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Research Article

Maturation and spawning frequencies of *Atropus atropos* from Mangalore coast, Karnataka, India

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ABSTRACT

The cleftbelly trevally (*Atropus atropos*) belonging to the family Carangidae is one of the important pelagic fish landed by trawlers along the Mangalore coast. Maturation studies carried was out on *A. atropos* samples collected from commercial landings during August 2015 to May 2017 showed the dominance of female with the male to female ratio of 1:1.16 & 1: 1.23. The Gonado Somatic Index values ranged between 0.43 to 2.09 in male and in case of the female, it fluctuated from 1.03 to 3.53 during the year 2015- 16 and 0.62 to 2.32 & 1.51 to 3.56 for male and female respectively during the year 2016-17. The fecundity ranged from 33,298 to 1, 88,675 eggs with an average of 94,083 eggs. The ova diameter ranged from 0.113 mm to 0.787 mm. From the maturity stage study it is clear that *A. atropos* is a prolonged spawner from September to December and March to May during both the years. The minimum size at sexual maturity was at 160-180 mm and 180-200 mm (TL) for male and female respectively. The logarithmic relationship between fecundity, total length, body weight and ovary weight were also calculated.

INTRODUCTION

The fishes of the family Carangidae are one of the important resources from Indian waters as they constitute nearly 13.22% of the annual marine fish landings of 3.73 mt during the year 2016-17 as against the all-time high of 3.94 mt during 2012 (Anon., 2017).

The state of Karnataka has a coastline 320 km and constitutes nearly 15% of the coastline with numerous river mouths, lagoons, bays, creeks, and a few islands. Mangalore fishing harbor is one of the important landing centers of Karnataka coast, contributing more than 40 percent of the total catch of Karnataka. There are about 96 fish landing centers in the state. Mangalore and Malpe in South and Karwar in the north are major landing centers. The main types of fishing are purse-seine, trawl and gill net. Number of trawlers operating along the Karnataka is 2847 of which 1050 trawlers are operated from Mangalore fishing harbor (Kumar *et al.*, 2015)

From studies conducted on the fishery and biology of various carangids from the Mangalore area, it was observed that *A. atropos* which is locally known as "Kurchi" occurred in small quantities in the commercial catches throughout the year. A perusal of literature revealed that information available on fishery and biology of *A. atropos* of trawling grounds along Mangalore coast is meager except a brief account of its presence in carangid landings (Sreenivasan, 1974; Rao *et al.*, 1985; Kasim *et al.*, 1986 and Anon., 2017).

MATERIALS AND METHODS

The present study on *A. atropos* from Mangalore is based on a random sample of 1601 specimens, in the size range from 100 to 265 mm (TL), consisting of 704 males and 897 females. Fortnightly samples were collected from the Mangalore fishing harbor (Lat. 12°50'54"N; Long. 74°50'11"E) and fish market from August 2015 to May 2017 (Plate. 1 & 2). The length, weight, sex, and stage of maturity of individual fish in each sample were noted. The gonad was then carefully removed and preserved in 5% formalin for further analyses.

In the laboratory, the total length (mm), weight (g), sex and maturity stage of individual fish were noted. The ovaries of matured females were preserved in 5% formalin for further studies. Six stages of maturity (immature, maturing, early mature, late mature, gravid and spent) were recognized on the macroscopic appearance of the ovary and microscopic characteristics of ova. Eggs were measured by an ocular micrometer. Frequency polygons were drawn for all the stages of

maturity to find out the frequency of spawning. Gonado Somatic Index (GSI) was calculated by using the formula, gonad weight x 100/ fish weight. Size at first maturity was determined by cumulative percentage frequency method and the relative condition factor (Kn) values at various size groups were calculated. Fecundity was estimated by using ovaries of stages IV and V. Sex-ratio was calculated for different months and different size groups of fish.

