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Studies on some aspects of biology of Uranoscopus cognatus Cantor, 1849 (Pisces: Uranoscopidae) off Visakhapatnam, central eastern coast of India

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Present study aims at generating baseline data on biology of the most common species, *Uranoscopus cognatus* that includes length frequency distribution, Length-Weight Relationship (LWR), population parameters and various aspects of reproductive biology. These studies are based on 618 specimens of length range 51-189 mm TL collected during the period January 2015 to December 2016. The present study contributes to an improved understanding of biology of fish communities and the possible impact of fishing on the long-term sustainability of exploited ecosystems.

[Key words: stargazer, LWR, reproductive biology, India]

Introduction

Uranoscopus cognatus Cantor, 1849 (Fig. 1) is distributed along the eastern Indian Ocean[1]. Being a benthic fish, this species spends most of its life on sandy or muddy bottoms along the upper slope of continental shelf from 15 to 400 m depth[2,3]. It is comparatively smaller in size and slender than the other species of the genus and is unique in possessing two pairs of basipterygial processes. It mainly feeds on crustaceans and small fishes and occasionally is preyed by other fishes[4]. Stargazers are considered medically important due to their venomous "cleithral" or shoulder spines. Uranoscopids spend most of their time buried in the sand or mud with only their eyes and a portion of their mouth protruding out, waiting patiently for their prey to approach nearby.

Previous studies on some biological aspects of other species of the genus *Uranoscopus* were carried out by few authors[5-10].The present study aims at generating baseline data on biology of *U. cognatus* that includes length frequency distribution, Length-Weight Relationship (LWR), population parameters and some aspects of reproductive biology such as maturity stages, ova diameter frequency distribution, gonado-somatic index, size at first maturity and fecundity for the first time. These biological studies are essential for assessment of population stock dynamics of the fishes. Studies on ova diameter frequency distribution and fecundity are conducted to establish the abundance and rate of recruitment of the specific fish populations.

Material and Methods

Samples of *U. cognatus* were collected twice a week from trawl by-catches landed at Visakhapatnam fishing harbour and traditional fish landing centres (Fig. 2) employing beach seine, gill net, shore seine and trammel net, in the period of January 2015 to December 2016.

Total length was taken from tip of the snout to the distal end of caudal fin (TL) measured to the nearest millimetre and weighed to the nearest gram. A total of 618 specimens of *U. cognatus* of length range 51-189 mm TL, weighing 3-132 g were collected during this period. For length frequency distribution studies monthly data was pooled and subsequently grouped into classes of 10 mm intervals. LWR was studied following standard works[11]. The relationship between length and weight of the fish is estimated by the equation $W = aL^b$ Where, W -body weight of the fish (g); L-total length (mm); a-coefficient related to body form and b-exponent. Values of *b* provide information on fish growth and may range from 2.5 to 3.5[12].

Fig. 1 — *Uranoscopus cognatus* - 115 mm TL

Fulton's conditionfactor (K) was calculated as: $K= 100 (W/L^3)$, where, W= total body weight (g) and L= total length (cm). Some population parameters like $L\infty$, growth constant (*K*), natural mortality (M), fishing mortality (F), exploitation ratio (E) and total instantaneous mortality (Z) were estimated using FiSAT (version 1.2.2).

Fifty-six ovaries from female fish specimens of *U. cognatus* were analysed by macro- and microscopic examinations. Maturity stages were ascertained following standard references[13,14]. Two sub stages "Primitive" and "Advanced" were assigned to Stages I, II and III. The methodology for estimation of GSI, length at first maturity and fecundity follows standard procedures[15,16]. Estimation of spawning period was done by calculation of monthly mean gonadosomatic index from the equation GSI =100 X (W_g/W) Where, W_g = weight of the gonad (g) and W = weight of fish (g).

Length at first maturity was estimated as TL (mm) at which 50% of the specimens were in a mature condition. After measuring the total lengths of the fish, gonads were extracted and weighed to the nearest 0.1 g and preserved in 5% neutral formalin for further analyses. Gonad in maturity stage III and IV were used for fecundity and ova diameter frequency estimation. Fecundity was estimated by multiplying the number of mature oocytes in the samples taken from the anterior, middle and posterior region of ovaries by the ratio of ovary weight to sample weight. The relationships between fecundity and the three variables, total length (L), fish total weight (W) and weight of gonad (GW) were also calculated using the following equation: $F = aL^b$ Where, L = total length/ fishweight/ovary weight; *a* and *b* are constants.

