# Feeding Habits of the Green Jack (*Caranx caballus* Günther, 1868) on the Coast of Manzanillo, Colima, México

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**Abstract:** To increase the knowledge on the biology and the ecology of *Caranx caballus* (green jack), a dietary analysis was carried out. Stomachs of 271 specimens from the commercial catches of the artisanal fishery along the coasts of Manzanillo, Colima, México from December 2000 to December 2001 were analyzed. Prey items in the stomach contents were identified, counted and weighed, the percentage frequency of occurrence, percentage by number and percentage by weight were calculated. We also determined indices of relative importance, diversity of trophic spectra and feeding. Forty two dietary components from five taxa were apparent: fishes, crustaceans, mollusks, cnidarians and chaetognaths. Percentage weight and volume did not vary throughout the year, and showed a distinct preference for fishes, whereas the numeric index showed a preference for crustaceans followed by fishes, chaetognaths and cnidarians. There was no difference between the diets of females and males. Feeding between green jack size groups changed with development: in terms of weight percentage, small fish fed on crustaceans, medium and large jacks fed on fishes, crustaceans and cnidarians.

**Keywords:** Dietary index, diet spectrum, fish, gender, length, trophic niche.

## INTRODUCTION

Fisheries, especially of the artisanal type are basic for the local economy in the northern region of Colima, México. *Caranx caballus* Günther, 1868 belongs to the Carangidae family and, although it is not a commercially important species because of its dark meat, it is fished very extensively and consumed locally, as a cheap popular option. During 2000, 60t of *C. caballus* were landed (Fishery Statistics in Colima). In spite of its high populations, very little is known of its biology and ecology [1]. This paper describes the range of sizes of *C. caballus* fished with gillnets in the artisanal fishery of a tropical area.

Studies on feeding generate information fundamental to understanding the dynamics of the ecological interactions between species. Species within the Carangidae are demersal or pelagic and typically gregarious, and live on the continental shelf, generally near the coast but also in water deeper than 100m [2, 3].

Carangids have been divided into three groups according to their food preference: piscivores (e.g. species of *Caranx* and *Seriola*), planktivores (e.g. *Decapterus* and *Selar*) and mollusk-feeders (*Trachinotus*) (Randall, 1967 in [4]); *C. caballus* belongs to the first group. Studies have shown that young individuals of *C. rubber* feed on planktonic organisms whereas adults feed on fishes [5]. These authors [5] also showed that *C. bartholomaei* feeds primarily on fishes belonging to the Labridae and Scaridae families. Others [6] have described the feeding of *C. hippos* and, similarly, found its diet to comprise mostly fishes. Again, observations of *Oligoplites saurus* and *O. palometa* have shown that the main dietary components were fishes and crustaceans [7]. *C. caballus* feeds mainly on fishes (generally species exhibiting silver-plated colour), shrimp, crabs and other invertebrates [8, 9].

To increase knowledge of the biology and ecology of *C. caballus*, we analyzed the composition and quantity of this species' diet over a full year, paying particular attention to variation according to fish length and sex. Two hypotheses were studied: diet does not change from juvenile to adulthood, and diet changes throughout the year, depending on presence of prey.

## METHODS

The study area is located on the Mexican Pacific, to the north of Michoacán and the south of Jalisco state, 19°03'N and 104°19'W. Its continental platform is 1,340km$^2$ [10], in which the isobath of 200 fathoms (366 m) is at the northern part 9km from of the coast and 24km south. The coast is approximately 157km long; characterized by a succession of steep rocky coasts and flat sandy beaches.

Monthly samplings from December 1999 to December 2000 were of the commercial captures of the artisanal fishery of the coast of Colima. Fish were captured mainly with gill nets, coastal seine and pound nets. Of each organism total length (from the mouth to the end of the caudal fin) was measured with individual icthyometer (1 millimeter of

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precision). Individual weight was determined with a semi-analytical balance (0.1 g of precision).

The stomach of each organism was obtained and conserved in 10% formaldehyde, properly labeled for later analysis.

In the lab, contents of each stomach was drained in a Petri dish and analyzed with stereoscopic microscope. Each prey was identified to the lowest possible taxonomic level, using specialized keys for the different groups: [11-16] for invertebrates; [2, 3, 17] for fish; for plankton [18] and [19] for icthyoplankton, and the help of specialists in each taxonomic group. Each prey was counted, weight and its volume measured to calculate the indices:

Percentage by number (numeric index %N) [20]: total number of individuals of a group, expressed as percentage of the total individuals.

