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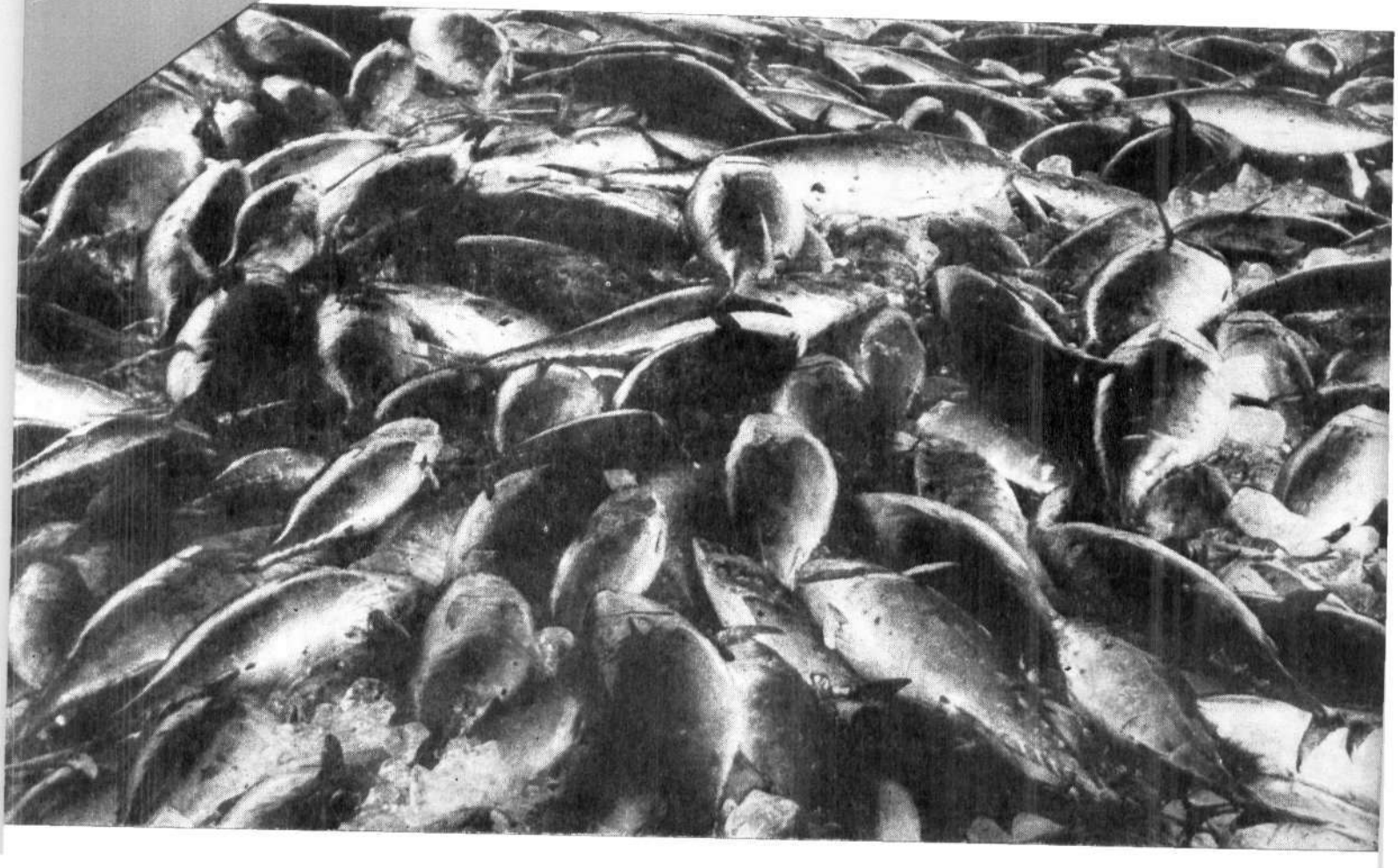

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MATURATION AND SPAWNING OF *EUTHYNNUS AFFINIS*, *AUXIS THAZARD* AND *AUXIS ROCHEI* IN THE MANGALORE INSHORE AREA DURING 1979-82

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A perusal of the literature on the spawning habits of tunas of the Indian waters indicates that except for the observations on these aspects by Rao (1964) and Silas (1969) information on the above lines on *Euthynnus affinis*, *Auxis thazard* and *Auxis rochei* is wanting.

With the advent of purse seiners in the mid-seventies and the operation of mechanised gill netters off late along the Karnataka Coast, the resources of the above species have come within the reach of the indigenous gears and have gained commercial importance. In order to have a clear picture on the reproductive potential of the population of these species, investigations were carried out on the maturation and spawning aspects of the above three species from 1979 through 1982 in the inshore waters along Mangalore Coast and the results are presented.

Material for the study was collected from the purse seine landings at Mangalore as well as from the drift gill net catches at Kaup (Fig. 1). Fork length and weight to the nearest 10 g of each specimen were recorded. Ovaries were weighed to the nearest gram and later they were preserved in 5% formalin for further studies.

ICES scale was followed for determining the maturity stages *viz.*, immature (I & II), maturing (III), mature (IV & V), ripe (VI) and spent (VII) (Wood 1936).

For the purpose of fecundity study, fishes in stages IV& V alone were considered. 38 ovaries of *E. affinis*, 69 ovaries of *A. thazard* and 85 ovaries of *A. rochei* were examined during the present study. Moisture was removed from the ovaries with blotting paper and they were then weighed in an electric monopan balance to the nearest 0.5 g. A small portion of the ovary was separated and weighed to the nearest 0.001 g employing an analytical monopan electric balance. The weighed portion was placed on a microslide and a drop of glycerin was added to the sample before the ova were teased out. Mature ova were counted and the total fecundity was estimated employing the following formula :

$$\frac{\text{Total weight of the ovary}}{\text{Weight of the sample}} \times \text{No. of ova in the sample}$$

The relationship between fecundity and length and weight was calculated by the least square method :

$$F = Y + aL^b$$

where Y = the factor to be estimated, L = the variable, a = a constant and b = regression co-efficient.

Relative condition (Kn) was calculated as per the method described by LeCren (1951). Gonado-Somatic Index (G.S.I.) was estimated applying the method of June (1953).

Study on the sex ratio was undertaken employing the X^2 method of Fisher (1970).

MATURITY

Euthynnus affinis

The relationship between the maturity and length was based on 183 and 198 females respectively. The percentage occurrence of mature fish in various size groups is given in Fig. 2. It is seen that mature females were observed when they were in 39 cm length and those of males at about 44 cm. Fish measuring more than 60 cm in length were all mature. The 50% maturity, representing the mean length for minimum size maturity in the case of females was at 43 cm. Males in the 36-42 cm size groups were not represented in the samples examined. The mature males were above 42 cm size and 70% of the males were mature (stage

IV and V) at 44 cm. The minimum size at maturity of females and males at 43 and 44 cm respectively closely corresponds to the lengths as evidenced from the relative condition. In the Philippine waters the smallest female in mature condition was recorded at 38.5 cm (Ronquillo, 1963) and in spent condition at 47.7 cm (Bunag, 1958). In the Indian Ocean, they

Auxis thazard

Fig. 2 presents the percentage occurrence of mature females and males based on the examination of 410 and 336 females and males respectively. It is evident that the mature stages in both sexes appear for the first time in the 28 cm size group. With growth, the percentage increased progressively till 40 cm when