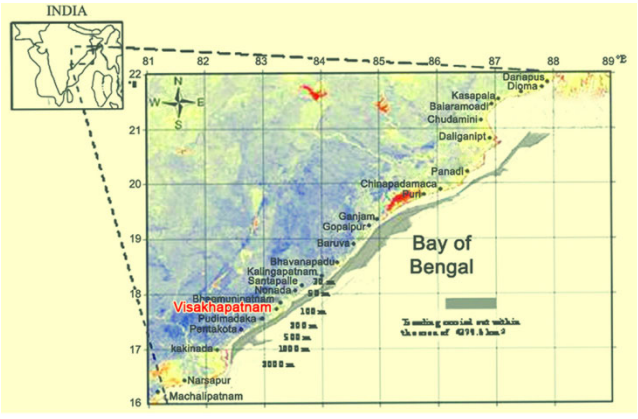

Fig. 2 — Map of the central east coast of India showing the sample collection centres.

Results

Uranoscopus cognatus of size groups 51-189 mm TL, with a mean of 139.91±1.25 mm TL, weighing 3-132 g with a mean of 54±1.30 g were represented in the catches. Juveniles in the range of 51- 92 mm TL were found in all the months in the catches. Females were in the range 93-189 mm TL, among these specimens of length range 118-189 mm TL were found with mature gonads in all the months except May and June owing to the trawl ban in the period. Males were present in the size range of 96-174 mm TL. Length frequency distribution graph is given in Fig. 3.

Males specimens displayed major mode at 111-120 mm TL, while females at 151-160 mm TL. In pooled samples major modes are present in the length groups 141-150 mm and 151-160 mm TL. Minor modes are present in the length groups 81-90 mm TL and 111-120 mm TL. Annual pooled length distribution graph is given in the Fig. 4.

The relationship between total length (L, mm) and total weight (W, g) was found to be represented by the following equations:

For males: $W=0.000195L^{2.512328}$ (r^2 = 0.935) (L range: 96-174; W range: 15-71)

For females: $W=0.000038L^{3.01048}$ (r^2 = 0.929) (L range: 93-189; W range: 15-132)

The LWR equation of *U. cognatus*is given in the Table. 1. Females exhibited isometric growth, malesnegatively allometric growth and pooled samples showed negatively allometric growth (Plate I, Figs. 1-3).

Fulton's condition factor (K) was calculated for males, females and the pooled data of the specimens in the study period. Mean value of condition factor (K) for males was 1.72±0.22 with a minimum value of 1.17 and maximum of 2.08, mean K for females was 1.81±0.22 with a minimum value of 1.02 and

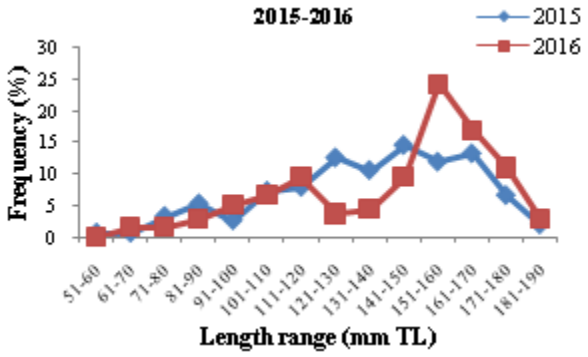

Fig. 3 — Length frequency distribution of *U. cognatus* during the period Jan 2015-Dec 2016 in the catches of Visakhapatnam

maximum of 2.41 and for the pooled data mean K was estimated to be 1.78±0.24 with a minimum value of 0.29 to maximum of 2.73 (Fig. 5a, b).

Calculated using FiSAT (version 1.2.2), L_∞ was estimated to be 195.30 mm TL, while growth constant (*K*) was 1.00 year^{-1}, naturalmortality, M was estimated to be 1.041 year^{-1} at 27° C, fishing mortality, F=1.65 year^{-1} and exploitation ratio, E = 0.61, instantaneous total mortality coefficient, Z was 2.69 year^{-1} (Fig. 6).