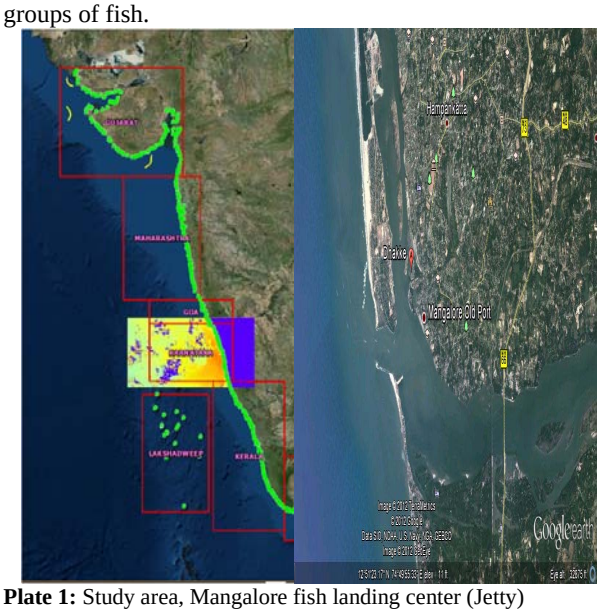

Plate 1: Study area, Mangalore fish landing center (Jetty) Lat.12°50'54"N; Long. 74°50'11"E

Plate 2: Cleftbelly trevally (*Atropus atropos*)

RESULTS AND DISCUSSION

Ovaries belonging to seven stages of maturity were selected and the ova diameter frequency polygons of these ovaries were drawn. The data are presented in (Fig. 1).

In stage I, the size of ova ranged from 0.113 mm to 0.377 mm, the majority of them varying in size from 0.113 mm to 0.237 mm. There is only one batch of immature ova with a mode at 0.116 mm. While in stage II, the ova diameter had increased and the size of ova ranged from 0.237 cm to 0.398 mm with the mode shifted to 0.24. The maturing group had a modal value at 0.291 mm, while the largest ova measured 0.533 mm. As development progressed in stage III, this mode shifted to 0.29. In stage IV, the mode formed at 0.312 mm, the maximum size being at 0.567 mm. The mode formed at 0.29 mm progressed to 0.31mm with a secondary mode at 0.225 mm. In stage V, the ova ranged from 0.425 mm to 0.742 mm, although the major mode shifted to 0.42 mm, the secondary mode observed at 0.33 mm. In stage VI, this progressed to 0.575 mm, the maximum size was 0.787 mm. the mode at 0.42 mm progressed to 0.575 mm with a secondary mode at 0.36 mm. In stage VII, there was a mode as 0.195 mm, the maximum size of ova being 0.385 mm. this stage resembled I or II stages, only immature ova were discernible with the mode at 0.195 mm fish seems to remain in this condition until the cycle commences again.

Poojary *et al.* (2015) studied reproductive biology of the Indian scad, *Decapterus russelli* from Maharashtra waters, north-west coast of India. They reported that the ova diameter ranged from 0.01 to 0.97 mm.

Spawning habits

A. atropos may be considered as prolonged spawner spawning twice in a season as evidenced from the ova diameter studies.

Spawning season

The spawning season was determined on the basis of occurrence of individuals in mature, ripe and spent stages of maturity in each month. The changes in occurrence of gonads of *A. atropos* in different stages of maturity are presented in Fig. 2 A & B, for the year August, 2015 t0 May, 2016 and Fig. 3 A & B, for the year August, 2016 t0 May, 2017 respectively.

August, 2015 to May, 2016

Male

The results of the gonadal maturity of male during August showed only I, II, III and VII stage, stage I and II being most predominant. In September IV, V, VI and VII stages were present, with stages IV and VI being most predominant. In the month October the maturity stages of III and IV were present but stage IV being most predominant. In November I, II, III, IV and VI stages were present, stages I & II were predominant. January showed I & II stages, stage I was most predominant. In February stages I, II, III & IV were recorded with stage I and II being dominant. In March & April stages I, II, III & V were observed with the dominance of stage I & II in the month of March, whereas in the month of April stage III & V being dominant. Maturity stages II to VI were recorded during May, the dominant being stage VI.