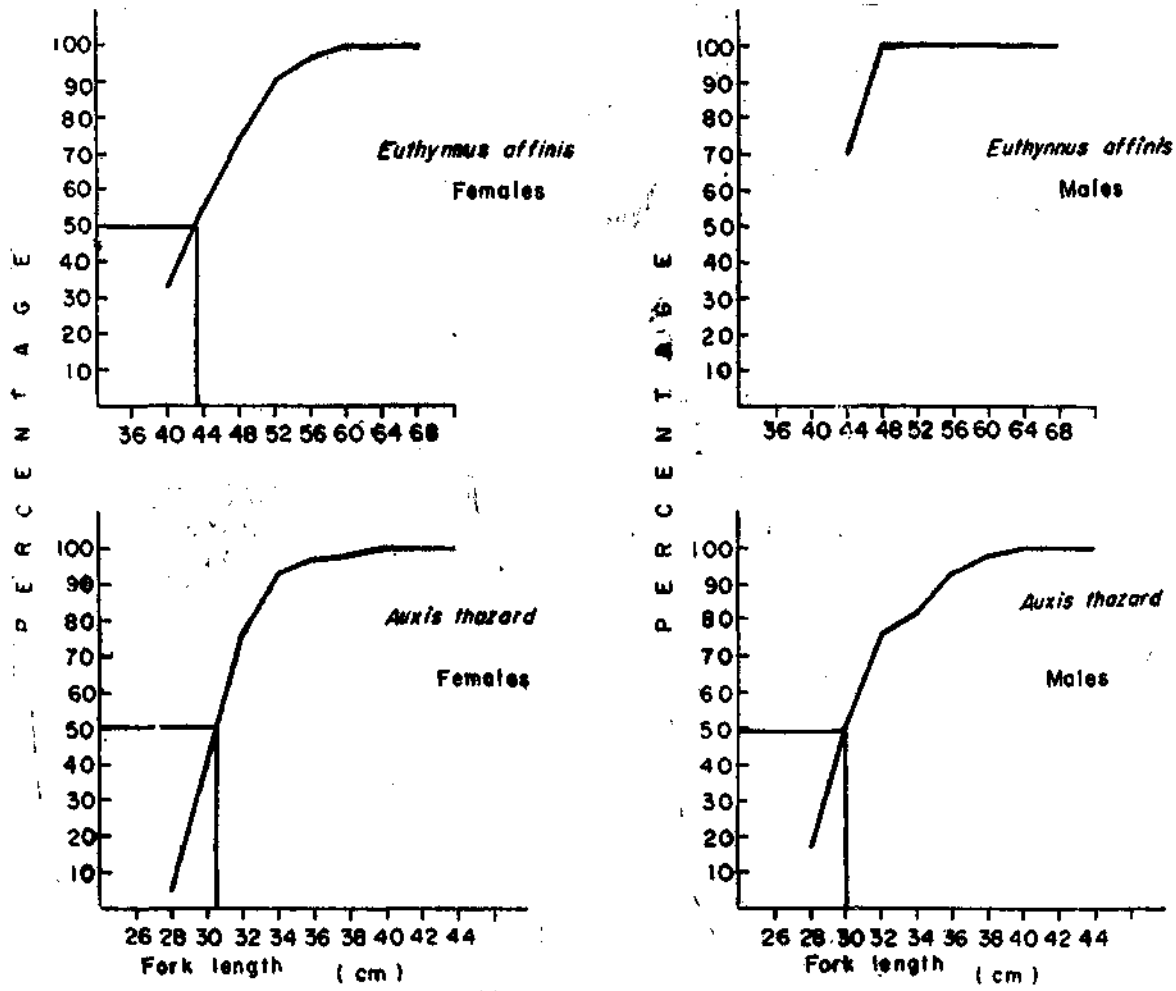

Fig. 1. Percentage occurrence of mature females and males of *E. affinis* (upper panel) and *A. thazard* (lower panel) at Mangalore.

attained maturity between 50 and 65 cm in TL (Ommanney, 1953) and 55 and 60 cm TL (Williams, 1956, 1963). Rao (1964) has recorded a female of 48 cm in ripe running condition off Vizhinjam along the southwest coast of India. According to Williamson (1970), *E. affinis* attains maturity at around 50 cm in the South China Sea. The present observation of minimum size of maturity of 43 cm for females is similar to the findings by Ronquillo (1963).

all fishes were found to be mature. The size at minimum maturity at 50% level was 30.5 cm for females and 30 cm for males. Rao (1964) has recorded a female of *A. thazard* of 41.6 cm in ripe running condition from Vizhinjam. Gonadial studies by Tester and Nakamura (1957) indicated that *A. thazard* matures at a size of about 35 cm. The present study indicates that the minimum size at first maturity with regard to males and females are when they attain the length of

30 cm and 30.5 cm, this finding is in agreement with that of Yasui (1975).

Auxis rochei

For determining the minimum size at maturity 292 and 354 males and females in the size range of 20-32 cm were considered (Figs. 3, 4). Mature fish occurred for the first time at a length of 23 cm in both sexes and all fish beyond 26 cm were mature. The length at which 50% of the females attain maturity was at 23.8 cm and for males at 24 cm. Yoshida and Nakamura (1965) observed milt flowing from the vent of males of *A. rochei* ranging from 29.2 to 32.9 cm in fork length. Rodriquez-Roda (1966) reported that the size of *A. rochei* at first spawning was 35 cm for the females and 36.5 cm for the males.

Fecundity

Euthynnus affinis

Fecundity varied from 2,01,542 (47 cm FL) to 15,69,733 (67 cm FL) ova. The smallest matured female (39.4 cm) had 4,47,326 ova. The fish which had the highest no. of ova measured 67 cm and the gonad was in fully ripe condition, occupying the whole body cavity and the weight of the ovary was nearly 0.5 kg. Fecundity varied in fish of the same length but, increased with length. The relation between length (L) and fecundity (F) is given in Fig. 5. The linear expression observed was :

Log F = −3.66219 + 2.36111 Log L, and the correlation coefficient $r = 0.725$

The relation between body weight (W) and fecundity (F) of *E. affinis* is plotted in Fig. 5 and the regression observed was :

Log F = −0.70091 + 1.03108 Log W, and the correlation coefficient $r = 0.851$.

The only information about fecundity of *E. affinis* in the Indian Seas is that by Rao (1964) from Vizhinjam, who reported that *E. affinis* spawned 2,10,000 to 6,80,000 ova per spawning and 7,90,000 to 25,00,000 ova for the spawning season. He also indicated that the production of ova increased with the length of the fish.

Auxis thazard

Fecundity ranged between 78,803 (31.5 cm FL) and 7,17,895 (39 cm FL) ova. As in the case of *E. affinis* the fecundity in *A. thazard* showed fluctuations in the fish of the same length, but generally it showed an increase corresponding with increase in length. The relation between fecundity (F) and length (L) (Fig. 6) could be expressed as :

Log F = −9.77991 + 4.75748 Log L, and the correlation coefficient $r = 0.907$.

The relation between body weight (W) and fecundity (F) (Fig. 6) was :

Log F = 1.270675 + 1.27111 Log W and the correlation coefficient $r = 0.853$.

Rao (1964) reported that an individual of 44.2 cm produced 2,80,000 eggs per spawning and 1.37 million eggs in the spawning season. Silas (1969) estimated the fecundity based on 9 ovaries and it was 1,97,000 to 1.056 million eggs per spawning at an average of 6,01,000 ova per spawning.

Auxis rochei

Fecundity ranged from 52,570 (25.2 cm size) to 1,62,777 (33.7 cm size) eggs. Though variations were observed in fishes of the same size, the fecundity increased with the length of the fish as in *E. affinis* and *A. thazard*. The relationship between fecundity (F) and length (L) is shown in Fig. 6. The relationship was :

Log F = −1.70881 + 1.50244 Log L and the correlation coefficient $r = 0.958$.

The relation between fecundity (F) and body weight (W) was :

Log F = 0.02921 + 0.79045 Log W and the correlation coefficient $r = 0.890$ (Fig. 6).