The females of the species showed five stages of maturity (I-V) with two sub stages in stagesI, II and III (Plate II, Figs. 1-8).

Stage I – Immature- primitive: In this stage oocytes are very small and not easily separable; Immature-advanced: some small oocytes can be seen in various states of meiosis.

Stage II– Early maturing: ovaries were dark pink and oocytes however small can be easily distinguished; Late maturing: ovaries are light yellow in colour. Small eggs are visible to naked eyes.

Stage III– Primitive: This stage was defined with large elongated ovaries occupying three-quarters to almost filling the body cavity, yellowish in colour, and many oocytes in vitellogenesis; Advanced: ovaries are elongated as well as wide with most of the oocytes seen in vitellogenesis.

Ripe stage IV was defined as translucent oocytes mostly larger than in stage III, in migratory

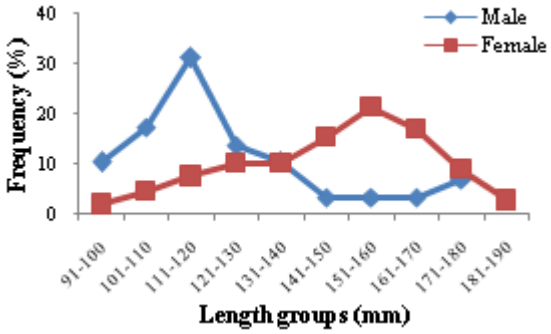

Fig. 4 — a. Length frequency distribution of *U. cognatus* male and female during the period Jan 2015- Dec 2016 in the catches of Visakhapatnam

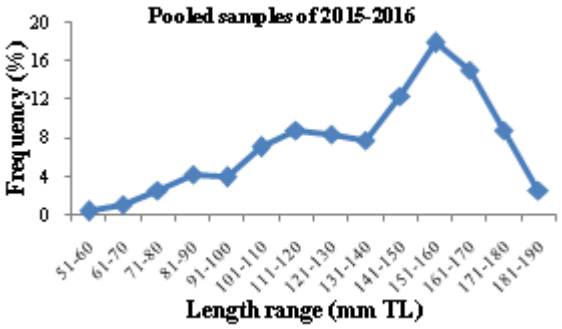

Fig. 4 — b. Annual length frequency distribution of pooled samples (J, ♂, ♀, and US) of *U. cognatus*

Plate I

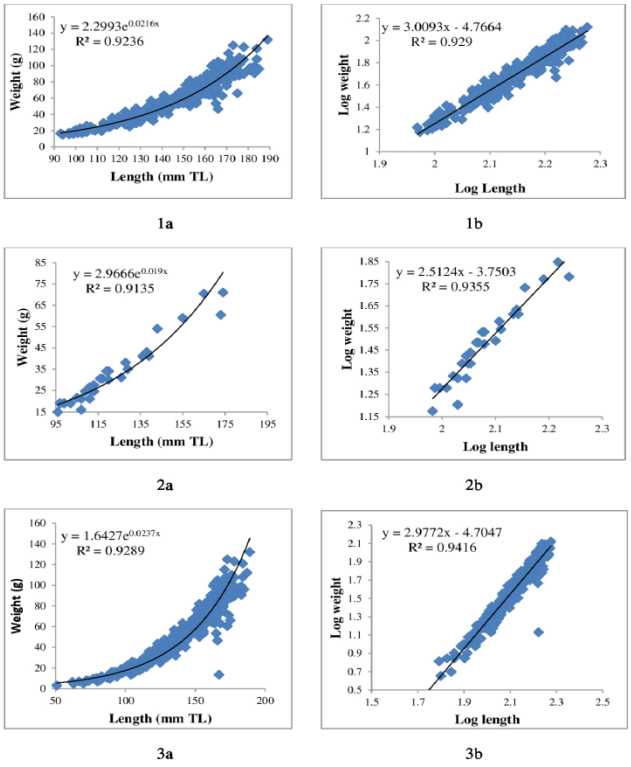

Fig. 1 — Length-weight relationship of female *U. cognatus*
Fig. 2 — Length-weight relationship of male *U. cognatus*
Fig. 3 — Length- weight relationship of pooled data of *U. cognatus*