Female

The results of the gonadal maturity of the female during August showed only II, III and VII stage, stage II and III being most predominant. September & October showed the presence of III, IV and V stages with stages III and IV being most predominant. In the month of November and December stage I to VI were present but the stage I and II being most predominant in November and stage I to III were dominant in December. January

showed I, II, III and VII stage, stage I & II were most predominant. February showed I, II & III stages but with the percentage of stage III increased compared to previous months. In March stages I, II & IV were recorded with stage I and II being dominant. In April stages I to VI were observed with the dominance of stage II whereas in the month of May stages II to VII was present with stage V being dominant

August, 2016 to May, 2017

Male

The results of the gonadal maturity of the male during August showed only I, II, III and VII stage, stage I being most predominant. September showed the presence of the maturity stages IV, V, and VI, with stages IV and V being most predominant. In the month of October the III, IV and V stages were present the stages III & IV being most predominant. In November all the stages were present except stage V. Stages I & II were most predominant. December showed I, II & III stages, stage I was most predominant. January showed I & II stages, stage I was most predominant. In February stages I, II, III & IV were recorded with stage I and II being dominant. In March stages I, II, III, IV & V were observed with the dominance of stage I & II. April showed I, II, III, V & VI stages, stage III was most predominant. In May stages II to VI was observed, stage VI was most predominant.

Female

The results of the gonadal maturity of the male during August showed only II, III, IV and VII stage, stage II and III most predominant. September & October showed III, IV & V maturity stages with stage III being most predominant. In the month November and December stages I to VI were present, the stages I and II being most predominant. January showed I, II & III stages, stage I was most predominant. February showed I, II, III & IV stages, I & II stage were most predominant. In March stages I, II & IV were recorded with stage I and II being dominant, but with the percentage of stage IV increased compared to previous months. In April all the stages were observed with the dominance of stage V & VI whereas in the month of May stages II to VII were recorded, stages IV to VI being dominant.

The relation between the size of the fish and maturity stage

Fishes were grouped sex-wise into ten-millimeter size groups and the details of percentage occurrence of fish in various maturity stages were calculated. Fish from stage III onwards were considered as mature. The data are presented in Table 1 A & B and Table 2 A & B.

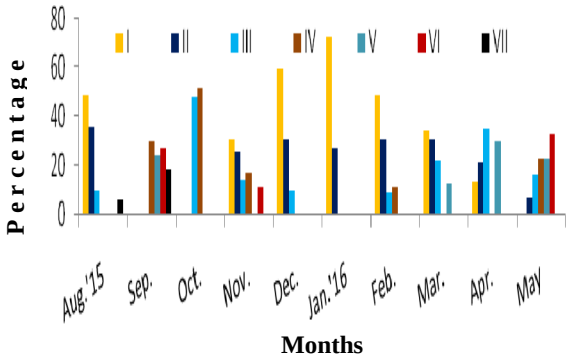

Fig. 2A: Month – wise percentage occurrence of testes in different stages of maturity of *A. atropos* (August, 2015 – May, 2016)

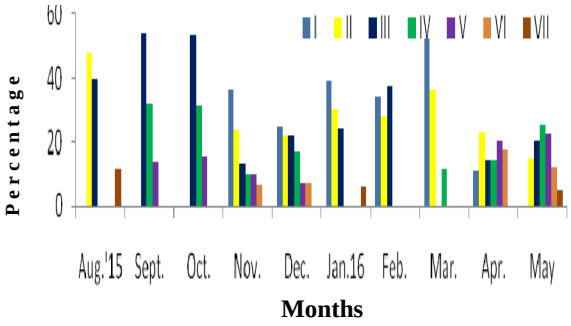

Fig. 2B : Month – wise percentage occurrence of ovary in different stages of maturity of *A.atropos* (August, 2015 – May, 2016)

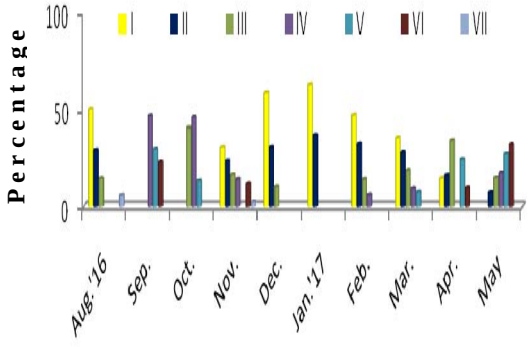

Fig. 3A: Month – wise percentage occurrence of testes in different stages of maturity of *A. atropos* (August, 2016 – May, 2017)