There is no published information on the fecundity of *A. rochei* except that by Silas (1969). Based on 4 ovaries he estimated the fecundity to vary from 31,000 to 1,03,000 ova with an average of 52,000 ova per spawning.

Spawning Season

Euthynnus affinis

184 males and 202 females respectively were considered for this study. The percentage occurrence of various stages of maturity for males and females is given in Tables 1 and 2. Fish with ripe gonads (stage VI) were encountered during September-October. Their percentage was relatively high during October when the ripe individuals were invariably observed in the catches over the years. Fish in stage V occurred during December and February-March. Spent fishes in large numbers were encountered in the catches during September-October and a few during January-March, which indicate that the peak months of spawning of *E. affinis* was September-October and to a certain extent prolongs upto March. Further supporting evidences from the study of the relative condition and

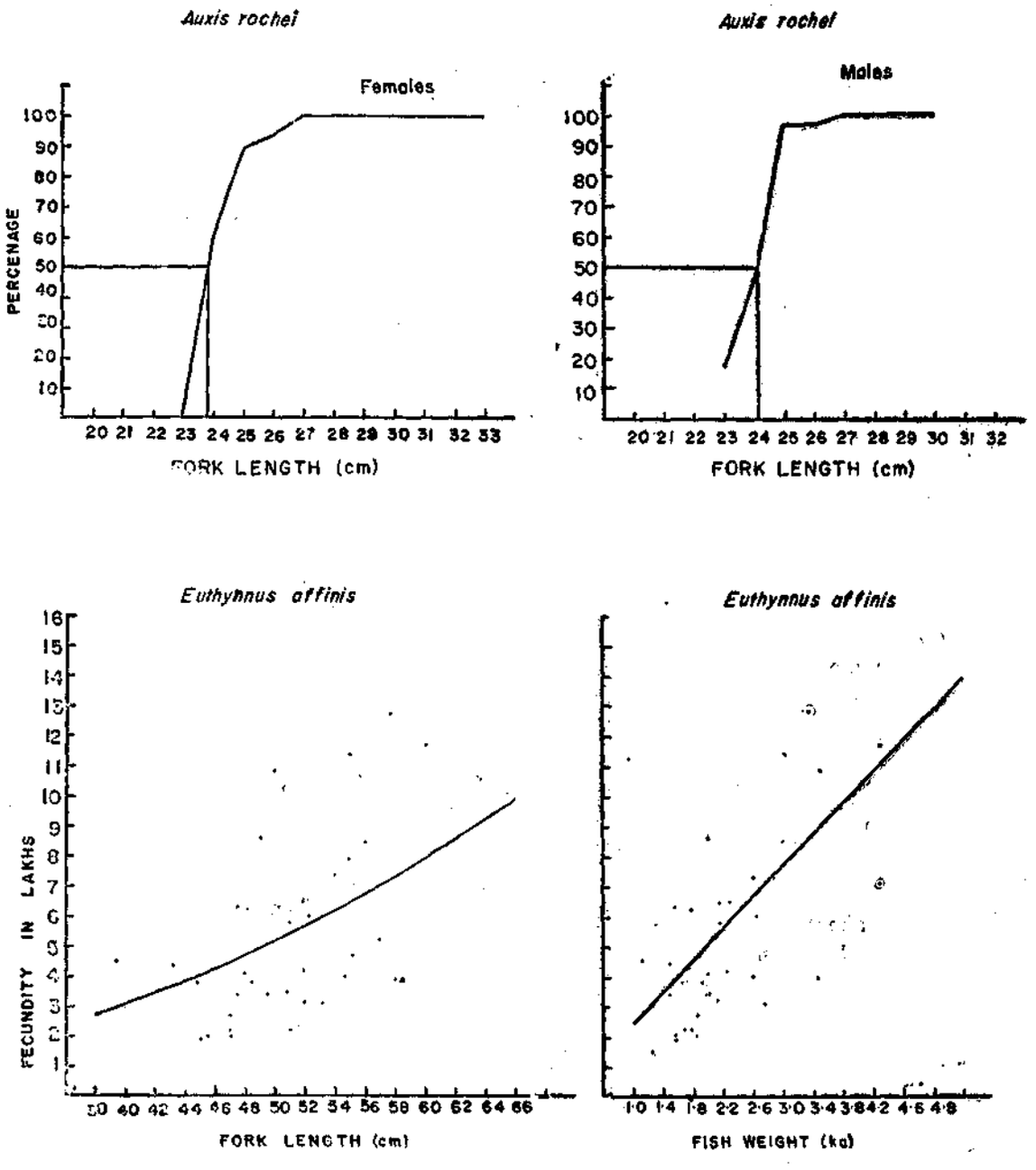

Fig. 2. Percentage occurrence of mature females and males of *A. rochei* (upper panel) and fecundity in relation to fork length and weight (kg) of *E. affinis* (lower panel) at Mangalore.

Gonado-Somatic Index confirm this finding. The availability of ripe *E. affinis* in large numbers in the gill net catches in the inshore waters of Mangalore during October every year provides further support to the observation that this species appears to approach the coastal waters for spawning.

April to September with occasional spawning in other months. Jones (1960) based on the capture of juveniles of *E. affinis* during January, May, June, September, October and November observed a rather protracted spawning season. The present findings also confirm the above observations.

TABLE 1. *Percentage of different maturity stages of males of* E. affinis *in various months*

Month	No. of specimens	Maturity stages						
		I	II	III	IV	V	VI	VII
January	2	..	..	..	..	..	..	100.00
February	3	..	..	..	..	..	..	100.00
March	3	33.30	..	..	33.30	33.30	..	..
April	9	11.10	..	22.20	66.70	..	..	..
May	8	..	..	12.50	87.50	..	..	..
June	5	..	..	..	40.00	60.00	..	..
July	No samples	..	..	..	..	..	..	..
August	No samples	..	..	..	..	..	..	..
September	22	..	..	9.10	50.00	18.20	4.50	18.10
October	110	3.60	3.60	3.60	42.70	34.50	6.40	5.40
November	20	100.00	..	..	..	..	..	..
December	2	50.00	..	..	..	50.00	..	..

TABLE 2. *Percentage of different maturity stages of females of* E. affinis *in various months*

Month	No. of specimens	Maturity stages						
		I	II	III	IV	V	VI	VII
January	No samples	..	..	..	..	..	..	..
February	2	..	..	..	..	50.0	..	50.0
March	6	..	33.3	16.7	16.7	16.7	..	16.7
April	3	..	..	33.3	66.7	..	..	..
May	10	10.0	10.0	20.0	60.0	..	..	..
June	3	..	..	..	..	66.7	..	33.3
July	No samples	..	..	..	..	..	..	..
August	No samples	..	..	..	..	..	..	..
September	20	..	..	25.0	40.0	5.0	..	30.0
October	134	3.0	6.0	5.2	47.8	14.2	14.2	9.7
November	24	100.0	..	..	..	..	..	..
December	No samples	..	..	..	..	..	..	..

