Stomach content and seasonal variation in diet composition of cobia, *Rachycentron canadum* in the Dungun coast, Malaysia

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Abstract

Aim: Analysis of food and feeding habit of cobia, *R. canadum* in Dungun coast, Malaysia was carried out in this research in order to provide information on their diet preference and feeding intensity of cobia in the area.

Methodology: Monthly samples were collected from licensed commercial trawls in Dungun, Terengganu, Malaysia for food and feeding studies.

Results: Out of 231 cobias examined between April 2014 and May 2015, 111 contained food in their stomach out of which 98 had at least one identifiable prey item. Analysis of gut content analysis showed that bony fish was consumed by cobia all the year round with *Hilsa* sp., *Alepes* sp. and *Carangides* sp. being the most frequently encountered species. Bony fish was the dominant group in the diet with percentage index of relative important (% IRI) value of 72.27 %, while crustacean and mollusc contributed less with % IRI values of 2.98 % and 24.75 % respectively. Higher stomach fullness index (SFI) was recorded during April (2.88), June (2.06) and November (2.42) months, while SFI was lower in May (0.67) and August (0.86). The percentage of empty stomach (EC) was higher in October (80%), August (70%) and July (69%), respectively, intermediate in the remaining months as values were about 50 %. This stomach fullness index SFI and EC suggest moderate feeding intensity of cobia in the waters of Dungun.

Interpretation: The dominance of squid by volume in April and July in cobia indicates the influence of habitat on their food preference, as seasonal availability of food items in the habitat may be a dictating factor. Fish dominated in diets of cobia for most of the months while crustaceans and molluscs can be regarded as occasional food. This study demonstrates that cobia in Dungun, Malaysia predominantly consumed bony fishes and squids.

Key words: Cobia, Dungun coast, *Rachycentron canadum*, Stomach contents

Stomach of Cobia

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Introduction

Cellular energy required by fish for physiological activities and all life processes such as growth, development, reproduction and migration is derived from food. Hence, food serves as a basis for all functions of an individual fish as well as the population. The quantitative assessment of feeding and prey interactions among fishes is required for understanding the trophic level and food-web construction as well as other ecosystem modelling (Pauly et al., 2001). Cobia, *Rachycentron canadum* is a migratory pelagic marine fish distributed in tropical and temperate regions (Briggs, 1960). Cobia is native to Malaysian waters, and is usually a non-target species. Nevertheless, their catch in this area is one of the highest worldwide, exceeding 1000 metric tonnes per annum (FAO, 2014). The feeding pattern of cobia in US (Arendt et al., 2001; Meyer and Franks, 1996; Smith, 1995) and Indian waters (Rohit and Bhat, 2012) has been studied in detail. These works reported that cobia exhibits a carnivorous feeding behaviour that hunt prey from water column, benthic and open water. The feeding preference of cobia in Malaysian waters, however, is lacking.

The study of food and feeding habit has been carried out in several fish species using methods like dissection and examination of gut contents (Ganga et al., 2012; Ara et al., 2011; Hyslop, 1980) or without sacrificing the fish in the extraction of gut contents using methods like gastroscopes (Van Den Avyle and Roussel, 1980), tubes (Gilliland et al., 1981), stomach suction (Elliot, 1972), stomach flushing (Hyslop, 1980), stable isotope analysis (Fanelli et al., 2010), direct observations (Colle, 1976) and fatty acid analysis (Budge et al., 2006).

Dissecting fish for stomach content analysis has gained popularity due to its high efficiency and this has been used to study the stomach content of cobia. Ganga et al. (2012) recorded five species of molluscs, five species of crustaceans and nineteen species of teleosts in the diets of cobia in the south-eastern Arabian Sea, west coast of India, and fish had the highest percentage index of relative importance. Arendt et al. (2001) recorded one species of bivalve, one species of hydroid, six species of crustaceans, one elasmobranch, and sixteen species of teleosts in the stomach contents of cobia in the lower Chesapeake Bay, US., with crabs having the highest %IRI. The feeding activity and ecological role of species may differ from one ecosystem to another due to varying habitat parameters and species composition. Thus, examining the foraging habits of species in different locations will provide useful information for the development of specific ecosystem-based management (Sagarese et al., 2011). In addition, it will provide information on fish life history, habitat selection, species coexistence and distribution. Investigations on the food and feeding habits of cobia, *R. canadum* in Dungun coast, Malaysia was carried out in order to provide information on their diet preference and feeding intensity in the area.

