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Population dynamics of cobia *Rachycentron canadum* (Linnaeus, 1766) off Cochin coast, south-eastern Arabian Sea

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ABSTRACT

Estimated landings of cobia from the Indian EEZ by the commercial fishing vessels are mostly as bycatch in hooks and line cum gillnet and trawl nets. However, the catches are substantial compared to that reported in several other countries of Asia. The species is also gaining considerable importance as a favoured candidate species for sea farming using cages. Very little is known about the fishery and biological characters such as maturation, fecundity and feeding preferences of cobia in Indian seas. Study indicated a fast growth rate with estimates of L_∞ = 184 cm (FL) and K = 2.6 (yr^{-1}) in cobia. The total mortality rate (Z) was estimated as 5.18, natural mortality (M) was 2.01 and fishing mortality (F) was 3.17 with an exploitation rate (E) of 0.61. The length at first capture (Lc_{50}) estimated from the catch curve was 72 cm. Fecundity was found to be high and variable, with mean fecundity estimated as 12,37,545 eggs with a coefficient of variation (CV) of 16.7. As inferred from the oocyte development pattern, spawning activity is brief and fish is classified as synchronous ovulatory type. The growth parameters and condition factor estimated in this study indicate that relatively high growth rates are also possible in wild stocks considering that food is abundant and the environmental temperature is in the optimum range. Feeding preferences indicated balistid fish and shrimps with a wide variety of food items including finfishes, crustaceans and molluscs present.

Keywords: Biology, Cobia, Population dynamics, *Rachycentron canadum*

Introduction

Cobia, *Rachycentron canadum* is a commercially important species belonging to the family Rachycentridae. These are reported to be solitary fishes which grow to maximum length of 2 m total length (TL) and due to their penchant for association with floating objects such as logs, buoys and fish-attracting devices, they are targeted by fishermen using hooks and line or gillnets while juveniles often occur as bycatch in trawl fisheries. Very little information is available on cobia in the Indian Ocean region (Daracott, 1977; Schaefer and Nakamura, 1989). According to FAO (2009) capture production of cobia in 2007 was 10,484 t, landed mainly by countries such as Pakistan, Phillippines, Malaysia and Iran with each state contributing 1500 – 2000 t. Catch statistics recorded by Central Marine Fisheries Research Institute, Kochi with respect to the Indian EEZ, were not included in this database and an estimated 4486 t (average for 2007 - 09) were landed by gears such as drift gillnets, hooks and lines and as bycatch in trawl nets which means that regional catch estimates of cobia could be higher. As the chances for total mortality rate (Z) including that due to natural causes (M) and fishing (F) can be high even for solitary fishes such as cobia (Richards, 1967), assessment of fishery is considered essential. Estimation of growth and mortality parameters are important inputs for fish stock assessment which was attempted in this study.

Most of the published information on the biology of this species is from the United States (Shaffer and Nakamura, 1989; Arendt *et al.*, 2001), Gulf of Mexico (Biesiot *et al.*, 1994; Franks *et al.*, 1996) and Australia (van der Zelde *et al.*, 2009; Fry and Griffiths, 2010). Due to its fast growth rate, and excellent flesh quality (Chou *et al.*, 2001) it is considered a top species for aquaculture and several studies for inducing maturation and spawning in captivity were initiated (Arnold *et al.*, 2002; Holt *et al.*, 2007). Cobia has been reported to exhibit an opportunistic feeding behaviour (Franks *et al.*, 1995; Mayer and Franks, 1996). However, besides throwing light on the transfer of energy through the food chain, information on diet composition of species of aquaculture importance is useful in determining feed composition especially with regard to the optimal concentration of fatty acids in controlled grow out systems (Tocher, 2003). The present study focuses on the fishery and biological aspects of cobia sampled from commercial landings by fishing vessels operating along the west coast of India, especially the south-west region.