Percentage by weight (Gravimetric index %W) [21]: total weight of individuals in a group expressed as percentage of the total weight.

Due to the difference in length of the prey the volumetric Index (%V) [20] was also used: Total percentage volume of displaced water of each consumed organism was measured, in a graduated test tube.

Percentage frequency of occurrence (FA) [22]: as total number of stomachs, in which each type of prey was found, expressed in appearance percentage of the total number of stomachs.

The Index of Relative Importance (IRI) was calculated with the mentioned indices, expressed in percentage, taking into consideration the importance of each prey individually [20]. It is outlined graphically in rectangular form, with the base representing the frequency of appearance (FA) and the height the sum of numerical (N) and gravimetric (W) indices.

$$IRI_W = (W + N) * F$$

$$IRI_V = (V + N) * F$$

Where: W = percentage of weight, V = percentage of volume, N = number of organisms percentage and F = appearance frequency percentage.

Total length was used to determine length classes of *C. caballus* and the number of classes was calculated with Sturges' formula [23]:

$$K = 1 + 3.322(\ell og_{10} n)$$

Where: K = number of class intervals, n = number of total data.

After determining the number of class intervals, its amplitude was calculated with the formula described in [23]:

$$A = \frac{R}{K}$$

Where: A = interval amplitude, R = maximum value minus minimum value and K = interval number.

Trophic spectrum amplitude (niche breadth) was evaluated with the diversity of the feeding spectrum [24]. Data of weight and number were used for this index, expressed in percentage and standardized for maximum amplitude [25] using a scale 0 to 1:

$$B = \frac{1}{\sum_{i=1}^{n} Pj^2}$$

$$B_a = \frac{B - 1}{n - 1}$$

Where: B = Levin's measurement of the diet spectrum; Ba = standardized Levins' measurement; Pj = proportion with which every prey category contributes to the diet and n = total number of feeding items. Values of Ba include a scale 0 to 1; it is the maximum value when species consume different items in the same proportion (wide trophic niche) and minimum when they feed mainly in one type of food (maximum specialization).

The most important group of prey in the diet of *C. caballus* as well as those consumed accidentally, were calculated with the Alimentary Index (AI) modified [26]:

$$AI = \frac{\%F * \%W(\%A)}{100}$$

With feeding preferences (%F) and relative importance of the prey, in weight (%W) or area (%A), AI brings together feeding items in a function that allows the preferred food from those of low frequency be distinguish [21]. Values of AI vary from 0 to 100% and are categorized according to their relative importance as follows: 1) preferential food (AI > 50), 2) secondary food (25 < AI< 50), 3) frequent food (10 < AI < 25) and accidental food (AI < 10).

## RESULTS

From commercial catches in Manzanillo, Colima, México, 1,084 individuals were caught and 582 stomachs analyzed, of which 311 (53%) were empty and 271 (47%) with contents. January, September and November 2001 were the months with more abundance of *C. caballus*. The largest length was 57 cm and the smallest 21.5 cm, average length was 30.77 cm ± 6.98 standard deviation. All specimens under 22 cm were considered juveniles because its gender could not be visually determined [27], from 23 to 30 cm they were considered preadults their sex could be determined, but they were all immature; from 31 cm on, the organisms were considered adults.

Stomach content of *C. caballus* had 42 feeding items of 5 higher taxa (Table **1**): fish, crustaceans, mollusks, cnidarians and chaetognata. Analysis included two extra groups: "Crustacean larvae" due to its difference with the other Crustaceans and "Organic matter", elements that could not be identified.

Based on percentage in number (%N), monthly's most important feeding component changed throughout the year: fish in December 2000 (100%); crustaceans in March

(97.30%); cnidarians (66.66%) in January, and in July the most abundant item were crustacean larvae (100%) (Fig. **1**). Most months appeared to have crustacean as an important item in the diet.

