in 1964-65, from 0.43 ml (March) to 1.66 ml (May) in 1965-66, and from 0.73 ml (April) to 1.72 ml (August) in 1966-67.

Generally in any particular month the feeding intensity was more in the male than in the female.

In relation to size— For this study data collected during 1964-65 alone were considered since, as indicated earlier, the maximum number (768) of stomachs was examined, during this year, and most size groups were represented in these samples. From the frequency table (Table 3) it may be seen that the average volume of food per fish, when the Empty (E) and Everted (Ev.) are included, ranged from 0.66 ml observed in the size group of 120 mm to 1.04 ml recorded in the size group of 270 mm. When the E and Ev. are excluded, the average ranged from 0.73 ml in the 140 mm size-group to 1.16 ml in the 270 mm size group. In terms of average number of points per fish also, a similar trend could be seen. In other words, the range in the feeding intensity in terms of volume or points per fish was so narrow that it could almost be considered as uniform over the entire range (120 mm to 270 mm) of size groups considered. It may, therefore, be concluded that in *N. japonicus*, feeding intensity is not related to the size of fish. In order to judge the reliability of this conclusion, a χ^2 test was conducted. A χ^2 value of 34.87 with 28 d.f. was obtained. Since this value (34.87) is less than the table value (41.34) at the 5% level of significance, it may be concluded that the earlier conclusion that size and feeding intensity are not related in *N. japonicus* is tenable and consistent.

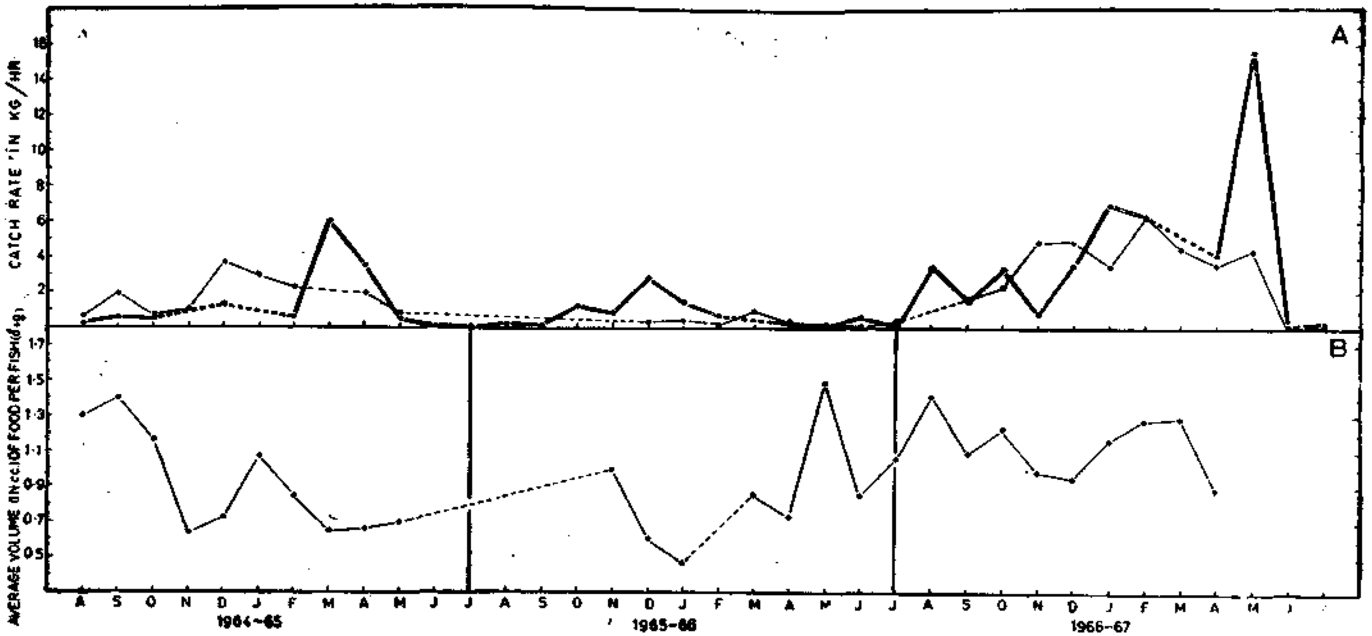

FIG. 10 Seasonal variations in the feeding intensity (B) of females and males considered together and (A) the catch rate of M.T. *Ashok* (double line) and M.V. *Champa* (single line) during the years 1964-65, 1965-66 and 1966-67. Broken lines indicate discontinuity in the data.