Materials and Methods

Monthly samples were collected from licensed commercial landing in Dungun, Terengganu, (Fig. 1) Malaysia between April 2014 and May 2015 for food and feeding studies. Fishing activities in this area were closed between December 2015 and February 2016 due to severe flooding, and, thus, it was not possible to obtain samples during this time.

Cobia was fisheries independent in the area and samples were incidental catches in gill net, trawls and hook and line. Specimens were measured for total length (cm), fork length (cm) and wet weight (kg). After dissection, stomachs were classified as full, one-quarter full, half full, three-quarter full or empty via visual observation using the characteristics described by Pillay (1952) (Table 1).

Stomach contents were preserved in 5% formalin and transported to the laboratory for further identification to the lowest possible taxa. The number of food items, weight (g) and volume (ml) was recorded and expressed as a percentage.

Stomach fullness index (SFI) was estimated using $SFI = (\text{stomach content weight [g]} / \text{fish weight [g]}) \times 100$ (Hureau, 1969). Index of relative importance (IRI) for all each food species was calculated by the formula $IRI = (\% \text{ Number} + \% \text{ Volume}) \times (\% \text{ Frequency})$ Pinkas et al. (1971), where percentage number (% N) is the proportion of a specific prey item in the total number of prey items in all the stomachs with food, percentage volume (% V) is the proportion of the volume of a specific prey item to the volume of all of the stomach contents, and percentage frequency of occurrence (% F) is the proportion of stomachs containing a specific prey item in all the non-empty stomach. The IRI value for each food item was converted into a percentage. Baited specimens were not used in this study.

Results and Discussion

Feeding intensity of *R. canadum* : Month wise analysis of stomach content revealed that cobia possessed a higher stomach fullness index in the month of April (2.88), June (2.06) and November (2.42), the SFI was lower in the months of March (0.93), May (0.67) and August (0.86). The monthly stomach fullness percentage showed that one-quarter full stomachs was dominant in all the months, while full and three-quarter full stomachs were rarely encountered (Table 2). The percentage of empty stomach, i.e., empty coefficient (EC) (Table 2) was highest in October (80 %) and lowest in May (41 %).

SFI represents the degree of satiation of fish from food items. Cobia in our study area appeared to be well fed in April and moderately in June and before the emergence of monsoons in September. The low EC and high SFI in April suggest that feeding activity of cobia was higher during this month in Malaysia. Sajeevan and Kurup (2014) reported that both male and female

Fig. 1 : Map of peninsular Malaysia showing the sampling location.

Table 1 : Description of stomach fullness classes used in this study

Level of fullness	Description
Full stomach	Stomach was extremely packed with food items, the stomach appeared cylindrical.
$\frac{3}{4}$ full stomach	Stomach was nearly filled with food items
$\frac{1}{2}$ full stomach	Stomach was filled with food items to approximately half of its length
$\frac{1}{4}$ full stomach	Only a little food item was found in this stomach
Empty stomach	No trace of food or watery digested

cobia exhibited high feeding intensities after the monsoons in the north-west coast of India. Among the identified factor for low feeding in cobia during monsoons is reduction in water temperature (Sajeevan and Kurup, 2014).