**Table 1. List of Prey Species (items) Found in Stomach Contents of *Caranx caballus***

| Fishes | *Trachysalambria brevisuturae* |
|---|---|
| Family Engraulidae | *Trachysalambria* sp. |
| Family Clupeidae | *Portunus xantusi* |
| *Ophisthonema libertate* | *Portunus* sp. |
| *Ophisthonema* sp. | *Pleuroncodes planipes* |
| Family Serranidae | Stomatopod larvae |
| Family Congridae | Anomura larvae |
| *Caranx* sp. | Brachyura larvae |
| Fish larvae | Portunid larvae |
| Pieces of fish | Megalops larvae |
| CRUSTACEANS | Mysis larvae |
| Brachyura | Crab Zoea larvae |
| Euphausiacea | Unidentified Crustacea |
| Ostracoda | MOLLUSKS |
| Caridea | Family Naticidae |
| Cladocera | *Nassarius gallegosi* |
| Copepoda | *Loliolopsis diomedae* |
| Calanoida Copepoda | Rests of mollusks |
| *Centropagues* sp. | CNIDARIANS |
| *Solenocera* sp. | Siphonophora |
| Stomatopoda juvenile | CHAETOGNATHA (unidentified) |
| *Rimapenaeus fascina* | Organic matter |
| *Rimapenaeus* sp. | |