Materials and methods

Assessment of growth parameters and mortality rates

Monthly sampling of cobia was made from the fish landings of commercial trawlers, drift gillnets as well as hooks and line units at Cochin Fisheries Harbour which is one of the major centres for berthing of multiday fishing vessels operating all along the west coast of India. According to availability, individual fish were measured for fork length (FL) and weight was recorded (g accuracy) using hand-held balance. Length-weight relationship was estimated from the equation as $W= a L^b$ where W (in g) and L (in cm), using fishes of size range 52 – 152 cm FL. Based on the sampling days observations, monthly length frequency distribution of 4 cm interval was made. The samples were pooled appropriately using raising factors to the total monthly landings of cobia from the Cochin Fisheries Harbour estimated using the stratified multistage random sampling method (CMFRI, 2010). The annual length frequency data (2009-10) was used to arrive at growth parameters L_∞ and K (yr^{-1}) using ELEFAN (Electronic Length Frequency Analysis) routine of FiSAT (Fish Stock Assessment Tools, Ver.1.1). Mortality rates such as total mortality rate (Z) and fishing mortality (F) were estimated using the linearised catch curve method and natural mortality (M) using the Pauly's method in FiSAT. Exploitation rate (E) was estimated as F/Z.

Biological studies

Diet

Sampled cobia with stomachs >half-full by eye estimation were used for the study. Intact stomachs in fresh condition were removed by cutting above the oesophagus and below the pyloric sphincter and weighed to the nearest g. The stomach was slit open and contents were transferred to a container. The empty gut was weighed again to arrive at the total weight of stomach contents, which were further sorted to the nearest taxon possible and each item weighed/ counted separately. To obtain information on diet preferences, the Index of Relative Importance (IRI) was estimated as given by Pinkas *et al.* (1971) with modification of replacing volume factor by weight of the individual food items to accommodate partly digested food items.

IRI = (% number + % volume) x (% frequency).

Gonad staging and fecundity estimates

Gonad stages were assessed using macroscopic as well as microscopic characters (Wallace and Selman, 1981; Biesiot *et al.*, 1994). Whole oocyte diameter measurements from formalin preserved representative ovaries of each stage were done using an image analyser (Motic BA 310). Fecundity was estimated from ten ripe ovaries (weighing 48 – 370 g) characterised by hydrated translucent oocytes. Nine subsamples weighing 0.4 – 0.6 g equally distributed from the anterior, middle and posterior regions from each ovary were used to assess fecundity. Oocytes were teased apart from connective tissue and the number of oocytes were counted manually to estimate fecundity (F) as:

F = gonad weight * (sub-sample egg count/ gonad sub-sample weight).

Fecundity estimates from all samples were averaged to arrive at the mean estimate of total potential fecundity for the species.

Results and discussion

Length frequency distribution and growth parameters

Size range of cobia in the commercial catches (all gears combined) was 25 – 175 cm FL with mode at 95 and 155 cm (Fig.1). Growth parameters estimated were L_∞=184 cm (FL) and K = 2.6 (yr^{-1}).

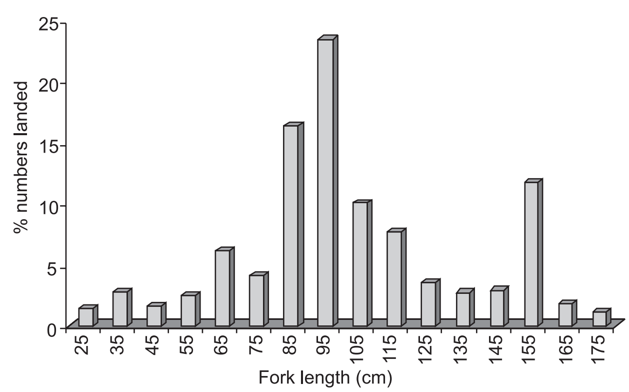

Fig. 1. Length frequency distribution of cobia in the commercial fishery

Length-weight relationship

The length-weight relationship for both sexes combined was estimated as $0.0079\ L^{3.024}$ (cm, kg) and weights attained at various lengths are presented in Fig. 2. The results of the present study based on length-at-age estimates and the length-weight relation indicated that, until the fish attain a size of around 90 cm (about 4 months) weight gain is relatively slow but picks up rapidly thereafter and at about 120 cm (around 7 months) it weighs 15 - 17 kg.