The protracted spawning extending from October-November to April-May in *E. affinis* has been reported by Ommanney (1953) from western Indian Ocean. Rao (1964) stated that it spawned off Vizhinjam from

Auxis thazard

In the Mangalore inshore area *A. thazard* were observed only during September-December period of each year. The percentage occurrence of various

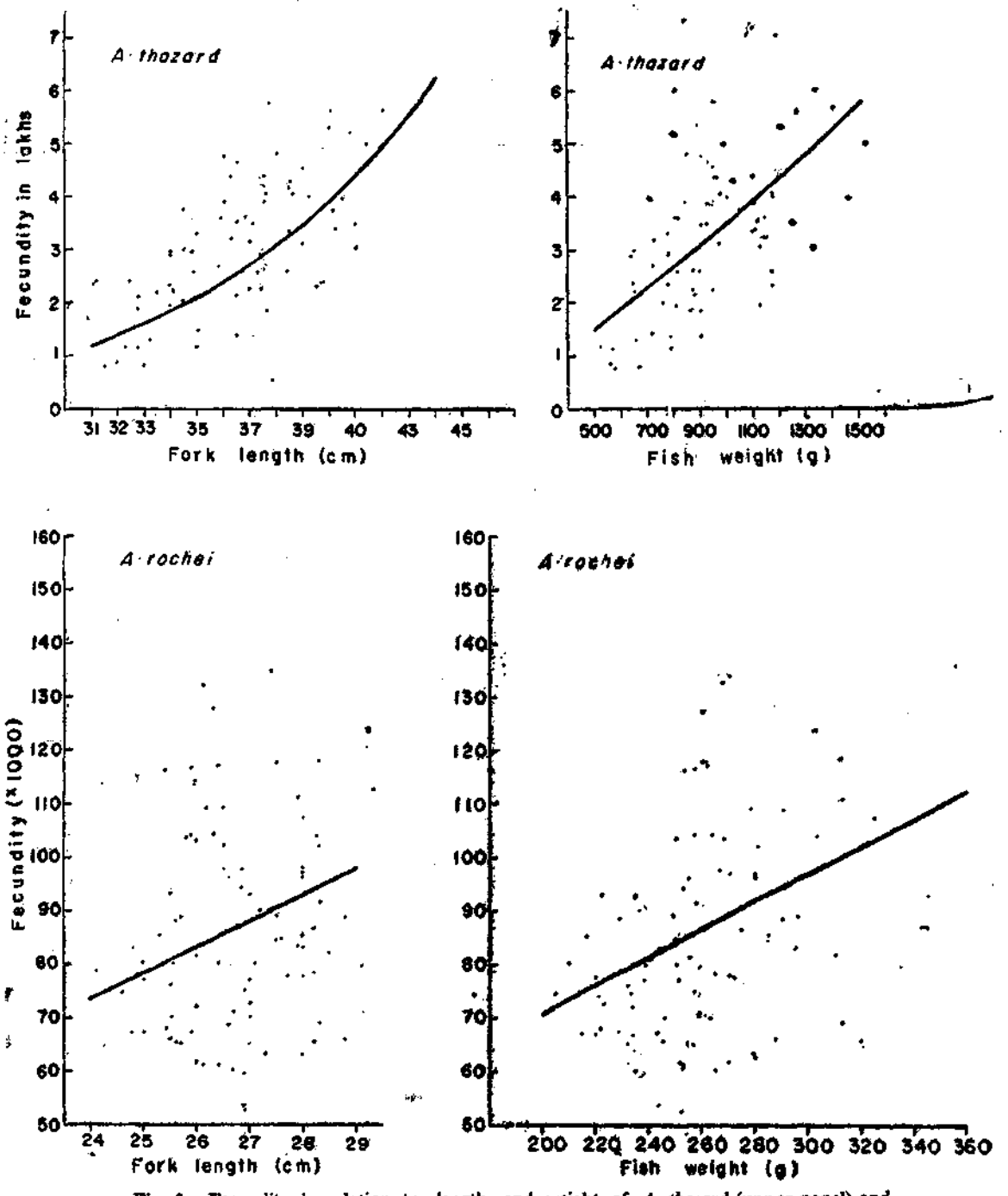

Fig. 3. Fecundity in relation to length and weight of *A. thazard* (upper panel) and *A. rochei* (lower panel) at Mangalore.

stages of maturity for males and females during different months is presented in Tables 3 and 4. Males and females in ripe condition were common in the catches during October-November period whereas spent fishes were recorded from October to December which indicates spawning of this species in the above months. Jones and Kumaran (1963) based on the capture of larval *A. thazard* observed that this species spawns during December-January in the area between 3° and 24° S at long. 50°E and during January-April in the Laccadive Sea. Rao (1964) observed that majority of this species were in the ripe and some in spent condition during August and September with a preponderance of spent specimens in November. The present observation is in conformity with the findings of Rao (1964).

TABLE 3. *Percentage of different maturity stages of males of* A. thazard *in various months*

Month	No. of specimens	Maturity stages						
		I	II	III	IV	V	VI	VII
January	No samples	..	..	..	..	..	..	..
February	No samples	..	..	..	..	..	..	..
March	No samples	..	..	..	..	..	..	..
April	3	..	33.3	..	33.3	33.3	..	..
May	3	..	100.0	..	..	..	..	..
June	No samples	..	..	..	..	..	..	..
July	No samples	..	..	..	..	..	..	..
August	No samples	..	..	..	..	..	..	..
September	50	..	4.0	..	26.0	28.0	4.0	38.0
October	196	14.3	13.3	16.3	15.8	12.8	9.7	17.9
November	85	75.3	8.2	5.9	2.4	..	..	8.2
December	No samples	..	..	..	..	..	..	..

TABLE 4. *Percentage of different maturity stages of females of* A. thazard *in various months*

Month	No. of specimens	Maturity stages						
		I	II	III	IV	V	VI	VII
January	No samples	..	..	..	..	..	..	..
February	No samples	..	..	..	..	..	..	..
March	2	..	100.0	..	..	..	..	..
April	1	..	..	..	..	..	..	100.0
May	1	..	100.0	..	..	..	..	..
June	No samples	..	..	..	..	..	..	..
July	No samples	..	..	..	..	..	..	..
August	No samples	..	..	..	..	..	..	..
September	43	2.3	4.7	7.0	44.2	21.0	4.7	16.3
October	240	4.6	24.6	5.0	30.4	11.7	10.0	13.8
November	116	62.1	18.1	4.3	0.9	..	..	14.6
December	6	100.0	..	..	..	..	..	..

Auxis rochei

A. rochei was observed in the Mangalore inshore waters during the September-December period only. Mature (stages IV & V), ripe and spent fishes occurred during this period and in a high percentage of occurrence in September (Tables 5 & 6) indicating that the spawning of this species is around September.

No information is available with regard to the spawning season of *A. rochei* from Indian waters. Jones and Kumaran (1963) opined that the areas between Madagascar and the coast of Africa are the possible spawning grounds for this species. Their assumption was based on the collection of 20 larval *A. rochei* in the *Dana* collection from the Indian Ocean. *A. rochei* is reported to spawn in August off Kaena Point, Oahu (Yoshida and Nakamura, 1965) and in late June in the waters off Kochi Perfecture and off Taiwan (Hamada *et al.*, 1973). Rodriquez-Roda (1966) had noted that one fourth of the females sampled during September had spent gonads.

TABLE 5. *Percentage of different maturity stages of males of* A. rochei *in various months*

Month	No. of specimens	Maturity stages						
		I	II	III	IV	V	VI	VII
January	No samples	..	..	..	..	..	..	..
February	No samples	..	..	..	..	..	..	..
March	No samples	..	..	..	..	..	..	..
April	No samples	..	..	..	..	..	..	..
May	No samples	..	..	..	..	..	..	..
June	No samples	..	..	..	..	..	..	..
July	No samples	..	..	..	..	..	..	..
August	No samples	..	..	..	..	..	..	..
September	156	..	0.6	..	29.5	30.1	7.7	32.1
October	27	29.6	37.0	3.7	3.7	..	3.7	22.2
November	60	5.0	90.0	..	..	..	..	5.0
December	21	100.0	..	..	..	..	..	..