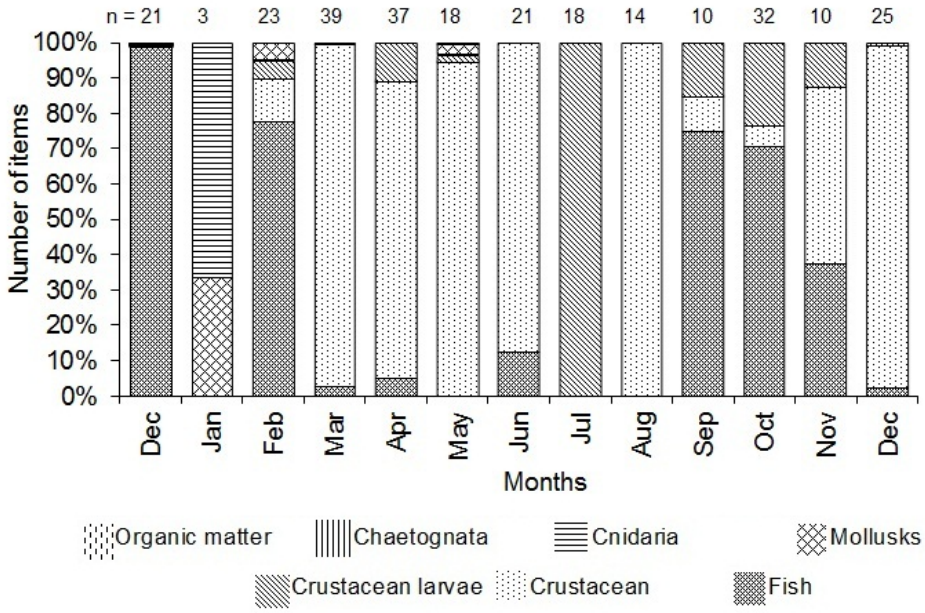


**Fig. (1).** Numeric index (%N) of the prey groups of *Caranx caballus* during one year.

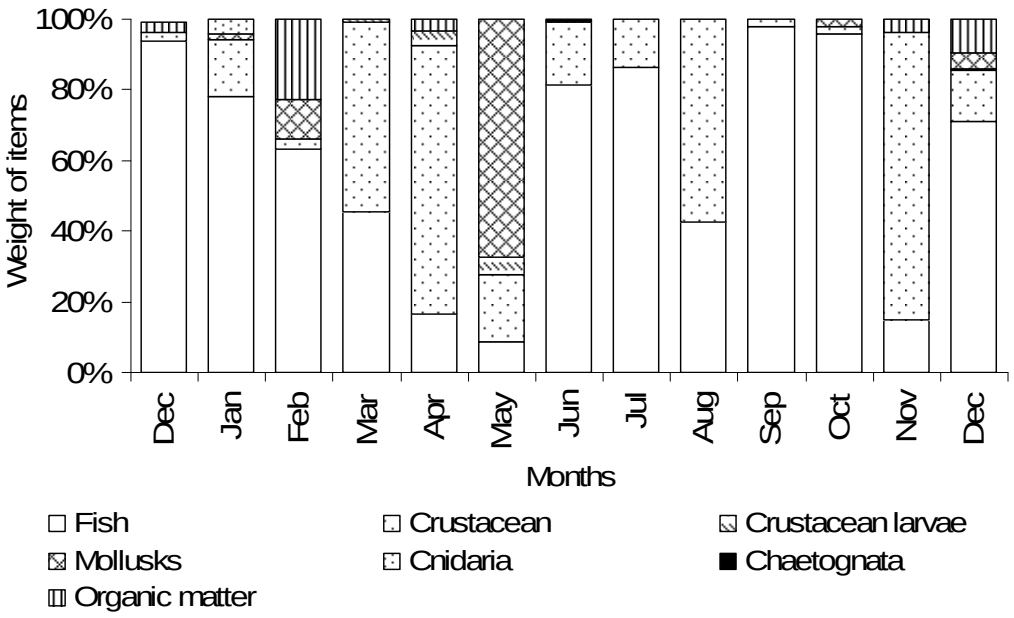


**Fig. (2).** Gravimetric index (%W) of the prey groups of *Caranx caballus* during one year.

Feeding components as percent weight (%W) indicated fish as preference for *C. caballus* throughout the year, mainly in September (97.93%) and October (96.01%). There was also an important consumption of crustaceans in April (76.20%) and November (81.36%); and of mollusks (67.17%) in May (Fig. **2**).

The volumetric index (%V) was very similar to the gravimetric in the preference to fish during almost the year round, and probably a periodic behavior with maximum from December to February and from June to October. Crustaceans were especially important in March (52.52%), April (81.66%) and August (65.15%). There was little preference for mollusks in most months except May (69.34%). Preference for crustacean larvae were observed in November (51.76%) (Fig. **3**).

The Index of Relative Importance calculation in weight ($IRI_W$) showed greater consumption of fish from December to February, and from June to October; crustaceans were the group with greater percentage during March (58.4%), April (92.2%), August (76.2%) and November (96.5%) and