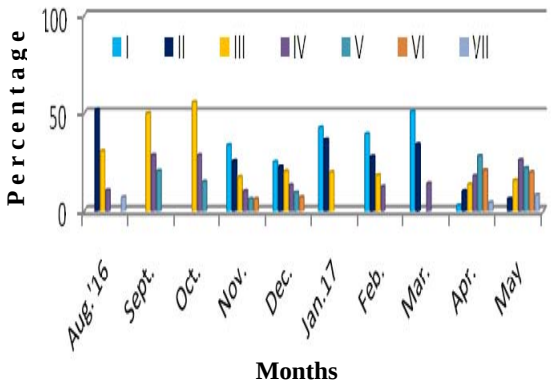

Fig. 3B: Month – wise percentage occurrence of ovary in different stages of maturity of *A. atropos* (August, 2016 – May, 2017)

From Table 1 A, it could be seen that of all the males in the size range of 10 - 12 cm, were immature. From 12 - 14 cm size group onwards mature fish start appearing. In the size group 14 - 16 cm 34.24% mature fish were found which increased to 50 % in 16 – 18 cm size group. About 58.09 % of fishes were found to be matured in the size group 16 – 18 cm. From this group onwards mature fish gradually increased to reach 100% at 24 – 26 cm.

In case of a female (Table. 1 B), all the fishes were immature up to 10 - 12 cm. From 12 - 14 cm size group onwards mature fish start appearing. The percentage of mature fish increased up to 57.33 % & 76.74% in the size group of 14 – 16 cm and 16 - 18 cm. In the size group, 18 – 20 cm, most of the fish were found to be mature (66.67 %). From this group onwards the percentage of mature fish gradually increased and found to be 58.73% and 85.7 %, at 20 - 22 cm and 22 - 24 cm size group respectively. From this group onwards mature fish gradually increased to reach 100% at 24 – 26 cm.

From Table 2 A, it could be seen that of all the males in the size range 10 - 12 cm, were immature. From 12 - 14 cm size group onwards mature fish start apperaing. In the size group 14 - 16 cm 25.84% mature fish were found which increased to 50 % in 16 – 18 cm size group. About 54.54 % of fishes were found to be matured in the size group 16 – 18 cm. From this group onwards mature fish gradually increased to reach 100% at 24 – 26 cm.

In case of female (Table. 2 B), all the fishes were immature up to 10 - 12 cm. From 12 - 14 cm size group onwards mature fish start appearing. The percentage of mature fish increased up to 47.43 % & 73.13% in the size group of 14 – 16 cm and 16 - 18 cm. In the size group 18 – 20 cm, most of the fish were found to be mature (51.72 %). From this group onwards the percentage of mature fish gradually increased and found to be 53.33% and 78.79 %, at 20 - 22 cm and 22 - 24 cm size group respectively. In the size group 22 - 24 cm to 24 - 26 cm all the fishes were in mature condition. From this group onwards mature fish gradually increased to reach 100% at 24 – 26 cm.

Poojary *et al.* (2015) studied reproductive biology of the Indian scad, *Decapterus russelli* from Maharashtra waters, northwest coast of India. They reported that the length at which 50% of the females attain maturity was calculated as 153 cm, which is in conformity with the observations of Murty (1991) and Manojkumar (2007). However Raje (1997) reported a very high value of 189 cm as the length at first maturity for *D. russelli* from Mumbai waters.

Size at first maturity

In order to determine the size at first maturity, cumulative percentage frequencies of fishes from the III stage onwards were plotted against size groups. The size at 50 % cumulative percentage was considered to indicate the overall reproductive maturity of the population as a whole. As seen from the Fig 4, it is clear that the male mature at 16 - 18 cm and female at 18 -20 cm TL respectively (August 2015 – May 2016 & August 2016 – May 2017).