TABLE 6. *Percentage of different maturity stages of females of* A. rochei *in various months*

Month	No. of specimens	Maturity stages						
		I	II	III	IV	V	VI	VII
January	No samples	..	..	..	..	..	..	..
February	No samples	..	..	..	..	..	..	..
March	No samples	..	..	..	..	..	..	..
April	No samples	..	..	..	..	..	..	..
May	No samples	..	..	..	..	..	..	..
June	No samples	..	..	..	..	..	..	..
July	No samples	..	..	..	..	..	..	..
August	No samples	..	..	..	..	..	..	..
September	217	..	..	0.9	36.0	44.7	1.4	17.0
October	15	..	73.3	..	..	..	..	26.7
November	53	5.7	92.3	..	..	..	..	1.9
December	38	100.0	..	..	..	..	..	..

SPAWNING PERIODICITY

Euthynnus affinis

The ova diameter frequency polygon of *E. affinis* depicting the development of ova through various stages of maturity is presented in Fig. 2. One micro-division indicates 0.0175 mm. In stage I evidently ova were immature and yolkless and 5-8 md size. In stage II the eggs were immature, transparent and commencement of deposition of yolk granules around the nucleus and spreading towards the periphery had been observed. A mode at 12 md was seen in this stage. Differentiation of ova from the egg could be seen in stage III forming two modes at 16 md and 12 md while the former mode representing the maturing group of ova had yolk layering almost 3/4 of each ovum area, the latter mode is represented by immature eggs. In stage IV there was a major mode at 32 md comprising the fully mature ova. Each ovum had perivitelline space and the transparency had commenced at the periphery. This mode was clearly separated from four modes at 16, 22, 16 and 12 md. Ova of the first two modes *viz.*, at 26 and 22 md were in the process of attaining maturity since all the ova appeared completly opaque, and ova of other two modes at 16 and 12 md represented maturing and immature eggs respectively. In stage V three modes could be observed at 36, 22 and 12 md representing fully mature, maturing and immature eggs. The ripe ovary (stage VI) indicated multimodes. One group of modes *viz.*, 56, 50, 46 and 40 md collectively represented the ripe ova. All the ova in these groups were transparent and vacuolated. The average diameter of ova in this group was 52.47 md (0.80 mm) in preserved material whereas they measured 56.15 md (0.89 mm) in samples drawn from fresh ovaries. Each ripe ovum possessed a single round and

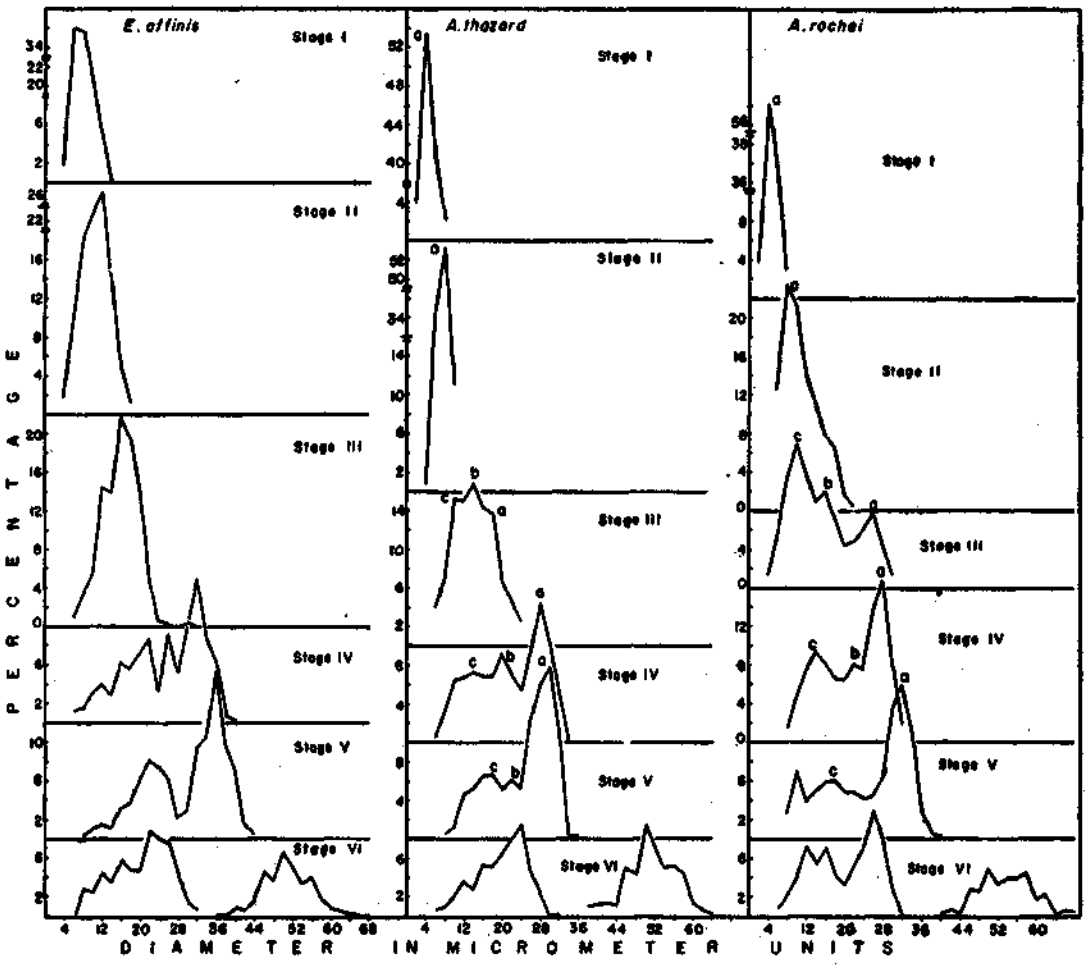

Fig. 4. Ova diameter frequency polygon of *E. affinis*, *A. thazard* and *A. rochei* at Mangalore.

yellowish oil globule measuring 15 md (0.24 mm) in both preserved and fresh material. The other groups of modes in the ripe ovary at 22 md represented mature ova ; at 16 md maturing ova and 12 and 8 md immature ova. Since these two groups of modes were separated from each other this would indicate that the ripe ova may be extruded soon in the ensuing spawning. Based on the ova diameter studies June (1953) and Bunag (1958) have shown that in several species of tuna all the ova destained to be spawned during the spawning season do not mature at once, but are developed and spawned in batches. Rao (1964) and Bunag (1958) reported that *E. affinis* spawns more than one batch of eggs during a spawning season. The present investigation is also in confirmity with the above findings. Rao (1964) reported that the ripe ovum of *E. affinis* measured 0.99 mm and 0.81 mm in fresh and preserved materials respectively and the oil globules measured 0.25 mm. Bunag (1958) speculated that the ripe eggs would probably be between 0.88 and 1.11 mm in diameter.

Auxis thazard

In Fig. 7 the size distribution of ova from various stages of maturity in *A. thazard* are plotted. In stage I and II the ova were immature coming under a single mode 'a' which is at 4 and 8 md respectively. In stage III, two modes 'a' at 18 and 'b' at 14 md representing ova are discernible, in addition to another mode 'c' at 10 md comprising of immature ova. In stage IV, mode 'a' shifted to 28 md and 'b' to 20 md and 'c' to 14 md representing three groups of ova *viz.*, mature, early mature and maturing. In stage V, mode 'a' progressed to 30 md, 'b' to 22 and 'c' to 18 md. The ova diameter studies show that in some ovaries of stage V the mature ova seem to, appear much smaller in size than the mature ova of some ovaries of stage IV. In the former the ovaries appeared granulated and the mature ova ranged from 25-31 md in diameter with an average of 27.7 md. The ovum vacuolation process seems to commence uniformly over the entire ovum rendering it semitranslucent. In the latter, the ovary appeared to have a granulated appearance and the mature ova varied from 27-37 md (average 31.7 md) in diameter. The periphery of the ovum looked transparent while major portion was opaque. In stage VI, the fully ripe ova have modes at 56, 50 and 46 md. Besides these ripe ova groups, the other groups representing mature, maturing and immature eggs have modes at 24, 16 and 12 md respectively. The above observations conclusively show that in this species also as in the case of *E. affinis* the spawning extends over a prolonged period and the eggs are released in successive batches as indicated by Rao (1964).