Table 1 — Length range and length-weight relationship of males, females and pooled samples of *U. cognatus* from the catches off Visakhapatnam

U. cognatus	n	Length range (mmTL)	Weight range (g)	Log a	*b*	*W-L* equation	(r^2) original data	(r^2) log transformed data	Growth type
Males	29	96-174	15-71	-3.750	2.512	$0.000195L^{2.512}$	0.935	0.913	-A
Females	353	93-189	15-132	-4.766	3.010	$0.000038L^{3.010}$	0.929	0.923	I
All	618	51-189	3-132	-4.704	2.976	$0.00002762L^{2.98}$	0.941	0.928	-A

n = number of samples; r^2= regression coefficient

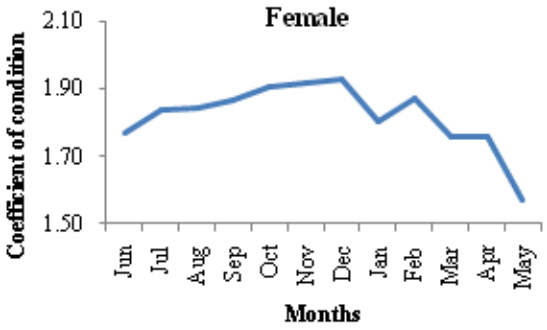

Fig. 5 — a. Monthly variation in Fulton's condition coefficient (K) of female *U. cognatus*

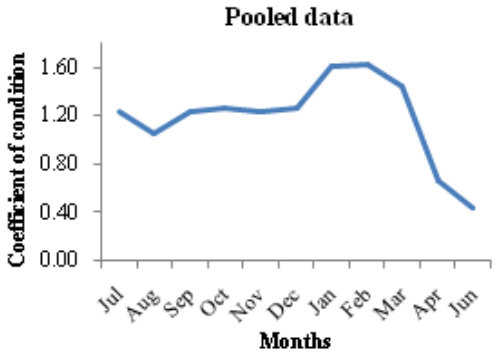

Fig. 5 — b. Monthly variation in Fulton's condition coefficient (K) of pooled data of *U. cognatus*

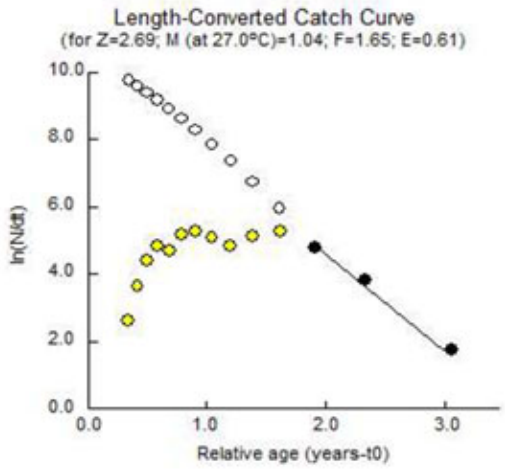

Fig. 6 — Catch curve of *U. cognatus* for estimation of total mortality (Z)

nucleus stage or hydration stage, with ovaries often flowing when applying pressure.

Stage V - spent stage had flaccid ovary of thick membrane with small mass of immature oocytes.

Detailed studies on male maturity stages could not be carried out due to lack of sufficient number of