Stomach content of *R. canadum* : The composition of cobia diet showed that they are carnivorous that feed primarily on marine teleosts in Dungun coast. Cephalopods, crustaceans and molluscs contributed less. The numerical abundance (N) value of various food items in the diets of cobia and their monthly variation

(Table 3) showed that teleost fish dominated during all the months, except in July 2014 and April 2015 where squid (*Loligo* spp.) dominated. Unidentified teleosts had the highest cumulative N value of 71, while among the identified teleost fish; *Hilsa* spp. had the highest occurrence in number with a cumulative value of 29. *Carangoides* spp. and *Alepes* spp. also occurred in a significantly higher value of N. The frequencies of occurrence (F) followed a similar pattern as N with unidentified teleosts having a higher value than individual identified fish. Crustaceans were represented by crab and shrimps while molluscs were identified

Table 2: Feeding level of cobia *R. canadum* in Dungun coast during different months in 2014-2015

Year	Month	Total number	Number of empty stomachs	Number of stomach with food	Level of fullness				Mean stomach fullness index	Empty coefficient (EC %)
					1/4	2/4	3/4	4/4		
2014	April	30	13	17	12	4	1	0	2.88±0.91	43.33
	May	2	1	1	1	0	0	0	0.67	50.00
	June	31	20	11	6	5	0	0	2.06±0.55	64.52
	July	17	12	5	3	0	1	1	1.48±0.31	70.59
	August	30	21	9	7	2	0	0	0.86±0.20	70.00
	Sept.	10	5	5	3	2	0	0	1.71±0.98	50.00
	Oct.	30	24	6	3	2	1	0	1.24±0.26	80.00
	Nov.	27	15	12	9	2	1	0	2.42±0.51	55.56
2015	March	19	8	11	7	3	0	1	0.93±0.20	42.11
	April	18	6	12	2	5	3	2	2.48±0.17	33.33
	May	17	7	10	5	4	1	0	1.21±0.31	41.18

Table 3: Monthly variation in numerical abundance of prey items in the stomach contents of *R. canadum*

		Identified taxa																						
Year / Months		<i>Perna</i> spp.	<i>Loligo</i> spp.	<i>Sepioteuthis</i> spp.	<i>Uca</i> spp.	<i>Portunus</i> spp.	<i>Squilla</i> spp.	unid crust	<i>Dasyatis</i> spp.	<i>Chiloscyllium</i> spp.	<i>Hilsa</i> spp.	<i>Dactyloptena</i> spp.	<i>Parupeneus</i> spp.	<i>Megalopsis</i> spp.	<i>Sphyrna</i> spp.	<i>Butis</i> spp.	<i>Lutjanus</i> spp.	<i>Pseudorhombus</i> spp.	<i>Carangoides</i> spp.	<i>Strophidon</i> spp.	<i>Alepes</i> spp.	<i>Upeneus</i> spp.	<i>Thunnus</i> spp.	unidentified fish
2014	April	1	1	0	1	0	0	0	1	0	1	2	2	3	1	1	1	1	0	0	0	0	0	5
	May	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	June	0	1	1	4	0	0	0	1	0	2	0	0	0	0	1	0	0	0	0	0	0	0	
	July	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Aug.	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2	8	0	0	
	Sept.	0	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	
	Oct.	0	0	0	2	0	0	0	0	1	2	0	0	0	0	0	0	0	1	0	6	1	0	
	Nov.	0	2	0	1	1	3	0	0	0	14	0	0	0	0	0	0	0	0	4	1	0	0	
2015	March	0	2	0	1	1	1	0	0	0	4	0	0	0	0	0	0	0	0	4	0	0	0	
	April	0	51	0	1	0	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0	0	
	May	0	0	0	1	0	0	0	0	0	5	0	0	0	0	0	0	0	7	0	1	0		
	Total	1	65	2	13	2	5	2	2	1	29	2	2	5	1	2	1	1	15	10	16	1	10	

as bivalves. The number of taxa recorded month wise was highest in April 2015.

Index of important (% IRI) of prey items: Estimation of relative important index (IRI) of various food items showed that fish had the highest IRI 1822.75 in the diet of cobia (Table 4), while crustaceans and molluscs had an IRI value of 74.98 and 624.26, respectively. The IRI percentage is shown in Fig. 2. There was no correlation between the stomach length (cm) and the weight of prey (g) consumed by cobia (Fig. 3).

