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BIOLOGY, AGE, GROWTH AND POPULATION DYNAMICS OF THREADFIN BREAM *NEMIPTERUS JAPONICUS* *

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ABSTRACT

The family Nemipteridae forms an important component of the demersal fish catches in the Arabian Gulf and especially in Kuwait. Three species of *Nemipterus* have been reported to occur in the Arabian Gulf, but only two species are known from Kuwait waters, *Nemipterus japonicus* and *Nemipterus tolu*. Single species assessment was carried out on *N. japonicus* which is one of the more important and abundant species in Kuwait's trawl fishery.

Nemipterus sp., locally known as Bassi form 11-18% by weight in the by-catch category of finfish landed by the Industrial trawlers in Kuwait. *Nemipterus japonicus* were collected from the Research Vessel trawl catches in Kuwaiti waters during 1979-1985. Age determinations were made on whole sagittal otoliths in young and on sections in older and bigger fish during 1984-1985. Growth curves were obtained from the age at length data. Growth parameters obtained for males and females were L 30.3 cm (TL), K. 0.542, t 0.19 and L 26.5 cm (TL), K 0.595 to 0.03 respectively. Age varied from 0-6 years and length varied from 5-31 cm. The growth rate in males were faster than in females. The length-weight relationships for males and females were obtained and were significantly different at 1% level. Condition factor (Kn) values for different months of the year for females were calculated and suggest that two spawning periods, March-May and September-October. Total mortality (Z) estimated from the age composition of the sample gave a value of 0.873 (P 0.001) and 0.802 (0.01 p 0.001) for 1984 and 1985. Natural mortality (Z) estimated by the method of Pauly (1980) was higher than total mortality (Z). No method applied so far, provided the estimates of F and M needed for accurate stocks assessment of *N. japonicus*.

INTRODUCTION

THE COMMERCIAL fish resources of the Arabian Gulf comprise, like other tropical areas, a large assemblage of species with no single species or group being dominant. Such a diverse resource base makes it difficult to assess and manage the multispecies stocks in these areas. Landing statistics are available for some commercially important demersal and pelagic fish landed in Kuwait from 1980-1984 (Morgan, 1981 ; Baddar and Morgan, 1983 ; Hakim *et al.*, 1983, 1984, 1985). These fishes were caught mainly by fish traps (gargoor) and gill nets (set or driftnets). No information, however, is available on the landings of by-catch species by either industrial or artisanal shrimp trawlers. Nevertheless, exploitation of the by-catch could increase the total landings in the Arabian Gulf significantly. Grantham (1980) estimated demersal by-catch resources of the Gulf as 30,000 t/year, which were caught, but not marketed. By applying the mixed fish ; mixed shrimp ratio to shrimp landings, Mathews and Samuel (1984) estimated that the available volume of small by-catch species, could be as high as 8,000-12,000 t/annum in

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Kuwait waters alone. The quantity of by-catch species marketed and sold in the Kuwait fish markets have increased from 1978-1982 (Hopkins *et al.*, 1984). Therefore it is necessary to assess the major by-catch species.

The threadfin bream *Nemipterus* sp. locally known as Bassi, is one of the few by-catch species for which the Central Statistical Office provides separate records of sales and wholesale and retail prices. The Bassi category includes two important species of threadfin bream in Kuwait, *Nemipterus japonicus* and *Nemipterus tolu*. The quantity of fish landed by the industrial shrimp trawling fleet varied around 600 t/year (ranging from 538 t—605 t from 1982-1985). The Bassi landing varied from 89 t-108 t/year during the same period. This forms 11-18% of finfish landed by the industrial trawlers alone.