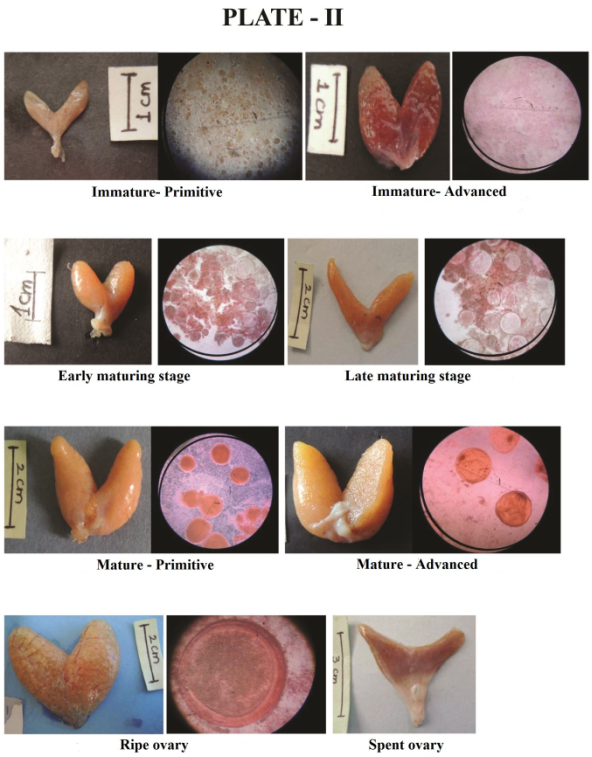

Fig. 1 — 8. Female gonadal maturity stages of *U. cognatus;* 1a-7a. Different maturity stages of oocytes observed under microscope: Fig. 1 — Immature- primitive, Fig. 2 — Immature- advanced, Fig. 3 — Early maturing stage, Fig. 4 — Late maturing stage, Fig. 5 — Mature- primitive, Fig. 6 — Mature- advanced stage, Fig. 7 — Ripe, Fig. 8 — Spent. a. Female gonad, b. Photograph showing different maturity stages of oocytes of *U. cognatus* under microscope

specimens in various stages of maturity during the study period. Only specimens in stage II (n=26) in the months of January and April and Stage IV (n=3) in November could be collected from the catches.

Ova diameter frequency polygons of different maturity stages of *U. cognatus* are given in Fig. 7. The immature stages have very small diameter, 0.11-0.25 mm. In stage II primitive, maturing eggs formed a major node at 0.45 mm with a maximum diameter at 0.65 mm. In stage II advance (late maturing stage), maturing eggs formed a major node at 0.45 mm and a minor node at 0.75 mm with a maximum diameter at 0.85 mm. In stage III primitive, major node was observed at 0.95 mm, while in stage III advance, major node was at 1.05 mm, maximum diameter being 1.25 mm. In stage IV (ripe gonad), major node was observed at 1.45 mm, while minor mode was observed at 0.95 mm, with a maximum diameter at 1.75 mm. Maturing and mature both types of ova were present in the ripe gonad indicating thatthere is prolonged spawning period.

Monthly trends in gonadosomatic index (GSI) of only females was calculated as number of male specimens were very less. As shown in the graph (Fig. 8), two peaks of GSI were seen, one in the month of July (2.48) and the other in the month of November (3.66), while the lowest was in the month of April (0.46). Percentage occurrence of females in different stages of maturity in different months during the present study has been summarised in Fig. 9. Based on Fulton's condition factor and the trend of GSI it is inferred that this species spawns twice in Indian waters, once from May to August with peak period of spawning from October to January.