Fry and Griffiths (2010) using cobia in the size range 13 – 163 cm FL, estimated L_∞ as 116 cm (FL) and K as 0.63 (yr^{-1}). Generally very low annual growth rates (K= 0.09 to 0.63) have been reported in wild cobia by several authors (Edwards *et al.,* 1985; Franks *et al.,* 1999; Somvanshi *et al.,* 2000; Fry and Griffiths, 2010) compared to the present study. However, the results obtained from

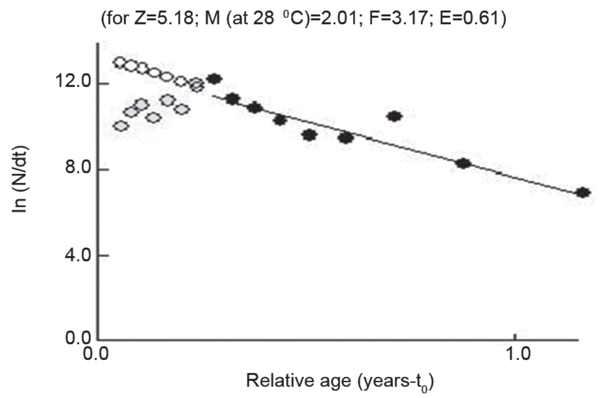

Fig. 2. The length converted catch curve of cobia indicating relatively high E (0.61)

captive cobia reared in sea cages indicate that they show very high growth rates reaching six to eight kilograms in about 8 - 12 months (Chou *et al.,* 1999; Liao *et al*., 2004; Bennetti *et al.,* 2010; Gopakumar *et al*., 2011) as recorded in the present study on wild caught cobia. Cobia grown in open sea cages have been observed to be in good condition, having condition factor (CF) in the range 3.2 - 3.3, whereas wild caught cobia had lower CF of only 2.8 (Benetti *et al.,* 2010). The growth parameters estimated in this study indicate that relatively high growth rates in wild stocks are also possible provided that food is abundant and the environmental temperature is in the optimum (25 – 30 ^{0}C) range as reported by Benetti *et al.* (2010) .

Mortality rates

The total mortality rate (Z) was estimated as 5.18, natural mortality (M) was 2.01 and fishing mortality (F) was 3.17 with an exploitation rate (E) of 0.61 (Fig. 3). The length at first capture (Lc_{50}) estimated from the catch curve was 72 cm. The only study on population dynamics and

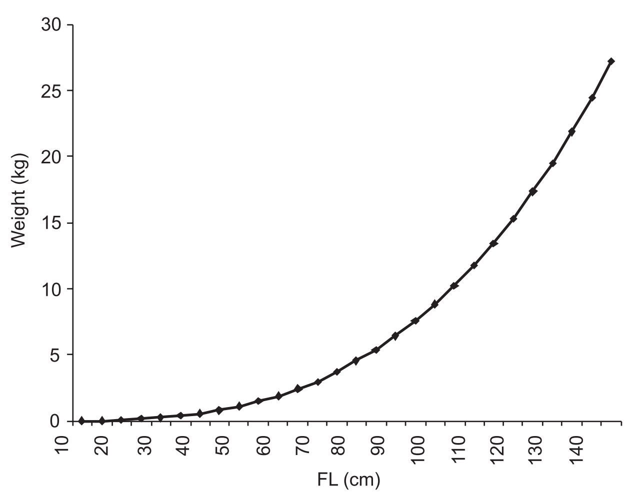

Fig. 3. Weight-at-length for cobia (combined sex)

stock status of cobia is from the recreational fisheries of Australia (Fry and Griffiths, 2010) who reported an exploitation rate of 0.59 where catch regulatory measures such as a minimum legal length (MLL) of 750 mm (TL) and a possession limit of up to two fish per person for recreational fishermen are in place. The present study suggests that although cobia is rarely targeted as in the case of recreational fisheries elsewhere in the world, the exploitation rate is similarly sufficiently high (E > 0.5) to suggest management measures. Considering that cobia is caught in several gears as bycatch (in gillnets and hooks and line units targeting oceanic tunas and sharks as well as trawls targeting cephalopods and shrimps), implementation of catch limits may not be feasible. However, considering that cobia are mainly solitary fish that sometimes aggregate and come close to fishing boats, when they are caught, certain self regulation by fishermen groups either by avoiding fishing of juveniles and ripe spawners or meeting demands of hatcheries for live spawners, on-board stripping of spawners caught and release of fertilized eggs into sea are some options that can be considered.