The biology, length-weight relationship growth and spawning of *Nemipterus* sp. were studied in India (Krishnamoorthi, 1971, 1973, 1974, 1976; Dan, 1977; Vinci, (1982) and Eggleston (1971), Weber and Jothy (1977) in Malaysia. Hoda (1976) and Fursa (1979) have studied the length-weight relationship and seasonal nature of spawning of *N. japonicus* in Pakistan and in the eastern part of the Arabian Sea. Pauly and Martosubroto (1980) studied the population dynamics of *N. marginatus* off Borneo and Hsi-chiang liu *et al.* (1985) studied the trawl cod-end mesh selectivity for some fishes in north-western Australia. No similar work has been reported on *Nemipterus* sp. from the Arabian Gulf region. The objective of this paper is to provide information on the biology, age, growth and population dynamics of *N. japonics*, which is the larger of the two species found in Kuwait waters.

Material and Methods

Regular random samples of *N. japonicus* have been obtained since 1979 from the trawl catches of research vessels (Oloum-1) and Bahith during the monthly fishery biological surveys carried out in Kuwait waters. The study area lies in the northwestern side of the Arabian Gulf. Samples were taken within the area bounded by 47°45′ E to 49°00′ E and 28°30′ N to 29°45′ N (Mathews and Samuel, 1984). The data on length and age discussed in the present paper, however, were taken from 1985 and 1984-1985 respectively. The biological parameters studied includes total length, weight, sex and gonadal stage. Sagittal ololiths were collected for age determination.

Length frequency

Total length was measured to the nearest 1 cm under (the length from tip of the snout to the end of the lower caudal lobe, 10.0-10.9=10 cm). Weber and Jothy (1977) and Murty (1984) used the same definition of total length in their studies on this species. Fish were also measured from the Kuwait city central fisn market from December 1985 to November 1986.

Age determination

Mathews *et al.* (1979), Bedford (1982) and Williams (1986) observed that marks on the otoliths from fish in Kuwait were clearer than those on fish scales. Moreover, it was observed that the marks on scales of older fish were more crowded with increasing age, affecting their readability and hence introducing bias in age reading. On the other hand, length frequency data cannot be objectively analysed by Petersen's method, except for the first 1-2 age groups. Therefore sagittae were used in age determination of *N. japonicus*. Williams (1986), Samuel and Mathews (1985) and Samuel *et al.* (1987) applied the established ageing methodology to Kuwaiti fish stocks. Sagittae were extracted from randomly selected samples from the research vessel catches and stored in specially prepared plastic envelopes on which necessary information such as total length, sex, gonadal stage, date, station numbers and weight (if measured) were recorded. Whole sagittae were

studied under a low power microscope after cleaning and immersing them in water in a black glass dish and were illuminated from above. The older specimens which were difficult to age this way were broken across the nucleus ; after smearing with almond oil, the cross sections were observed with reflected light for age de.ermination. The age readings from all specimens were used in the subsequent analysis. For some sagittae, readings were doubtful ; in these cases the most probable ages were used. The ages were assigned by taking an arbitrary birthday on the 1st January.

Validation of age

The procedure used here to age *Nemipterus* sp. includes all steps mentioned by Samuel and Mathews (1985) and Williams (1986), excepting a formal analysis based on the detailed examination the condition of the margin of a large number of otoliths needed to provide a final proof of the annual periodicity of these marks. Mathews (in press) considered that final validation was too expensive to be carried out except for major stocks such as *Epinephelus tauvina* (Hamoor), *Lutjanus coccineus* (Hamra), *Otolithes argesteus* (Hewaiby) in Kuwait.

Length-weight relationship

Total length and weight for males and females were observed and the length-weight relationship was established for males, females and sexes combined using the equation $W=aL^b$ LeCren (1951). Where W is the weight measured to the nearest 10 g, L is the total length measured to the nearest 1 cm under, and 'a' and 'b' are constants. The equation was fitted by means of a double logarithamic transformation.

A covariance analysis was carried out to study the difference between the slopes of the regression lines for males and females.

Estimation of growth parameters

Age and length of each fish were used to estimate the von Bertalanffy growth parameters. The growth curves were fitted using a computer programme Hall (1981) for each sex and sexes combined.