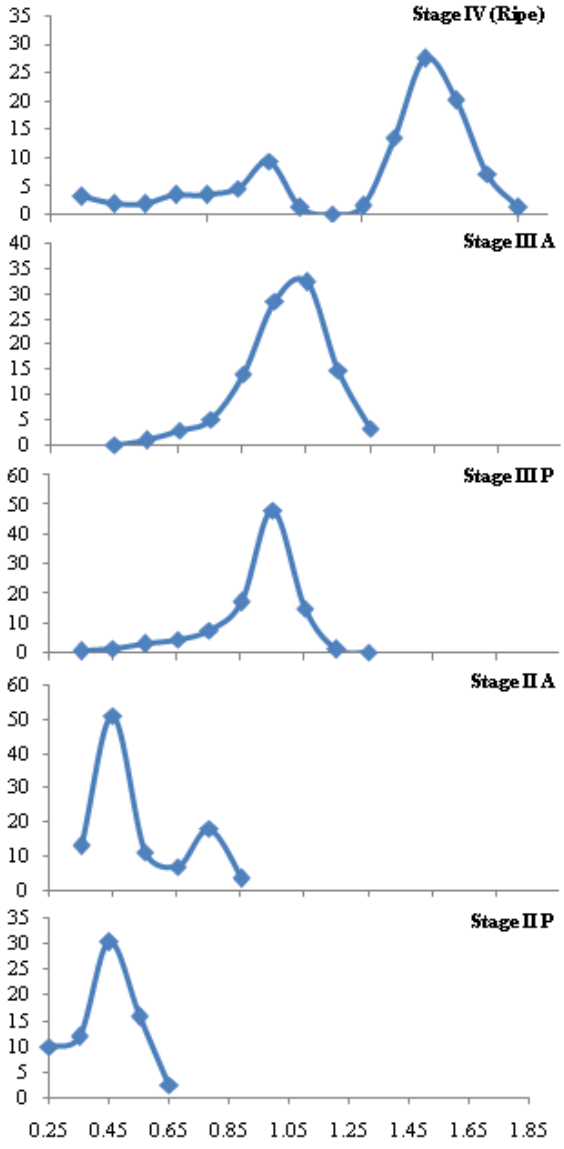

Fig. 7 — Ova diameter frequency polygons of different maturity stages of *U. cognatus*

The size at first maturity of *U. cognatus* has been estimated from a plot of percentage of mature fish in sample against total length (Fig. 10) from the monthly curve, it has been observed that 50% of females attain maturity at 133 mm TL. In the present study, it was observed that all the fish of range 92-99 mm TL were immature. They pass to maturing condition from 100 mm TL. All the fishes above 155 mm TL were mature. Size at first maturity of the males could not be determined owing to unavailability

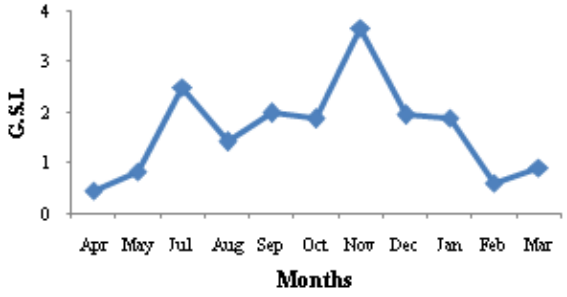

Fig. 8 — Monthly trends in gonado-somatic (G.S.I.) index of female *U. cognatus*

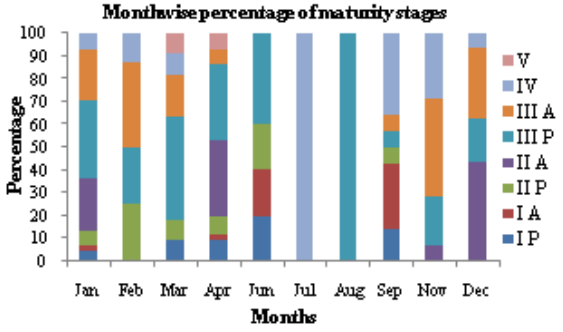

Fig. 9 — Percentage occurrence of females of *U. cognatus* in different stages of maturity in various months represented in the catches off Visakhapatnam

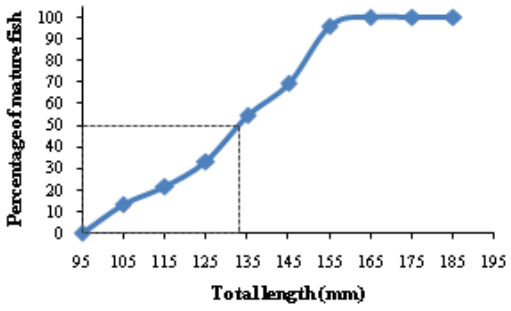

Fig. 10 — Size at first maturity (L50) of female *U. cognatus* off Visakhapatnam

of mature males in months other than January, April and November.

Fecundity of fishes is usually determined from the number of ova of the mature group of ovary. Fecundity studies were conducted by counting of eggs from 56 specimens of *U. cognatus*of length range 130-185 mm TL with mature (stage III) and ripe (stage IV) ovaries (Table. 2). The fecundity varied from 1,379 to 18,858 with an average of 7,361. Minimum and maximum fecundity were observed in fishes measuring 140 and 175 mm TL respectively; maximum ovary weight was 6.65g.

The logarithmic relationship between fecundity (F), total length (L), fish weight (W) and gonad weight (GW) are given in Plate III, Figs. 1.a-c, respectively.