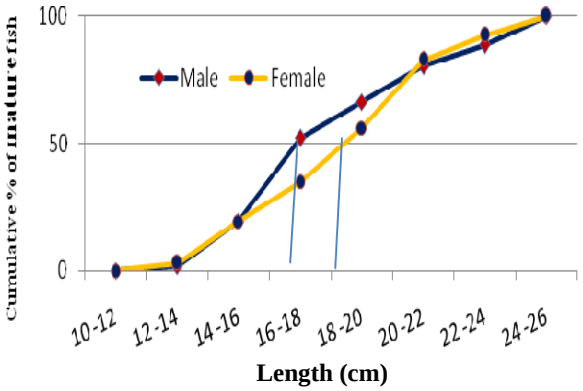

Fig. 4: Cumulative percentage frequency of mature gonads of both male and female of *A. atropos*

Gonado-Somatic Index

Gonado-Somatic Index (GSI) was calculated for each individual fish with male and female were taken into consideration separately. The average GSI values were plotted against each month and the results are presented in (Fig. 5 A & B).

During August 2015 – May 2016, the G.S.I values of male ranged between 0.43 and 2.09. The lowest G.S.I, the value was recorded in January while the highest was in May. The G.S.I. values gradually increased from February to May and fluctuation in GSI values was noticed during the period August to December.

In case of the female, the G.S.I. values fluctuated between 1.25 and 3.53. The lowest G.S.I. the value was in August, while the highest was recorded in the month of November. The G.S.I. values gradually decreased from December and January, again increased in February, March & April.

During August 2016 – May 2017, the G.S.I values ranged between 0.62 and 2.32 in case of the male. The lowest G.S.I, the value was recorded in January while the highest was in May. The G.S.I. values gradually increased from February to May and GSI values showed fluctuation during the period August to December.

In the case of the female, the G.S.I. values fluctuated between 1.51 and 3.56. The lowest G.S.I. the value was in January, while the highest was recorded in the month of May. The G.S.I. values gradually increased from February to May and fluctuation in GSI values was observed during the period August to January.

In the Indian waters, Sreenivasan (1981) reported prolonged spawning for *D. dayi* extending from February to

November with a peak during February and March. Raje (1997) reported November to May as the spawning season.

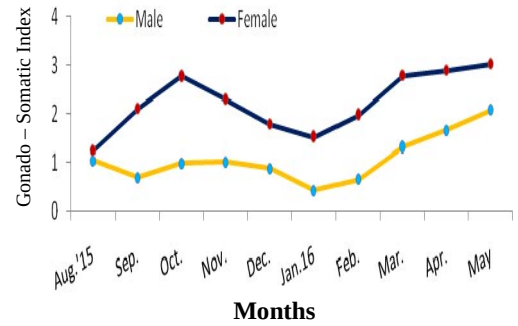

Fig. 5A: Monthly variations in Gonado-Somatic Index of *A. atropos* During August, 2015 – May, 2016.

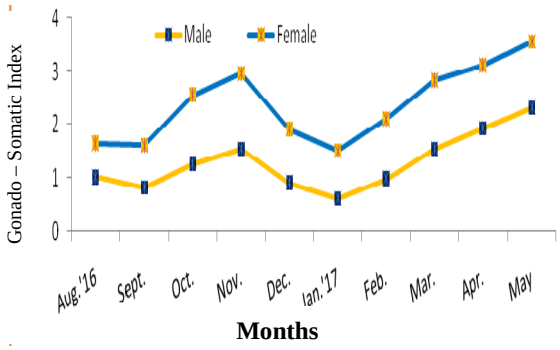

Fig. 5 B: Monthly variations in Gonado-Somatic Index of *A. atropos* During August, 2016 – May, 2017.

Fecundity

Only the mature ova were considered for the estimation of fecundity. In *A. atropos* a clear demarcation of mature and immature ova was noticed from the IV stage onwards. Hence, for fecundity studies, stages IV, V and VI were considered. Fecundity was estimated by counting the number of ova in a small portion of the ovary (anterior, middle and posterior part) of known weight and computing the total number of ova based on this count and total weight of ovary.

The details of the fecundity studies are presented in Table 3. Fecundity ranged from 33,298 to 1,88,675 eggs with an average of 94,083 eggs. The minimum weight of the matured *A. atropos* was 8.11 g. and maximum weight was 115.7 g. with length varying between 162 cm to 209 cm TL. The number of ova increased generally with an increase in length and weight. However, variations in fecundity with respect to both length and weight were also noticed.