Spawning and size at maturity

On an average 20 specimens were examined each month from the research vessel catches during the year 1984 and 1985. The gonadal stage of female *N. japonicus* was determined by a scale of maturity I-VIII (Laevastu, 1965). Some of the maturity stages of *N. japonicus* males were difficult to determine in the field. Krishnamoorthi (1971) also experienced this difficulty in his studies in the east coast of India; hence no attempt was made to determine the gonadal stage of males in the present study. For females the gonadal stage was analysed by plotting samples into 5 cm size groups.

Relative condition factor

Because of the difficulty in identifying the spawning season by means of the gonadal stage it was necessary to determine the spawning period by measure of the relative condition factor (Kn) using the formula :

$$Kn = \frac{W \times 100}{w'}$$

W is the observed weight measured to the nearest 10 g and w' is the weight determined by the length weight relationship for females and Kn is the relative condition factor. A fall in the value of Kn corresponds to the time of spawning and the peak value corresponds to the peak fatness of the body (LeCren, 1951).

Estimation of total mortality (Z)

Total instantaneous mortality (Z) was estimated by the catch curve method. The natural logarithms of numbers at age were plotted against age and a linear regression was fitted to the straight descending right hand limb of the curve. The slope of the right hand limb provided an estimate of total mortality.

Estimation of natural mortality

In the absence of catch and effort data natural mortality was estimated using the equation of Pauly (1980) which uses the von Bertalanffy growth parameters and the mean annual sea water temperatures; log M= —0.0066 — 0.279 log L + 0.6543 log K + 0.4634 log T_o, where M is the natural mortality, L and K are the von Bertalanffy growth parameters and T_o is the mean annual sea water temperature.

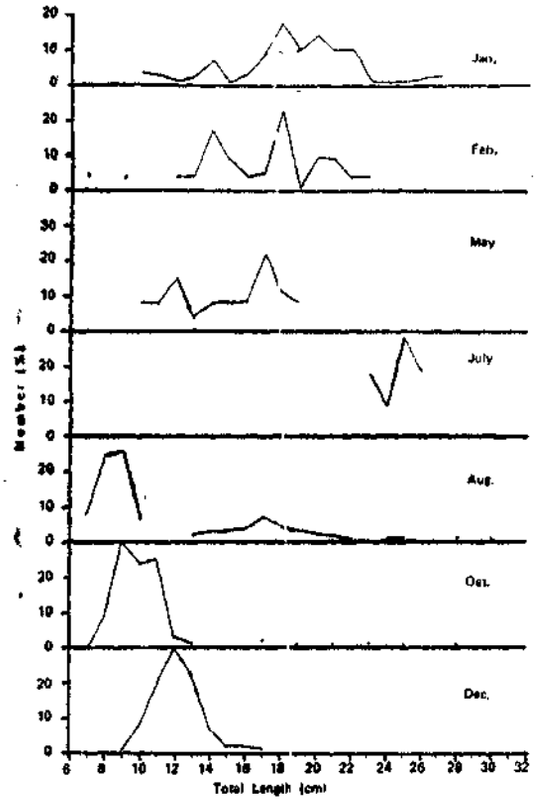

Fig. 1. The percentage length frequency of *N. japonicus* from R/V Oloum during 1985.

Results and Discussion

Length and age composition

Fish length varied from 6-31 cm in the research vessel catches. The minimum and maximum size of *N. japonicus* on the catches did not vary greatly during the study period with the majority of the fish occurring in the 8-20 cm size range (Fig. 1). Fig. 1 shows that young of the year were recruited to the fishable population during August/September. Fish from commercial landings at the markets were also measured regularly. It was difficult to find the smaller length group in the market landings, because the smaller fish were often discarded at sea.

The length ranges observed in Kuwait waters were similar to that reported from India (Krishnamoorthi, 1971 ; Vinci, 1982) and from the South China Sea (Weber and Jothy, 1977).

Seven age groups were observed in the fishery with the majority of the trawl catches in Kuwait waters consisted of 1 and 2 year old fish with 0 and 3 year olds in lesser numbers and 4 and 5 year old fish very rare. Only 3 fish of six years old in the whole sample during the study was taken. Krishnamoorthi (1971) reported that the *Nemipterus* fishery in India was based on two year old fish, however the present studies show that *N. japonicus* seems to be fully recruited to the fishery when they are 1 year old and nearly 80% of the fish sampled were of 0-2 year olds.