Fecundity

Ripe oocytes of mature ovaries were distinguished by the presence of lipid droplets and oocyte diameter distribution in ripe ovaries ranged from 0.6 – 0.9 mm of which 72% were in the size range 0.7 – 0.8 mm (Fig. 4 and 5). Fecundity was found to be dependant on ovary weight (R^2= 0.89) and in ripe ovaries with weight ranging from 48 – 370 g, the mean fecundity was estimated as 12,37,545 eggs with a CV of 16.7.

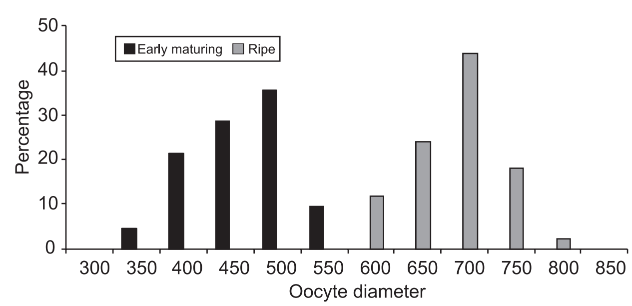

Fig. 4. Oocyte size distribution in early maturing and ripe ovaries with eggs ready to spawn indicating progressing modes from 500 μ

Fecundity estimates of 1.9 to 5.4 million eggs have been reported in cobia from Atlantic Ocean (Richards, 1967) which is comparable to the present study. Some workers have concluded that cobia is a multiple spawning fish due to the presence of post-ovulatory follicle (POF) along with mature oocytes (Richards, 1967; Brown-Peterson *et al.*, 2001;). However our observation of a single mode in oocyte diameter of developing and ripe

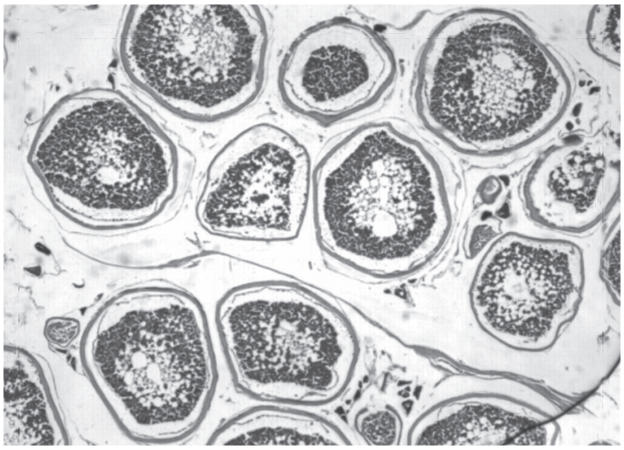

Fig. 5. Vitellogenic oocyte distribution in maturing ovaries (H&E; X100)

ovaries suggests that cobia has homogenous oocyte development as also reported by Lotz *et al.* (1996). Hence the fish is more apt to be classified as a "synchronous ovulatory" with group synchronous oocyte development pattern which includes those species where the whole clutch of yolked oocytes ovulates at once and eggs are shed over a very short period of time, a week or two but as part of a single episode (Holden and Raitt, 1996; Murua and Saborido-Rey, 2003). This also means that total egg count in ripe ovaries is likely to be indicative of the total annual potential fecundity assuming the fish spawns only once during a season. However, in order to understand how many times the individual fish actually spawns over a period, tagging studies or studies by rearing in captivity need to be undertakem, and with such studies, the total annual fecundity estimates may be much higher.