The gut content analysis of cobia examined in this study showed that feeding intensity was moderate in Dungun coast, Malaysia during the study period. This can be inferred from the

levels of stomach fullness recorded, which were predominantly a quarter full. This was also supported by the mean percentage empty stomach, which was 51.9 % overall. Sajeevan and Kurup (2014) assessed the feeding intensity of cobia in the north-west coast of India and described it as low, at about 56 % of total stomachs examined were found in a feeding status. The situation where wild fish specimens possess empty stomach could be attributed to the fishing method, sampling period, fish behaviour and habitat. The period of feeding for many marine fish cannot be ascertained, as sampling hours may not coincide with the feeding time of the species. This is reflected in the abundance of digested, unidentified food, which is predominantly fish. The percentage frequency of occurrence and percentage numerical abundance

Table 4 : Estimated important relative index of different food items in the stomach of *R. canadum*

	N	%N	F	%F	V	%V	IRI	%IRI
Mollusc								
<i>Perna</i> spp.	1.00	0.39	1.00	0.78	5.00	0.07	0.35	0.01
<i>Loligo</i> spp.	65.00	25.10	16.00	12.50	1889.92	24.64	621.65	24.65
<i>Sepioteuthis</i> spp.	2.00	0.77	2.00	1.56	51.50	0.67	2.26	0.09
Crustacea								
<i>Uca</i> spp.	13.00	5.02	10.00	7.81	198.40	2.59	59.42	2.36
<i>Portunus</i> spp.	2.00	0.77	2.00	1.56	36.80	0.48	1.96	0.08
<i>Squilla</i> spp.	5.00	1.93	5.00	3.91	106.50	1.39	12.96	0.51
Unidentified crustacean	2.00	0.77	1.00	0.78	4.00	0.05	0.64	0.03
Chondrichthyes								
<i>Dasyatis</i> spp.	2.00	0.77	2.00	1.56	415.50	5.42	9.67	0.38
<i>Chiloscyllium</i> spp.	1.00	0.39	1.00	0.78	15.50	0.20	0.46	0.02
Osteichthyes								
<i>Hilsa</i> spp.	29.00	11.20	14.00	10.94	794.40	10.36	235.73	9.35
<i>Dactyloptena</i> spp.	2.00	0.77	2.00	1.56	188.50	2.46	5.05	0.20
<i>Parupeneus</i> spp.	2.00	0.77	2.00	1.56	117.00	1.53	3.59	0.14
<i>Megalopsis</i> spp.	5.00	1.93	4.00	3.13	186.70	2.43	13.64	0.54
<i>Sphyræna</i> spp.	1.00	0.39	1.00	0.78	20.50	0.27	0.51	0.02
<i>Butis</i> spp.	2.00	0.77	2.00	1.56	123.00	1.60	3.71	0.15
<i>Lutjanus</i> spp.	1.00	0.39	1.00	0.78	68.00	0.89	0.99	0.04
<i>Pseudorhombus</i> spp.	1.00	0.39	1.00	0.78	50.00	0.65	0.81	0.03
<i>Carangoides</i> spp.	15	5.79	9	7.04	429.6	5.6	38.97	1.55
<i>Strophidon</i> spp.	10.00	3.86	6.00	4.69	299.80	3.91	36.42	1.44
<i>Alepes</i> spp.	16	6.18	9	7.03	447.77	5.84	49.85	1.98
<i>Upeneus</i> spp.	1.00	0.39	1.00	0.78	7.00	0.09	0.37	0.01
<i>Thunnus</i> spp.	10.00	3.86	2.00	1.56	240.95	3.14	10.94	0.43
unidentified fish	71.00	27.41	34.00	26.56	1975.10	25.75	1412.04	55.99
Total	259.00	100.00	128.00	100.00	7671.44	100.00	2522.00	100.00

Fig. 2 : Percentage relative important index of groups of food in the stomach of *R. canadum*. **Fig. 3 :** Relationship between fork length and weight of prey consumed by *R. canadum*.