Estimation of growth parameters

Table 1 shows the von Bertalanffy growth parameters obtained by the length at age for all the fish sampled for males (n=135), females (n = 314) and sexes combined (n = 449) for Kuwait and compared with the value obtained by others. *N. japonicus* males attain 29 cm by 5 years and females grow about 26 cm by 6 years in Kuwait waters. Figs. 2 and 3 show the growth curve obtained for the length at age data for Kuwait for different sexes and sexes combined.

Table 2 shows the growth in length in *N. japonicus* males, females and sexes combined and values reported by others for sexes combined. Males grow faster than females after the

TABLE 1. *Growth parameters of* N. japonicus *for males, females and sexes combined for Kuwait and other areas*

Sex		$L\infty$	K	t_0	N	Author
Male	..	30.28	0.542	0.19	n=135	
Female	..	26.53	0.595	0.03	n=314	Present study
Sexes combined	..	27.66	0.580	0.10	n=449	Kuwait
Sexes combined	..	30.54	0.314	−1.11		Krishanmoorthi (1971) ; India
Sexes combined	..	31.4	0.751	0.17		Murty (1984) ; India
Sexes combined	..	29.1	0.31	+0.05		Edwards (1984) ; Aden

N=number of fish sampled.

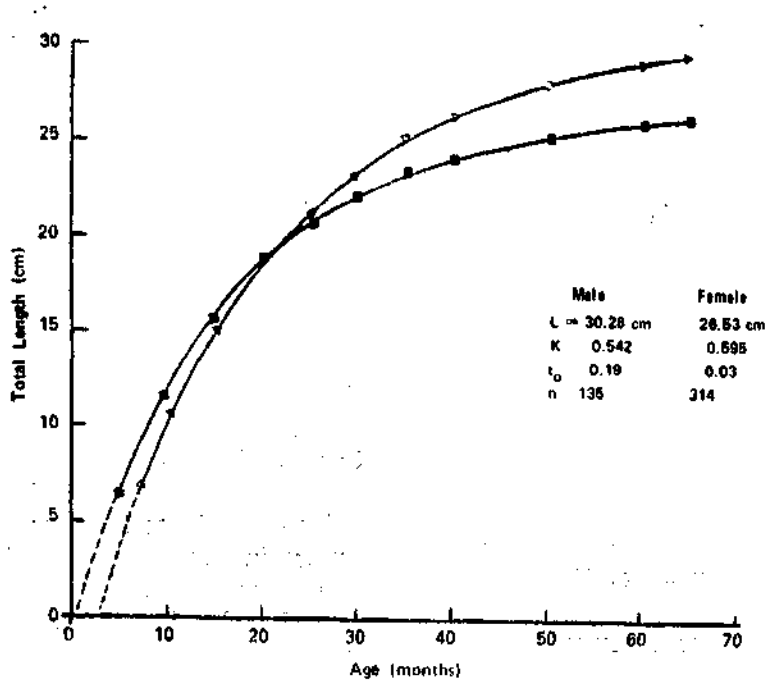

Fig. 2. The von Bertalanffy growth curve for male and female Bassi *N. japonicus* fitted to the mean length at age data.

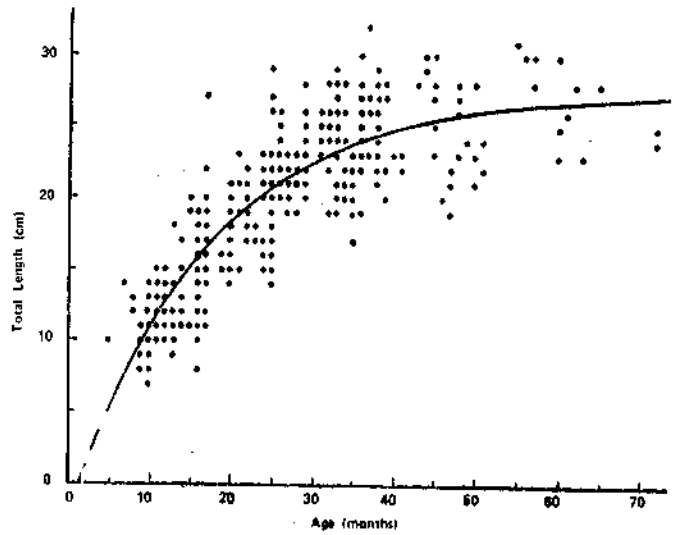

Fig. 3. The von Bertalanffy growth curve for sexes combined for *N. japonicus* (age at length data).