TABLE 3. *Frequency occurrence of stomachs in various degrees of fullness and the average volume of food per fish and number of points per fish in relation to size in* N. japonicus.

Size Group	No. of stomachs observed in degrees of fullness								Average volume of food (in ml) per fish		Total	No. of Points Average per fish	
	E	Ev	1/4	1/2	3/4	F	G	Total	Including E & Ev	Excluding E & Ev		Including E & Ev	Excluding E & Ev
80			2					2	0.25	0.25	10	5.0	5.0
90	1			1	1			3	0.51	0.77	25	8.3	12.5
100	1		4		1	1		7	0.47	0.55	55	7.9	9.1
110		1	1	2	1	1	1	7	0.91	1.07	85	12.1	14.2
120	1			1	2	3		7	0.66	0.77	100	14.3	16.7
130	1		1	5	4	2	1	14	0.88	0.95	180	12.9	13.8
140		1	7	6	4	2	1	21	0.69	0.73	220	10.5	11.0
150	4	1	4	9	2	11	2	33	0.88	1.03	410	12.4	14.6
160	1	1	12	4	8	14	4	44	0.97	1.01	600	13.6	14.3
170	4	3	15	9	20	11	4	66	0.80	1.00	785	11.9	14.8
180	7	2	24	14	8	17	5	77	0.76	0.86	845	10.9	12.4
190	6	7	15	18	23	20	10	99	0.90	1.04	1250	12.6	14.5
200	7	6	29	13	21	21	12	109	0.89	1.01	1295	12.2	13.9
210	7	2	23	19	11	20	9	91	0.87	0.96	1095	12.0	13.4
220	3	2	19	12	12	11	8	67	0.88	0.95	815	12.2	13.1
230	2	1	10	8	2	9	5	37	0.94	1.03	465	12.6	13.7
240	1	1	12	9	3	6	1	33	0.68	0.72	340	10.3	10.9
250			6	3	3	3	2	17	0.91	0.91	215	12.6	12.6
260	2	1	5	4	1	5	1	19	0.75	0.89	205	10.8	12.8
270	1		2	1	3	1	2	10	1.04	1.16	135	13.5	15.0
280			1		1		1	3	1.25	1.25	45	15.0	15.0
290								0					
300							1	1	2.60	2.60	25	25.0	25.0
310								0					
320						1		1	1.39	1.39	20	20.0	20.0
Total	49	29	192	138	131	159	70	768			9220		
Ave. vol of food per fish in ml	0	0	0.250	0.63	0.90	1.39	2.60						

E- Empty; Ev - Everted

In relation to maturity— For this study, only females were considered since the stage of maturity among the males could not be decided with certainty even after a microscopic examination of the gonads. It is seen from Table 4 that in terms of average volume of food per fish and of average number of points per fish, there is an increase in the feeding intensity with increasing stages of maturity. As in the previous study, a χ^2 test was conducted and a χ^2 value of 43.02 was obtained.

Since this value is less than the table value of 43.77 with 30 d.f. at 5% level of significance, there seems to be some relation between the two.

TABLE 4. *Number of stomachs observed in different degrees of fullness and average volume of food per fish/number of points per fish in relation to various stages of maturity in* N. japonicus.

Stage of Maturity	No of stomachs observed(expected) in degrees of fullness								Average volume of food (in ml.) per fish		No. of Points		
	E	Ev	1/4	1/2	3/4	F	G	Total	Including E & Ev	Excluding E & Ev	Total	Average per fish Including E&Ev	Average per fish Excluding E&Ev
I	3	1	7	2	5	3	—	21	0.56	0.59	190	9.0	11.2
II	5	2	10	6	7	5	2	37	0.67	0.82	365	9.9	12.1
III	4	3	22	9	8	7	3	56	0.64	0.73	535	9.6	10.9
IV	5	—	18	15	17	26	11	92	1.20	1.08	1290	14.0	14.8
V	6	—	21	9	17	16	10	79	0.94	1.02	1020	12.9	14.1
VI	—	—	—	1	1	4	—	6	—	1.18	105	17.5	17.5
Total	23	6	78	42	55	61	26	291	0.85	0.95	3505		
Average vol. of food in ml	—	—	0.25	0.63	0.90	1.39	2.60						