In fresh material, the ripe ova were spherical and tinged pinkish. The average diameter of the ova measured 0.87 mm and 0.80 mm in fresh and preserved material respectively. Each ripe ovum contained a single oil globule the average diameter of it was 0.23 mm. Rao (1964) stated that the average diameter of ova in ripe ovaries as 0.97 mm and 0.86 mm in fresh and preserved material respectively and oil globule measuring at an average of 0.22 mm. Yoshida and Nakamura (1965) observed that the residual eggs of *A. thazard* measured between 0.75 mm and 1.30 mm with an average size of 1.08 mm.

Auxis rochei

Ova diameter frequency polygons of different maturity stages of *A. rochei* are given in Fig. 27. In stage I immature eggs formed a mode 'a' at 4 md and in the subsequent stage it shifted to 8 md. In stage III the ova got differentiated into three batches forming modes 'a' at 26 md 'b' at 16 md and 'c' at 10 md representing mature, maturing and immature ova groups respectively. In stage IV, mode 'a' shifted to 28 md ; 'b' to 22 md and 'c' to 14 md. In stage V mode 'a' and 'c' could be seen at 32 md and 18 md respectively whereas mode 'b' disappeared. This may be due to the fast growth of this group of ova and got included with mature group 'a'. Besides this, another fresh batch of ova with mode 'd' at 10 md was also observed. In stage VI the ripe ova measured between 40 and 68 md and had distinct modes at 42, 46, 50, 58 and 62 md. These modes were clearly separated from the mature ova with mode at 26 md, the maturing groups of ova at 16 md and immature group of ova at 12 md. The presence of ripe ova group besides the mature, maturing and immature ova groups indicates that the spawning in this species is similar to that of *E. affinis* and *A. thazard*, by releasing eggs in batches and as such the spawning is extended over a protracted period. The ripe ova of *A. rochei* on an average measured 0.84 mm in the preserved material. Each ovum possessed a single round oil globule, saffron in colour and measured on an average about 0.20 mm.

Relative Condition (Kn)

Euthynnus affinis

Mean Kn values for different months and in relation to various sizes in respect of 82 males and 70 females are shown in Fig. 8 and 9. It can be seen that in both sexes Kn values showed a peak in June followed by an

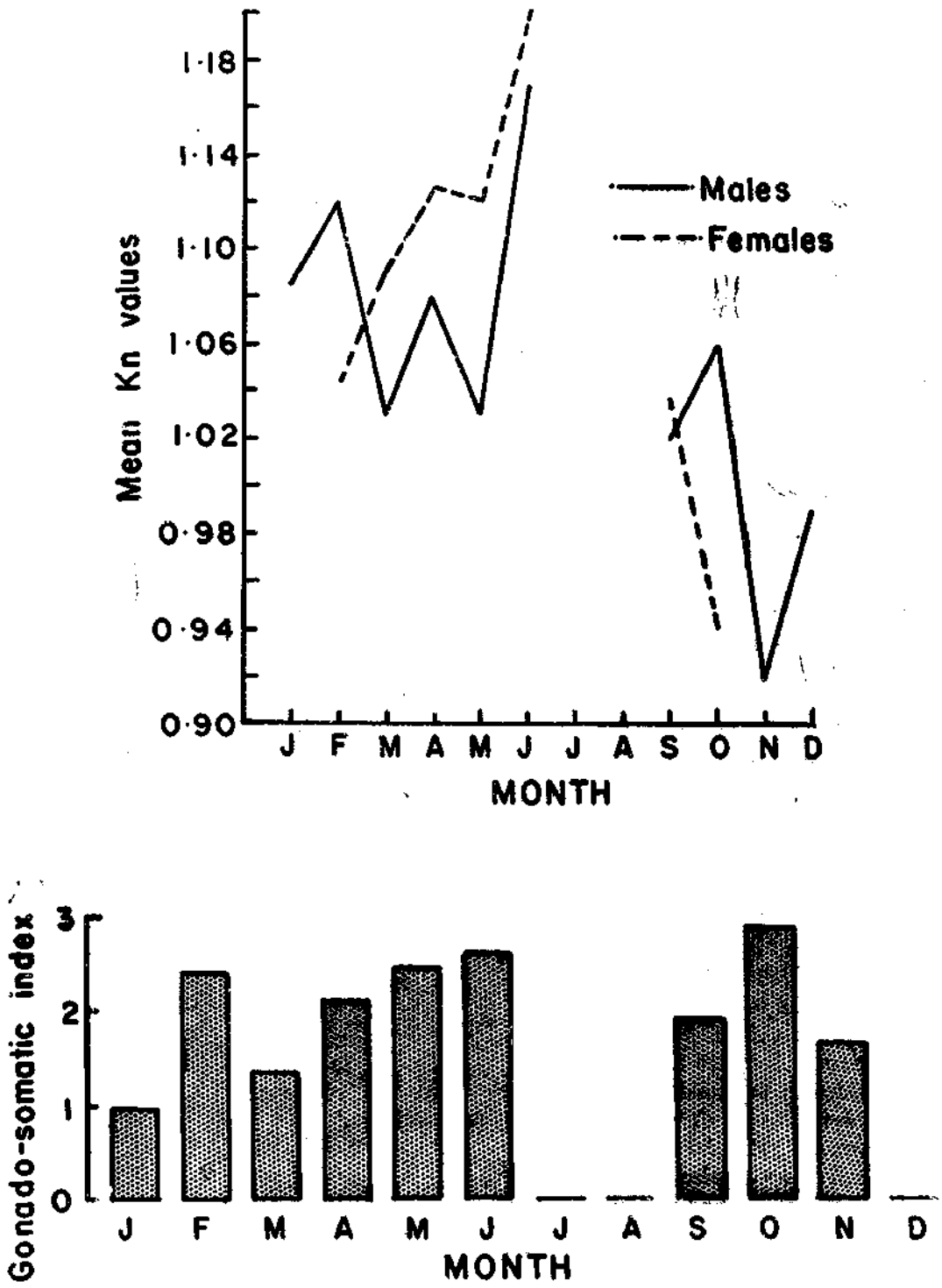

Fig. 5. Mean Kn values of males and females of *E. affinis* in different months (top) and gonadosomatic index values of males and females of *E. affinis* in different months (bottom) at Mangalore.

abrupt fall in September and attaining a minimum in October-November. Thereafter, in males the values increased till February and dropped slightly in March. Again there was another increase in April and fall in May. In females the values showed increasing trend from February. Higher Kn value in June appears to be due to accumulation of fat in the body prior to maturation and the low values in September-December are an indication of the onset of spawning. The low values in February in the case of females and March in the case of males may be attributed to spawning of another batch of ova as it is evident from the ova diameter studies that in this species spawning is fract. tional.

High Gonado-Somatic Index values (Fig. 8) are based on the study of 80 males and females in October, February and May-June may be attributed to the full development of gonads and it is indicative that this species spawns during the above months.

Mean Kn values derived out of 183 and 198 males and females respectively for different size groups are given in Fig. 9. It may be seen that the values for females showed a gradual rise from 34 cm size group onwards, reaching a peak in 40 cm size group. A decreasing trend in the values was seen from the next size and attaining the lowest in the 46 cm size group. Since fish in 34 cm size groups are immature, the high values in the 40 cm size might be due to the accumulation of fat prior to spawning and the decreasing trend in the 42-46 cm size could be due to spawning activity. The rise in the values in 52, 58 and 64 cm size and the immediate fall in the next size groups in 54 and 62 cm seems to be associated with later successive spawnings.