Table. 2 — Fecundity estimates of *U. cognatus* represented in the catches of Visakhapatnam

S.No.	TL (mm)	W (g)	GW (g)	F (in 1000s)
1	130	37.5	0.74	2456.8
2	131	41.5	1.098	2562.00
3	138	40	1.216	4373.68
4	138	54	1.375	4990.7
5	139	50.5	1.389	2450.04
6	140	51.5	0.778	1678.84
7	140	61	2.192	6127.64
8	143	47.5	1.765	3927.12
9	145	56	1.390	4198.96
10	145	60	1.063	3396.4
11	146	60	6.51	13801.2
12	146	57	1.280	3061.96
13	146	60	1.851	3246.37
14	150	53.5	1.73	7723.21
15	151	56	0.435	2476.15
16	151	60	1.388	4341.19
17	151	69.5	2.651	9681.91
18	152	64	2.41	7350.5
19	152	54	1.26	2742.92
20	155	63	1.080	4363.2
21	156	53.5	1.00	3533.33
22	156	60.5	1.913	9692.53
23	156	62	2.082	7121.39
24	156	78.5	4.990	7297.87
25	156	59	3.255	4276.18
26	156	94	3.431	9294.10
27	157	71	2.426	8280.75
28	157	62	3.980	8934.69
29	157	79	2.0234	7829.68
30	157	76.5	2.390	14023.7
31	158	83.5	1.954	17195.2
32	159	74.5	3.064	14832.5
31	158	83.5	1.954	17195.2
32	159	74.5	3.064	14832.5
33	160	66	2.361	9444.00
34	160	63	1.697	4675.41
35	160	65	2.289	4532.22
36	161	90	4.297	11578.03
37	162	64	2.210	7027.8
38	163	84	2.263	5696.52
39	164	71	1.226	4938.05
40	164	92	1.270	12439.49
41	165	72	0.745	4363.57
42	165	80.5	4.027	13179.27
43	165	94.5	2.706	16946.3
44	168	87	1.57	5463.6
45	168	87	2.452	6884.46
46	168	93	2.002	7260.98
47	170	93	2.220	6342.86
48	170	75	1.369	4928.4
49	174	87	3.047	15304.25
50	175	97	6.65	18857.5
51	176	107	6.299	14261.87
52	177	106.5	2.34	5105.45
53	178	107.5	2.28	3625.57
54	182	96	1.897	3095.10
55	183	90.5	0.713	1316.31
56	185	96	1.093	3981.6

TL: Total Length; W: Fish body weight; GW: Gonad weight; F: Fecundity

Discussion

In the present study, more number of females of the species *U. cognatus* were found in the by-catches than males. The study shows the growth rate of females to be higher than males. This result agrees with other species *U. scaber*[6, 19], *U. guttatus*[9] and *U. marmoratus*[10]. The maximum size of *U. cognatus* recorded till now was 183 mm TL[17] from Australian waters. This study extends it to 189 mm TL. The study of LWR of this species showed non-significant differences between males and females. The result agrees with that of *U. scaber* from Spanish water[19], Mediterranean[6] and Black Sea[8].

Condition coefficient is an indicator of the variables attributed to growth. This study reveals *U. cognatus* to be in above average condition, indicating good health of fishes in the by-catches during the study period. The mean values of K correspond with *U. scaber* from Mediterranean Sea[6] (1.226 - 1.702 for males; 1.198-1.522 for females; 1.100 – 1.620 for pooled) and Black Sea[7] (1.48 - 1.84 for males; 1.54 - 1.95 for females).

L_∞ of *U. cognatus* (195.30 mm TL) is in general close to the maximum total length observed in the study 189 mm TL. This agrees with *U. scaber* from