TABLE 2. *Mean length at age for* N. japonicus *in Kuwait and elsewhere*

Age Group (months)	Present study			Sexes combined values from literature (India)		
	Male TL(cm)	Female TL(cm)	Sexes combined TL(cm)	Krishnamoorthy (1974)	Murty (1984)	Vinci (1982)
9	9.18	10.67	10.08	—	—	—
12	12.84	13.26	12.90	15.00	18.5	13.6
24	20.92	20.03	20.33	21.00	25.5	18.6
36	25.40	23.35	24.02	24.00	28.5	23.6
60	28.75	25.76	26.76	—	—	—
72	—	26.15	—	—	—	—

TABLE 3. *'a' and 'b' constants of length-weight relationship of* N. japonicus *for Kuwait and for other areas*

Males		Females		Authors and areas of study
a	b	a	b	
—3.3435	2.0769	—5.2625	2.9423	Krishnamoorthi (1971) India. significant difference between males and females.
—5.503	2.8376	—5.4352	2.8689	Vinci and Nair (1974) India. Not sufficient.
—6.9152	3.0725	—5.2597	2.9245	Hoda (1976) Pakistan. significant at 5%.
—3.6505	2.43025	—4.7874	2.9569	Reddy (1979) significant at 5%.
0.02448	2.78952	0.01123	3.0399	Present study. Kuwait.

first 2 years of their life : growth in female is more or less equal to growth in males until they are 2 years old, after which males grow faster. However, a test on the variance of the mean length at age of male and female for different age classes showed that the differences in growth rates between male and female are statistically not significant at 0.15 level except for the two year-old fish. Therefore a combined growth curve (Fig 3) was provided for *N. japonicus*. The minimum size at maturity for female was around 14 cm (TL) and it seems probable that the growth rate after first maturity and spawning is retarded. The longest fish recorded in Kuwait was a male of 32 cm and the majority of the females were below 28 cm with very few fish 30 cm and above in the catches. While all populations of *N. japonicus* studied show faster growth in males, this is unusual and in most fish populations studied, females grow faster

The significance of difference between the values of 'b' for males and females in Kuwait was tested by analysis of co-variance (Snedecor and Cochran, 1967) ; the difference was found to be highly significant at 1% level. Table 4 shows the F values obtained. Therefore a single equation for both sexes could not be applied to calculate the weight from length for males and females.

The difference in length-weight relationship between sexes in other nemipterid fishes is well known. Eggleston (1971) recorded the difference in *N. virgatus* and Krishnamoorthi (1974) and Murty (1984) have also observed significant difference between *N. japonicus* males and females in other area. Vinci (1982) and Hoda (1976), however, did not find any significant difference between the sexes from the west coast of India and from Pakistan Coast respectively.

TABLE 4. *Analysis of co-variance*

Sex		R.f.	D.f.	s.s.	M.s.	F
Male	..	2.78952	82	3.78362	—	—
Female	..	3.03992	224	12.75622	—	—
		—	306	16.53984	0.05405	—
Pooled	..	2.97562	307	18.12058	—	—
			1	1.58074	1.5807	29.25

Comparison of slope F=29.25 Df=1,306 Significant at 1% level.

Length-weight relationship

Table 3 shows the values of 'a' and 'b' for the length-weight relationship. The calculated curves provided a good fit to the data with value of correlation coefficient r, (r) = 0.9713 (p 0.01>p>.001) and 0.9788 (p < < 0.001) for males and females respectively. There were considerable variations in the 'a' and 'b' values obtained from different areas ; however, the values obtained by Sivasubramaniam (1981) in the Arabian Gulf were very similar.