was 26.56 % and 27.41 %, respectively, in this study. Bakhoun and Faltas (2003) emphasised the importance of digested food in the diet of *Bagrus bajad* as their occurrence reached 27 % of examined stomachs in El-Nozha Hydrodrome, Egypt. Species behaviour, active swimmers, migratory and benthopelagic lifestyle of cobia may enhance fast digestion of food. Therefore, opportunistic samples obtained in this study may only provide a

glimpse into the diet composition of cobia in Malaysia. Cobia prey selectively on portunid crabs in the Northern Gulf of Mexico (Meyer and Franks, 1996), crabs and penaeid shrimp in Texas Gulf coast (Knapp, 1951), and portunid crabs in Chesapeake Bay (Arendt *et al.*, 2001), however, the energy demands of cobia in other regions may not be met by crustaceans, hence, they prey on fin fish like those in south-eastern Arabian Sea where fish was

Table 5: Monthly variation in volume (ml) of prey items consumed by *R. canadum*

Year	Month	Fish	Crab	Shrimp	Squid	Unidentified crustaceans	Bivalve
2014	April	968.50	5.00	0.00	30.00	0.00	5.00
	May	0.00	5.50	0.00	0.00	0.00	0.00
	June	804.00	120.00	0.00	37.50	0.00	0.00
	July	65.20	0.00	0.00	445.30	0.00	0.00
	August	304.17	3.00	13.00	34.92	0.00	0.00
	September	237.20	0.00	0.00	0.00	4.00	0.00
	October	212.00	5.20	0.00	0.00	0.00	0.00
	November	825.50	21.30	61.50	26.20	0.00	0.00
2015	March	585.30	34.50	32.00	46.00	0.00	0.00
	April	378.30	0.00	0.00	1270.00	0.00	0.00
	May	999.15	40.70	0.00	0.00	0.00	0.00
	Total	5379.32	235.20	106.50	1889.92	4.00	5.00

dominant (90 %) (Ganga *et al.*, 2012). Analysis of the stomach contents in cobia from Dungun coast, Malaysia in the current study also showed that fish had the highest % volume of 80.6. Hence, it had the highest index of relative importance (IRI) among all the food classes: fish (1822.75), crustacean (74.98) and mollusc (624.26). This study also showed that cobia prefers fish as food in Peninsular Malaysia as it dominated the bulk of food items throughout the year. In Dungun coast, *Hilsa* spp. is an important pelagic species in fisheries and constituted a significant proportion of fin fish diet of the sampled cobia. The food items from Dungun coast, Malaysia also included species that dwell in different parts of water body viz., pelagic, demersal and benthos.

Seasonal variation of stomach contents: The volume of prey categories (Table 5) showed that teleost fish were dominant throughout the year, but were lower in July to October, higher in November, March to April and highest in May. Year to year variation in cobia catch were reflected in a low number of samples (2) obtained in May 2014, while the highest volume of fish prey was recorded in the cobia stomach in May 2015. However, the numerical abundance (Table 3) was highest for squids in July 2014 and April 2015 and it represented the second most important food item of cobia. Crustaceans were mainly crab and shrimps, but were rarely encountered in the stomachs of cobia across the year in the coastal waters of Dungun.

Seasonal variation in feeding habits and feeding intensity, as indicated by SFI and EC, supported low feeding in July and higher feeding in April and November. The number of taxa in prey was also highest in April. Cobia is an active swimmer that feeds on benthic, demersal and pelagic organisms (Arendt *et al.*, 2001). Spawning is one of the factors that influence feeding intensity of fishes (Walter and Olney, 2003), however in cobia, feeding intensity is not attuned to spawning. The dominance of squid by volume in April and July in cobia indicates the influence of habitat on their food preference, as seasonal availability of food items in the habitat may be a dictating factor. Fish dominated in the diets of

cobia for most of the months, while crustaceans and molluscs can be regarded as occasional food. This study has demonstrated that cobia in Dungun, Malaysia predominantly consumed bony fishes and squids.

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