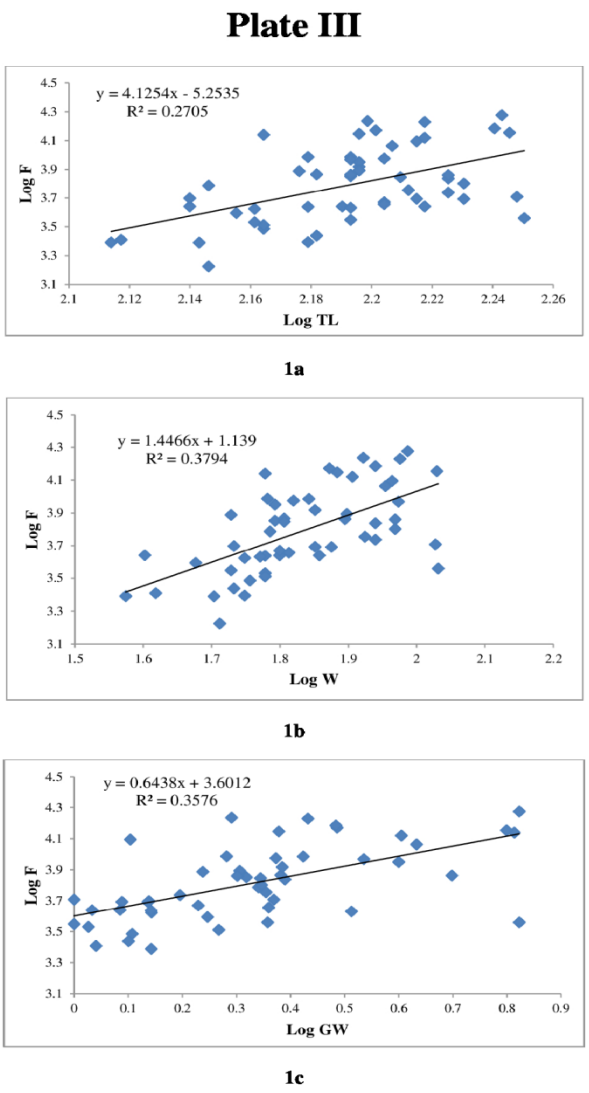

Fig. 1 — Realtionship between (a) fecundity (F)- total length (L), (b) fecundity (F) - body weight (W) and (c) fecundity (F) - ovary weight (GW) in *U. cognatus*.

Mediterranean Sea[6] and spanish waters[19]. L_∞ of *U. cognatus* is lesser than that of *U. scaber,* this may be due to the small size of the fishes of this species. Growth constant (*K*) of *U. cognatus* (1.00) was lesser than *U. scaber* (*K* = 1.67 in Black Sea; *K* = 1.603 and *K* = 1.413 in western and eastern Mediterranean Sea[6] respectively and *K* = 1.603 in spanish waters[19]) as it is the smaller and leaner fish species of the genus. Mortality rates of *U. cognatus* are much higher (Z = 2.69 $year^{-1}$, M = 1.041 $year^{-1}$) as compared to *U. scaber* from other seas- Mediterranean and Black Seas (Z= 1.24 – 0.901 $year^{-1}$ and M = 0.26 $year^{-1}$)[8]. Exploitation ratio (E) = 0.61 is high which means that this species is under threat of overfishing.

This is the first in detail study of maturity stages of this species. The diameter of mature ova ranged from 1.25-1.75 mm. In *U. scaber,* maximum diameter of 1.89 and 2 mm were reported [2&7]. This may be because *U. cognatus* is a smaller species compared to *U. scaber*, which can be the explanation for smaller ova.The difference in the spawning period compared to *U. scaber* may be due to lower temperatures in these seas in winter months than in summer and autumn months.

The female size at first maturity (L50) has been calculated for the first time for this species. L(50) of *Uranoscopus scaber* female has been reported to be 11.76 cm in Black Sea[7] and 14 cm in Mediterranean Sea[18]. Mean fecundity of *U. scaber* estimated as 11,556[5]and 16,185[7]. Thus compared to other species of this genus, *U. cognatus* is a moderate fecund fish.

Conclusion

Removal of large number of fish species as shrimp trawl by-catch has adverse effects on marine ecosystems, provoking changes in structure of trophic webs and habitats that pose risks for sustainability of current fisheries. Uranoscopids are strongly site-associated, benthic fishes having limited mobility, and possibly limited dispersal ability that makes them vulnerable to site-specific benthic impacts, e.g., trawling, dredging, etc. Being a predatory fish, they are an important part of marine benthic food chain.High exploitation ratio of this species indicates high discard rates in the by-catches of trawl and gill nets. It is imperative toimplement technical measures to reduce the risk of extinction of this species.

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