Food components in relation to size

It was stated earlier that *N. japonicus*, fed upon four or five major groups, and even among these the same component, was not fed upon all the time through a year's cycle. Therefore, to ascertain whether or not a relaton existed between the various components encountered in the stomachs of *N. japonicus* and the size of the fish, the total number of points gained by each food component was studied against the respective size group. Since the same number of stomachs have not been examined in each size group, to make the data from these amenable for comparison or for statistical treatment, the total points gained by each food component was scaled down to five stomachs in all those size groups where more than five stomachs had been examined and the rest of the size groups were ignored. Also not considered are food components such as *Hippa*, gastropods, bivalves and echinoderms since they were hardly of any importance in the diet of *N. japonicus*. Based on a table thus prepared with the total number of points scaled down to 5 stomachs against the size groups, a test was applied against the null hypothesist (H_0) that size and nature of food taken are not dependent. Since the χ^2 value of 5.74 was greater than 1.96 at the 5% level of significance (the sample being large), H_0 was rejected and it could, therefore, be concluded that size and nature of food in *N. japonicus* are dependent.

DISCUSSION

N. japonicus is, as these investigations have revealed, a carnivore feeding substantially on crustaceans, molluscs, annelids and echinoderms, and none of the 1,726 stomachs examined over a three-year period, revealed any vegetable matter in them. This observation is in accordance with that of Rao (1964) who examined stomachs of *N. japonicus* collected during various periods of a 24 hour cycle. Furthermore, the array of food components such as *Squilla*, crabs, carid prawns, squids and teleostean fishes which are actively moving animals, indicates that *N. japonicus*, like most perches (Job, 1940), is actively predaceous, perhaps also a sight-feeder.

The present observations on relative importance of some food components differ from some of the earlier accounts. According to Rao (1964) *Squilla* did form a part of the diet of *N. japonicus* but in low percentages 2.9% in the forenoon, 2% in the noon and 3.7% in the afternoon — and they were absent in specimens collected during night. The contribution of *Squilla* according to the present studies, however, was as high as 39.3% in 1964-65 and 29.4% in 1965-66. The low contribution of *Squilla* as obtained by Rao, may be due to geographical differences since his material was largely from the northern fishing grounds of the region between Waltair and False Point (Rao, personal communication).

Another difference from the observations of Rao (1964) is that in none of the 1,726 stomachs examined, planktonic organisms like copepods, euphausids, fish and bivalve larvae, cypris and magalopa stages etc., were met with. As their contributions were low, it is possible they were secondary inclusions. Otherwise it suggests the possibility that *N. japonicus* resorts to a certain degree of column feeding. The present investigations show *N. japonicus* to be a bottom feeder not only because the food includes, in fairly large quantities, purely bottom dwellers but also since the gill-basket in *N. japonicus* lacks the sieve-like straining mechanism which is characteristic of plankton feeders. Even the dispostion of the mouth is more suited for browsing and pecking off food from the gound. All the evidences are in favour of judging *N. japonicus*, like the perch *Epinepheulus tauvina* (Job, 1940), to be more a bottom feeder than a column and/or particulate feeder, and also primarily carcinivorous, turning to a molluscan (chiefly cephalopod) diet when the crustaceans are perhaps not available.

One of the objectives of the present investigations was to apply the knowledge gained on the food and feeding in *N. japonicus* for providing a credible basis to understand the observed fluctuations in the abundance of the fisheries for *N. japonicus* off the Andhra-Orissa coast (Krishnamoorthi, 1968). A comparison of the trends of fluctuations in the average volume of food (in ml)/stomach (Fig. 10B) with those of the catch rates in kg/hr (considered here as a measure of apparent abundance) obtained from the catches of the trawlers M.T. *Ashok* and M.V. *Champa* (Fig. 10 A), showed that in the years 1964-65 and 1966-67 there were two peaks each and one peak in 1965-66 both in the feeding intensities and in the catch rates.

Either the peaks in the feeding intensity coincided with the peaks in the catch rates as in September 1964 or August-September 1966, or the peak catch rates followed the peak feeding intensities, as in January 1965, November 1965 and March 1967, with a time lag of one month or at the most two months. Although there is thus some reason to believe that in *N. japonicus* food exerts an influence on fish abundance more evidence is required.

In *N. japonicus* there was a certain degree of regurgitation, but it hardly amounted to any high proportion, as in *P. diacanthus* (Rao 1963), the maximum recorded being only 14% in March, 1966.

In some fishes, there is a change in the composition of the diet as the fish grows in size, (Hynes, 1950 and Rao and Rao, 1957). In *N. japonicus*, while feeding intensity did not increase with increasing size, the nature of food components was size-dependent. The feeding intensity, however, was found to increase as the fish advanced to maturity as in *G. aculeatus* (Hynes, 1950).

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