In males (Fig. 9), the Kn values showed an increasing trend in the 36 cm and drop in 38 cm groups. Again an increase in 40 cm size followed by a slight fall in 42 cm and rise in 44 cm and thence a decreasing trend is evident. As seen in the case of females, the males upto 40 cm were immature. Hence the rise in the 44 cm size might be related to the building up of gonad activity and the decreasing trend after this size might indicate the first spawning. The rise in 56 cm and 60 cm and drop in 58 and 64-66 cm size might be due to the preparations prior to maturity and spawning activity respectively.

Auxis thazard

Fig. 10 show the mean Kn values for different size groups derived from 389 males and 401 females. Kn values for immature females in the 20-22 cm size groups were very low. An increase in the values in the next size (24 cm) and a decline in the 26 cm size seem

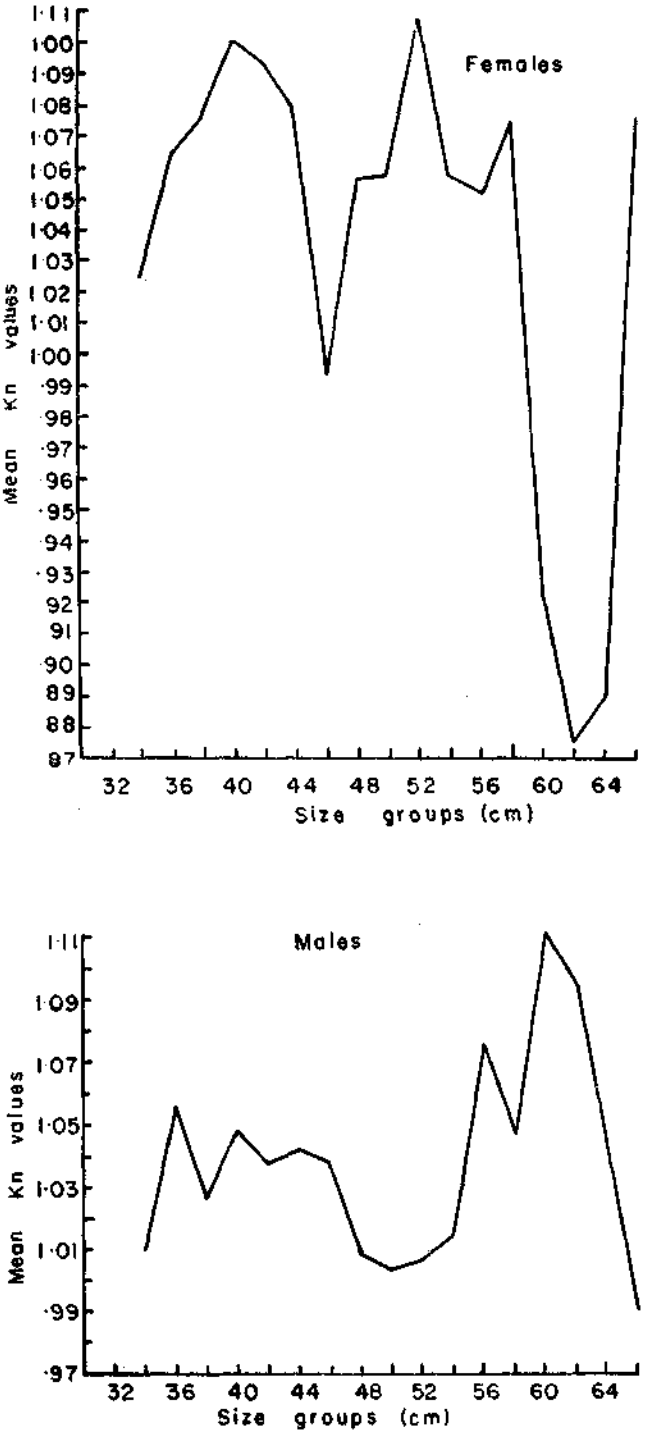

Fig. 6. Mean Kn value of females (top) and males (bottom) of *E. affinis* in different size groups at Mangalore.

to be associated with factors other than maturation of gonads, since fish in these sizes were already in maturing stage. Next to this size, values showed steady increase upto 30 cm indicating that the fish

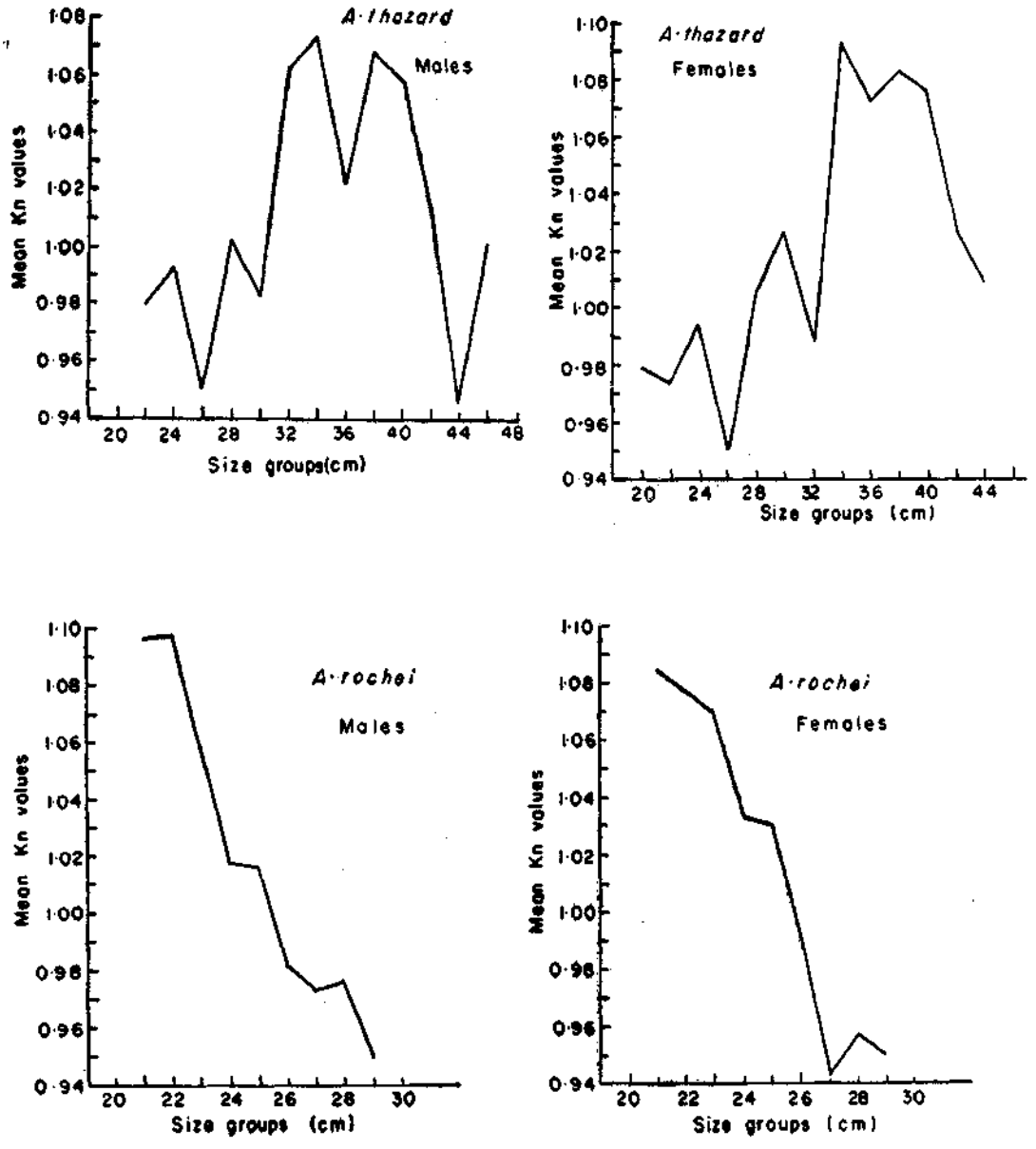

Fig. 7. Mean Kn values of males and females of *A. thazard* (upper panel) and *A. rochei* (lower panel) in different size groups at Mangalore.

accumulate fat in the body prior to spawning. The abrupt decrease in fish measuring at 32 cm size is indicative of the commencement of spawning. The Kn values were on the rise again in 34 and 38 cm sizes followed by decrease in their next size groups (36 and 40 cms) which may be related to the subsequent spawnings. The fluctuation in the Kn values for males follows a similar pattern as observed in the case of females except that the full growth of gonads in males is indicated at 28 cm size.