Spawning

The majority of the specimens examined were in the early stages of maturity. Mature and ripe females were seldom sampled in the catches. However, 3 fish taken in May and one fish in October 1984 were found to be partially spawned. One partially spawned fish was caught in May and another in December 1985 were sampled. The absence of sufficient numbers of mature males and ripe and running females during the study suggests that *N. japonicus* does not spawn in Kuwait waters.

However, paucity of data limits making any strong conclusion. Studies on the demersal resources of the Gulf waters showed that ripe and running *N. japonicus* occurred in deep waters outside Kuwait waters during March - June (FAO, 1981); this suggested that *N. japonicus* spawns offshore in deep waters outside Kuwait.

Relative condition factor

Fig. 4 shows the average relative condition factor of females through various months in 1985. Values of Kn for females show two peaks and two troughs. There was a building up of fatness in fish upto February followed by an abrupt and steep fall in March and April. Since the fall in the Kn values is an indication of the onset of spawning, March/April may mark the commencement of spawning of *N. japonicus*. A gradual but steady increase in the Kn values was observed from May to August; Kn values dropped in september. Although the second trough were not as deep as the first, it is possible that *N. japonicus* may spawn for a second time in September and October months.

Analyses of the fluctuations in relative condition factor, therefore, suggest that there are two spawning periods March/May and September/October in north western Gulf. The catch of ripe and ripe and running fish (5 out of a total sample of 188) at all times of year, suggests that the fish move into deeper water offshore as they ripen, while spawning itself probably occurs outside Kuwait.

While the studies conducted in India on *N. japonicus* showed that it spawns in September/November (Krishnamoorthi, 1971); studies in the eastern part of the Arabian Sea show that *N. japonicus* spawns throughout the year with peak spawning in October. Fursa (1979) and Sivasubramaniam (1981) stated that *N. japonicus* in the northern Arabian Gulf spawns in deep waters from March to June. Dan (1977) found that this species spawns twice a year during December-February and then June-July in the east coast of India.

Further trawling in southern deeper waters is needed to test the hypothesis that spawning occurs offshore in deep waters.

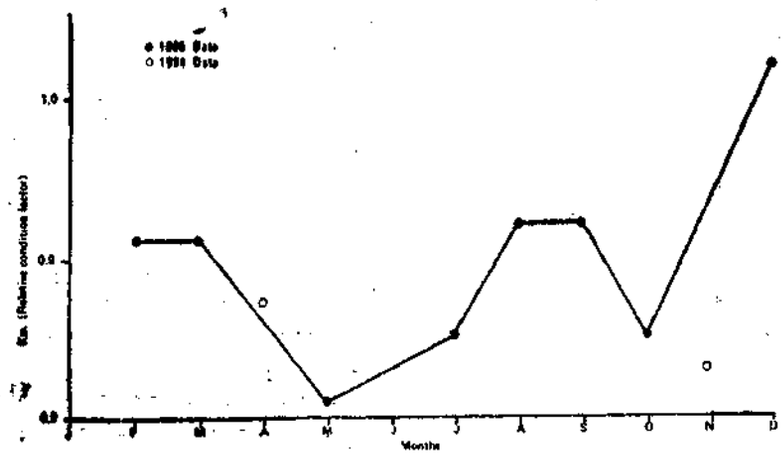

Fig. 4. The relative condition factor value for different months for *N. japonicus* females.

Size at maturity

The smallest mature *N. japonicus* female found in Kuwait was 14 cm. This was in confirmity with Sivasubramaniam (1981) who also reported a minimum mature size of 14 cm (TL) from the Gulf waters. Krishnamoorthi (1971) reported that 50% of the fish mature at about 16.5 cm and Murty (1984) has observed that 50% of the fish were mature at a length of about 12.5 cm in Indian waters.