The absolute fecundity ranged from 29,986 to 1, 52,123 eggs for the ovary weighing between 0.601 to 4.3 g. The findings on fecundity are comparable with those of Tamhane (1996). The number of ova generally increased with an increase in length and weight. However, variations in fecundity with respect to length and weight were also noticed.

The relation between fecundity and length of fish

When the logarithmic values of fecundity (Y) were plotted against logarithmic values of length (X), a linear relationship was noticed between the two variables. The relationship between length and fecundity was found to be Y = 3.138x - 5.613

Where Y = Log. fecundity and X= Log. length of fish

The correlation co-efficient "r" calculated from the logarithmic values of these two variables was 0.527.

The relationship between fecundity and weight of fish:

The relationship between the weight (W) and fecundity (F) of *A. atropos* was linear. The linear form of regression between the weight of fish and fecundity was calculated as

$$Y = 1.375x + 4.574$$

Where Y = Log. fecundity and X = Log. weight of fish

The correlation co-efficient "r" between fecundity and weight of fish was 0.565.

The relationship between fecundity and gonad weight

The logarithmic values of the fecundity (Y) when plotted against logarithmic gonad weight (X) of the fish indicated a linear regression equation of the form Y = AX + B. The calculated regression equation was given by Y = 1.248x + 9.401

Where Y = Log. fecundity and X= Log gonad weight

The correlation co-efficient "r" between fecundity and weight of ovary was 0.863.

Sex-ratio

The data on sex-ratio of *A. atropos* with respect to different size group are given in Table 4A & 4B. The predominance of female was noticed throughout the period of the study. The sex-ratio between male and female was 1: 1.16 and 1: 1.23 during August, 2015 – May 2016 and August 2016 – May 2017 respectively. The Chi-square test showed significant deviation from 1:1 during the month of August, September, and March. This may be due to fishing methods used, spawning and feeding migration.

The pooled sex-ratio (M : F) was found to be 1 : 1.23, which was statistically significant at 5 % level. It is believed that the following factors might be responsible for the sex composition, El-Farka and El-sedfy (1970). Segregation of the sexes through various periods of the year including segregation resulting from a sex difference in age and maturity. (b) Gear selectivity in relation to the sex difference in morphology and in physiological activity and (c) difference in natural and fishing mortality between sexes. Sex ratio may depend upon differential catch.

The sex ratio in different size groups showed that male *A. atropos* were dominant in the smaller size groups (10- 12 cm), while the female was dominant in the larger size groups (24- 26 cm). The dominance in the higher size groups of male and female i.e., after attaining the first maturity could be attributed to differential growth pattern. Males dominated over females in the commercial catches.

Jadhav and Mohite (2014) reported the sex-ratio of *M. cordyla* from Ratnagiri coast, Maharashtra. The results showed that in most of the months, females dominated over male and the overall male: female ratio was 1:1.3. The chi-square test showed significant deviation from 1: 1 during September and October.

Table 1A: Size – wise percentage occurrence of males in different stages of maturity (August, 2015 to May, 2016)

Size group (cm)	Number of fish	Male						
		Maturity stages						
		I	II	III	IV	V	VI	VII
10 - 12	10	70	30	-	-	-	-	-
12 - 14	23	21.74	13.04	65.22	-	-	-	-
14 - 16	73	20.55	31.5	13.71	10.95	15.07	8.22	
16 - 18	105	16.2	6.66	19.05	38.1	6.66	8.57	4.76
18 - 20	33	9.09	6.06	39.4	30.3	9.09	6.06	-
20 - 22	43	11.63	6.97	16.3	34.88	6.97	13.95	9.3
22 - 24	17	-	-	17.65	-	29.41	23.53	29.41
24 - 26	30	-	-	-	36.67	30	13.33	20

Table 1B: Size – wise percentage occurrence of females in different stages of maturity (August, 2015 to May, 2016)