Auxis rochei

Mean Kn values for various length groups calculated from 158 males and 221 females are shown in Fig. 10. It is seen that the values in females were high in the 21 cm size groups and showed a trough in the 24-25 cm and 27 cm size groups. Since fish upto 22 cm were in

immature stages of maturity and the occurrence of a few individuals in ripe gonads in the 23 cm size group indicates that the inflexion in the 24-25 cm and again in the 27-28 cm size might be due to successive spawning activities of the fish. The fluctuation in the Kn values for males follow a similar pattern as observed in the case of females.

Sex Ratio

Euthynnus affinis

Sexes could be differentiated in fish measuring more than 34 cm. A total of 405 specimens were examined for sex ratio analysis, of which 198 were males and 207 females. The male to female ratio was 1 : 1.05 showing no significant departure from the normal expected value.

The results indicated that the observed proportion of males in different months is not significant (Table 7). Further, the analysis of sex ratio (Table 8) in different size groups revealed that there was no significant departure from the 1 : 1 ratio upto 50 cm size, however, significant departure at 5% level was noticed in the 52 and 54 cm indicating the preponderance of females. In the case of males it was in fishes measuring 62 and 66 cm. Williamson (1970) observed that sexes were equally distributed from 38 to 49 cm group where as from 50 to 73 cm groups the males dominated.

Table 7. *Results of Chi-square test for the proportion of males of* E. affinis *in the monthly samples during* 1979-'82

Month	No. of specimens	Males	Females	Chi-square	Significant or not significant at 5% level
January	2	2	..	2.00	NS
February	5	3	2	0.20	NS
March	9	3	6	2.00	NS
April	12	9	3	3.00	NS
May	18	8	10	0.22	NS
June	8	5	3	0.50	NS
July	No sample	—	..	..	..
August	No sample	..	..	..	..
September	47	26	21	0.53	NS
October	258	120	138	1.26	NS
November	44	20	24	0.36	NS
December	2	2	..	0.20	NS

Degrees of freedom : 1 in all cases; NS = No significant; S = Significant.

Table 8. *Results of Chi-square test for the proportion of male in various size groups of* E. affinis *during* 1979-'82

Length group	No. of specimens	Males	Females	Chi-square	Significant or not at 5% level
34	24	13	11	0.17	NS
36	23	8	15	2.13	NS
38	15	7	8	0.06	NS
40	3	2	1	0.33	NS
42	4	1	3	1.00	NS
44	30	11	19	1.20	NS
46	22	10	12	0.18	NS
48	29	14	15	0.03	NS
50	31	11	20	2.61	NS
52	29	9	20	4.17	S
54	44	15	29	4.45	S
56	39	21	18	0.23	NS
58	31	18	13	0.81	NS
60	26	17	9	2.46	NS
62	16	13	3	6.25	S
64	13	9	4	1.92	NS
66	12	11	1	8.33	S
68	5	4	1	1.80	NS
70	2	2	..	1.00	NS

Auxis thazard

Differentiation in sexes could be made from 24 cm size onwards. Out of 774 fishes examined, 359 were males and 415 females (ratio 1 : 1.16) and it was significant at 5% level. The proportion of males during various months (Table 9) show that the females

Table 9. *Results of Chi-square test for the proportion of males of* A. thazard *in the monthly samples during* 1979-'82

Month	No. of specimens	Males	Females	Chi-square	Significant or not significant at 5% level
January	No samples	..	..	..	..
February	No samples	..	..	..	..
March	2	..	2	2.00	NS
April	4	3	1	1.00	NS
May	5	4	1	1.80	NS
June	No samples	..	..	..	..
July	No samples	..	..	..	..
August	No samples	..	..	..	..
September	96	53	43	1.04	NS
October	459	213	246	2.37	NS
November	202	86	116	4.46	S
December	6	..	6	6.00	S

dominated during October and November (significant at 5% level) and this period coincides with active spawning of this species. Significant deviation at 5% level was noticed (Table 10) in the 28 and 38 cm due to the predominance of females. Sivasubramaniam (1973) reported that in Sri Lanka waters, *A. thazard* showed no noticeable differences from expected ratio except in one area along the southwest coast of the island where the ratio was 1 : 1.5.

Auxis rochei

Sexes could be differentiated in fish measuring 21 cm size onwards. Out of 664 fish sampled, 326 were males and 336 females, the male to female ratio being 1 : 1.02 and found to be not significant. Monthwise sex ratio (Table 11) show that during October and December there was significant departure from 1 : 1 ratio at 5% level and this was due to the predominance of male. However, lengthwise, both sexes (Table 12) were equally distributed. Hamada *et al.* (1973), reported that both sexes of this species were equally represented in the waters of Kochi and Tohoku Perfecture, Japan and also off Taiwan. Studies by Rodriquez-Roda (1966) from Barbate, Tarifa and La Linea in Spanish waters showed no significant departure from 1 : 1 ratio except at La Linea where males dominated.

TABLE 10. *Results of Chi-square test for the proportion of males in various size groups of* A. thazard *during* 1979-'82

Length group	No. of specimens	Males	Females	Chi-square	Significant or not at 5% level
20	1	..	1	1.00	NS
22	5	2	3	0.20	NS
24	60	26	34	1.07	NS
26	122	64	58	0.30	NS
28	66	24	42	4.91	S
30	92	39	53	2.13	NS
32	75	38	37	0.01	NS
34	78	38	40	0.05	NS
36	108	41	67	6.26	S
38	83	40	43	0.05	NS
40	38	17	21	0.21	NS
42	13	6	7	0.08	NS
44	5	1	4	1.80	NS

TABLE 11. *Results of Chi-square test for the proportion of males of* A. rochei *in the monthly samples during* 1979-'82

Month	No. of specimens	Males	Females	Chi-square	Significan or not at 5% level
January	No samples	..	..	..	..
February	No samples	..	..	..	..
March	No samples	..	..	..	..
April	No samples	..	..	..	..
May	No samples	..	..	..	..
June	No samples	..	..	..	..
July	No samples	..	..	..	..
August	No samples	..	..	..	..
September	446	216	230	0.44	NS
October	45	30	15	5.00	S
November	114	61	53	0.56	NS
December	59	21	38	4.90	S

TABLE 12. *Results of Chi-square test for the proportion of males in various size groups of* A. rochei *during* 1979-'82

Length group	No. of specimens	Male	Female	Chi-square	Significant or not at 5% level
20	38	14	24	2.63	NS
22	139	74	65	0.58	NS
24	98	46	52	0.36	NS
26	260	124	136	0.55	NS
28	127	69	58	0.19	NS
30	2	1	1	0.00	NS

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