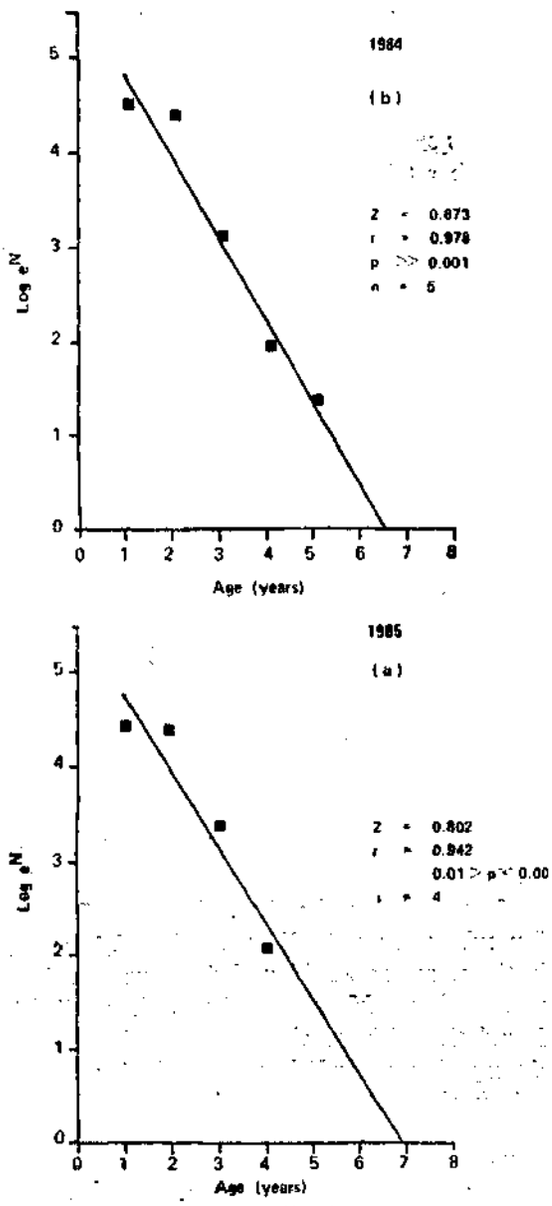

Fig. 5. The catch curve for *N. japonicus* for numbers at age data : a, for 1985 and b, for 1984.

Estimation of total mortality

Fig. 5 shows the regression line fitted to the log numbers at age data for different years for *N. japonicus*. The value of total mortality (Z) ranged from 0.873 ($P<0.001$) to 0.802 ($0.01 > P > 0.001$) for 1984 (Fig. 5 a) and 1985 (Fig. 5 b) respectively. The Z values obtained for different years by Krishnamoorthi (1976) varied from 0.3663-0.6093 with a mean of 0.5166. Edwards *et al.* (1985) reported a value of 0.67 from the Gulf of Aden. He used fish scales for age determination and obtained ages upto 8 years, which suggests that these data are comparable to those for Kuwait.

Natural mortality

The growth parameters presented here when used to estimate the natural mortality by means of equations 2 gave values of 1.16 and which exceeded the total mortality (Z) values : Therefore, this method could not be used to estimate natural mortality (M) for the Kuwaiti population of *N. japonicus*. No method, applied so far has provided the necessary estimates of F and M upon which stock assessment of *N. japonicus* can be based. Mathews and Samuel (in press) found that application of ELEFAN analysis also provided estimates of M that were greater than those of Z and came to a similar conclusion. Mathews and Samuel (in press) concluded that the by-catch species as a whole were exploited at or near MSY. This may be approximately true for *N. japonicus*. Following Gulland (1971) it may be assumed that, if the stock is fished near MSY, then F is probably equal, or larger than M, then if $Z = 0.8$, then M may be around 0.3-0.4. Pauly and Martosubroto (1980) found a value $Z = 1.73$ and assumed that $M = Z$, absence the stock was assumed to be unfished.

They applied the methods of Beverton and Holt (1956); which may give high values of Z. A more detailed analysis of data on the mortality rates and a reliable assessment are expected to be available from a study of the sea survey (1978-1986) data which is presently underway.

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