Size group (cm)	Number of fish	Female						
		Maturity stages						
		I	II	III	IV	V	VI	VII
10 - 12	7	71.43	28.57	-	-	-	-	-
12 - 14	15	26.67	20	20	33.33	-	-	-
14 - 16	75	20	14.67	8	37.33	20	-	-
16 - 18	43	11.63	6.98	4.65	34.88	25.56	16.3	-
18 - 20	87	10.34	14.94	8.05	33.33	21.84	11.5	-
20 - 22	109	13.76	8.25	19.26	41.3	11.93	5.5	-
22 - 24	14	-	-	14.3	-	21.43	28.57	35.7
24 - 26	20	-	-	-	35	45	15	5

Table 2A: Size – wise percentage occurrence of males in different stages of maturity (August, 2016 to May, 2017)

Size group (cm)	Number of fish	Male						
		Maturity stages						
		I	II	III	IV	V	VI	VII
10 - 12	28	67.86	32.14	-	-	-	-	-
12 - 14	37	51.35	35.14	13.51	-	-	-	-
14 - 16	89	19.1	30.34	24.72	12.36	7.86	5.62	-
16 - 18	110	16.36	8.2	20.91	36.36	6.36	7.27	4.55
18 - 20	45	11.11	6.67	37.78	24.44	11.11	8.89	-
20 - 22	51	15.7	13.72	15.69	33.33	11.76	9.8	-
22 - 24	21	-	-	23.81	-	42.86	19.05	14.28
24 - 26	29	-	-	-	44.82	31.03	17.24	6.91

Table 2B : Size – wise percentage occurrence of females in different stages of maturity (August, 2016 to May, 2017)

Size group (cm)	Number of fish	Female						
		Maturity stages						
		I	II	III	IV	V	VI	VII
10 - 12	28	71.43	28.57	-	-	-	-	-
12 - 14	49	55.1	24.49	20.41	-	-	-	-
14 - 16	78	24.36	16.67	11.54	25.64	21.79	-	-
16 - 18	67	13.43	8.96	4.48	34.33	25.37	13.43	-
18 - 20	87	11.5	17.24	19.54	28.74	12.64	10.34	-
20 - 22	120	14.17	10.83	21.67	29.17	15.83	5.83	2.5
22 - 24	33	-	-	21.21	-	15.15	27.28	36.36
24 - 26	25	-	-	-	36	40	12	12

Table 3: Number of mature ova in individuals

Sl No	Total length(cm)	Body weight(g)	Gonad weight(g)	Fecundity	Stages of maturity
1	162	70.1	2.88	33,298	IV
2	183	90.3	3.67	67,785	V
3	189	98.5	2.66	35,731	IV

4	201	99,1	2.67	36,423	V
5	205	113.7	3.78	58,166	V
6	209	115.7	8.11	1,88,675	V
7	211	124.9	4.57	80,985	VI
8	217	127.9	7.23	1,12,600	V
9	220	130	2.58	57,785	IV
10	223	133.7	3.57	62,565	VI
11	226	135.9	3.33	65,225	VI
12	229	145.1	4.35	78,954	V
13	231	155.7	4.79	80,985	V
14	237	160.2	5.55	92,422	VI
15	241	166.9	5.89	96,764	VI
16	243	173.3	6.04	1,78,650	VI
17	248	179.1	6.15	1,12,206	V
18	250	185.3	6.67	1,01,287	V
19	257	192.9	7.16	1,56,766	VI
20	260	216.1	8.45	1,84,396	VI

Table 4 A: Sex-ratio in different size groups of *A. atropos* (August, 2015 – May, 2016)

Size group (cm)	Total no. of fish	Male		Female		Sex - ratio	Chi - Square Values
		n	%	N	%	M : F	
10 -12	17	10	58.82	7	41.18	1 : 0.7	0.52
12 -14	38	23	60.53	15	39.47	1 : 0.65	0.42
14 -16	148	73	49.32	75	50.68	1 : 1.03	0.03
16 -18	148	105	70.95	43	29.05	1 : 0.41	25.96*
18 -20	120	33	27.50	87	72.50	1 : 2.64	24.30*
20 -22	152	43	28.29	109	71.71	1 : 2.54	28.66*
22 -24	31	17	54.84	14	45.16	1 : 0.82	0.42
24 -26	50	30	60.00	20	40.00	1 : 0.67	2.00
Pooled	**704**	**334**	**51.281**	**370**	**48.719**	**1 : 1.182**	**0.678**