Table 1. Diet preferences of cobia as indicated by IRI

Prey groups	% Occurrence	% Weight	% Number	Index of relative importance (IRI)	% IRI
Fishes					
Odonus niger	6.90	19.66	10.89	543.16	21.63
Saurida tumbil	4.31	1.84	4.46	69.93	2.78
Saurida spp.	1.72	0.77	1.49	10.04	0.40
Trichiurus spp.	1.72	0.68	0.99	7.41	0.30
Leiognathus splendens	2.59	1.14	2.97	27.38	1.09
Leiognathus sp.	2.59	0.46	1.49	12.96	0.52
Balistids	3.45	7.47	3.47	97.23	3.87
Stolephorus spp.	2.59	2.76	3.96	44.78	1.78
Nemipterus spp.	3.45	3.75	2.48	55.32	2.20
Catfish	1.72	10.06	0.99	49.11	1.96
Thryssa spp.	1.72	2.66	4.46	31.63	1.26
Tunas	1.72	5.27	0.99	27.83	1.11
Auxis rochei	2.59	9.29	1.98	75.11	2.99
Rastrelliger kanagurta	0.86	1.93	0.50	5.40	0.22
Exocoetus sp.	0.86	1.55	0.50	4.54	0.18
Selar crumenophthalmus	4.31	8.15	3.96	134.56	5.36
Decapterus spp.	1.72	2.27	1.49	16.70	0.67
Siganus spp.	1.72	0.80	0.99	7.95	0.32
Sphyraena obtusata	0.86	2.90	0.50	7.55	0.30
Digested fishes	12.07	6.41	6.93	415.00	16.53
Crustaceans					
Stomatopods	0.86	0.15	0.99	2.52	0.10
Sergestid shrimp	0.86	0.12	2.48	5.77	0.23
Shrimps (digested)	9.48	2.47	15.35	435.44	17.34
Portunus spp.	4.31	0.94	2.97	43.48	1.73
Charybdis smithii	7.76	2.61	8.91	230.45	9.18
Crab remains	2.59	0.51	2.48	19.89	0.79
Molluscs					
Cuttle fish/bones	5.17	0.87	3.47	57.81	2.30
Octopus	0.86	0.65	0.50	2.55	0.10
Unidentified squid	3.45	0.99	2.97	35.22	1.40
Unidentified bivalves	3.45	0.39	1.98	21.04	0.84
Gastropods	1.72	0.48	2.48	13.15	0.52

Diet composition

Diet preferences indicated dominance of fish (90%), crustaceans (7%) and molluscs (3%) with regard to percent composition of the items in weight. Percent occurrence of items (% O) indicated dominance of shrimps and the crab *Charybdis smithii*. Overall, IRI indicated a strong preference for balistid fish, especially *Odonus niger,* shrimps and crabs (Table 1).

The diet of cobia has been reported to be varied consisting of anchovies, shrimps, crabs, flatfishes *etc*. (Franks *et al.*, 1995; Mayer and Franks, 1996). The only report on feeding preferences of wild-caught cobia from Indian EEZ is based on a single sample of 23 cobia (41- 130 cm total length) sampled during an exploratory survey off the north-west coast, which recorded the dominance of puffer fishes and occasionally other items like scads, barracudas and squids (Somvanshi *et al.*, 2000). The present study used fishes sampled throughout the year and indicated an assorted diet composition. On the basis of frequency of occurrence (%O), Knapp (1951) has reported predominance of fishes (83%) followed by crustaceans (stomatopods, penaeid shrimps and portunid crabs) and squid which agrees with observations in the present study. Franks *et al.* (1996) also reported that based on IRI, the relative importance of fish as food is approximately three times higher than shrimps and still more with regards to molluscs such as squid. Cobia are carnivorous needing high dietary protein levels and commercial feed for cobia grow-out systems are reported to contain as high as 45% protein (Chou *et al*., 2001). The study suggests that considering the diet preferences of cobia in the wild, several low cost fish which occur as bycatch and are discarded can be profitably used for feed preparation.

Cobia resource is highly valued as a wild caught species as well for its potential as a fast-growing, high quality fish commodity for aquaculture purposes. As it is solitary in habit, the resource is mainly landed as bycatch in the hooks and line cum gillnet fishery and trawl nets, but due to increasing fishing effort in recent years, the fishing pressure on the resource is increasing. This study indicates that the resource is subject to considerable fishing pressure and it is desirable to ensure sustainability through self-regulation by fishermen regarding minimum sizes and capture of juveniles. Although the fecundity of individual spawners is high, the brief spawning peak and an oocyte development pattern indicating complete batch spawning followed by regression of ovaries , indicate that there is a need to conserve spawners. Diet preferences also indicate scope to use presently low-valued fish as feed ingredients in cobia grow-out systems.

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