*Significant at 5% level

Table 4 B: Sex-ratio in different size groups of *A. atropos* (August, 2016 – May, 2017)

Size group (cm)	Total no. of fish	Male		Female		Sex - ratio	Chi - Square Values
		n	%	n	%	M : F	
10 -12	56	23	41.07	33	58.93	1 : 1.40	1.78
12 -14	86	37	43.02	49	56.98	1 : 1.30	1.68
14 -16	167	89	53.29	78	46.71	1 : 0.87	0.72
16 -18	177	110	62.15	67	37.85	1 : 0.61	0.48
18 -20	132	45	34.09	87	65.91	1 : 1.90	13.36*
20 -22	171	51	29.82	120	70.18	1 : 2.35	27.84*
22 -24	54	21	38.89	33	61.11	1 : 1.60	2.66
24 -26	54	29	53.70	25	46.30	1 : 0.50	0.30
Pooled	**897**	**405**	**44.50**	**492**	**55.49**	**1 : 1.32**	**1.27**

* Significant at 5% level.

CONCLUSION

Maturation studies carried out on *A. atropos* samples collected from commercial landings from August 2015 to May 2017. A perusal of the data on the occurrence of males and females of *A. atropos* in different stages of maturity in relation to the size of fish indicated that first maturity was attained when females measured about 18-20 cm size range and males about 16-18 cm size range. The size at first maturity was also calculated from the relative condition factor. The peak point on the curve showing the determination of relative condition 'K' with increasing length at which sexual maturity is attained (Hart, 1946).

The size at first maturity was determined by cumulative frequency method. The cumulative percentage of fishes belonging to stage III, IV and V were taken into consideration to calculate the size at first maturity. The study indicated that the male attained maturity in the size range of 16- 18 cm with an average of 17 cm. and females attained maturity in the size range of 18-20 cm with an average of 19 cm. Studies on reproductive biology showed that *A. atropos* spawns twice in a year the spawning season extending from September to December and February to May along the Mangalore coast.

In the present study, the data on the Gonado-Somatic Index (GSI) revealed that it remained relatively high in both sexes during the months of October, November and May indicating the spawning period of *A. atropos* along Mangalore coast. Males always recorded lesser Gonado-Somatic Index values than females. Female showed higher

values of Gonado-Somatic Index (GSI) than male in all the months during the study period. The sex-ratio for male and female was found to be 1:1.123 which was not significant at 5% level.

In the present study, stages IV and V ovaries were taken into consideration for the fecundity estimation. Fecundity ranged from 33,298 to 1,88,675 eggs depending upon the size of the fish and the average being 94,083 eggs per female.

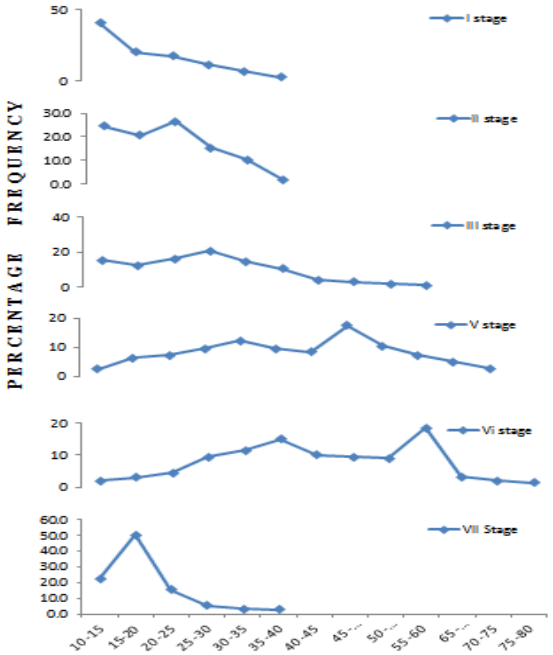

Fig. 1: Ova diameter frequency polygon of *A. atropos* (OVA Diameter (Occ.Micro.Div.) (1. O.M.D = 0.01 mm)

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