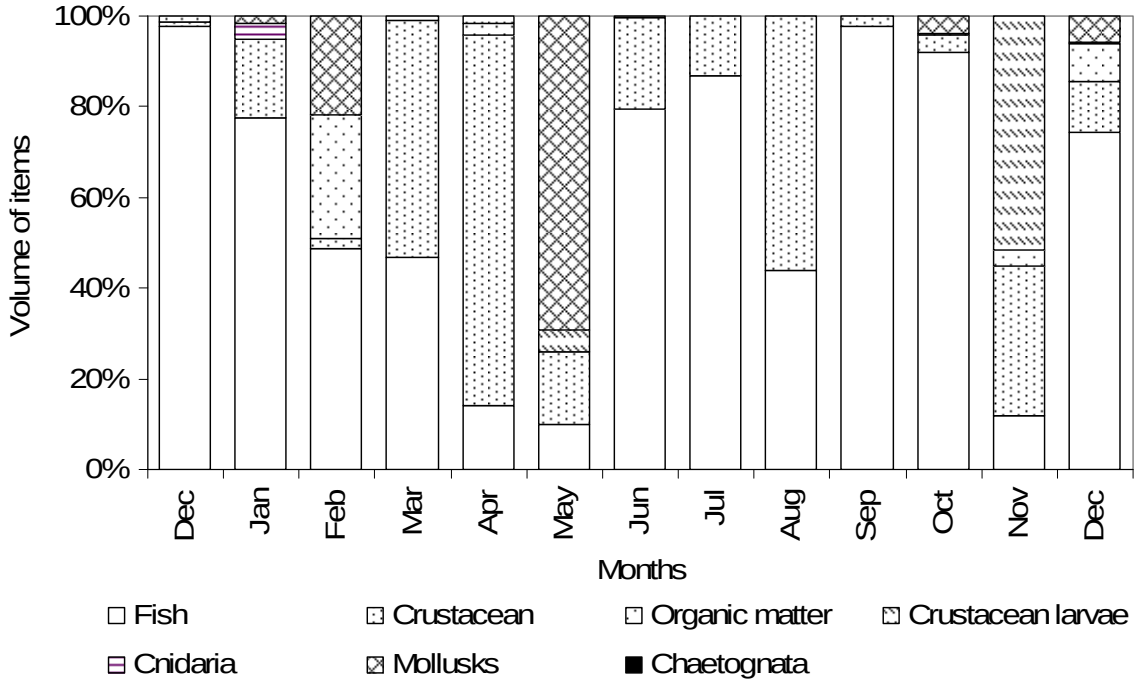


**Fig. (3).** Volumetric index (%V) of the prey groups of *Caranx caballus* during one year.

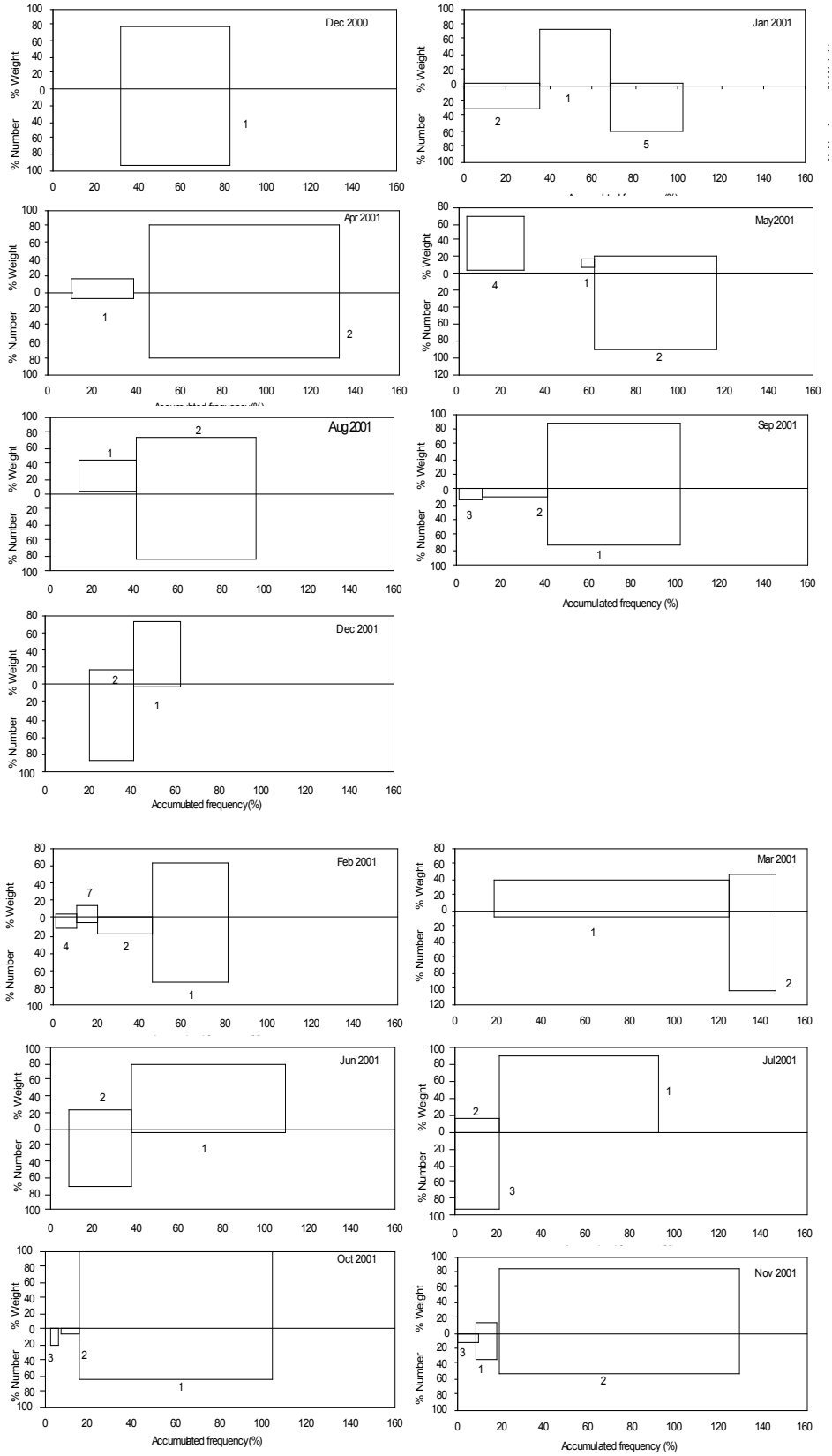


**Fig. (4).** Monthly $IRI_W$. Average numbers: 1 Fish, 2 Crustaceans, 3 Crustacean larvae, 4 Mollusks, 5 Cnidarians, 6 Chaetognata, 7 Organic matter, in the diet of *C. caballus.*

finally, in May the dominant group was of cnidarians (43.3%) (Fig. **4**).

The Index of Relative Importance in volume ($IRI_V$) was higher for the group of fish during the same months as $IRI_W$;

for crustaceans also the same months as $IRI_W$ were important and for mollusks only May stood out (Fig. **5**).

The number of consumed organisms index of *C. caballus'* diet, according to its length showed that small

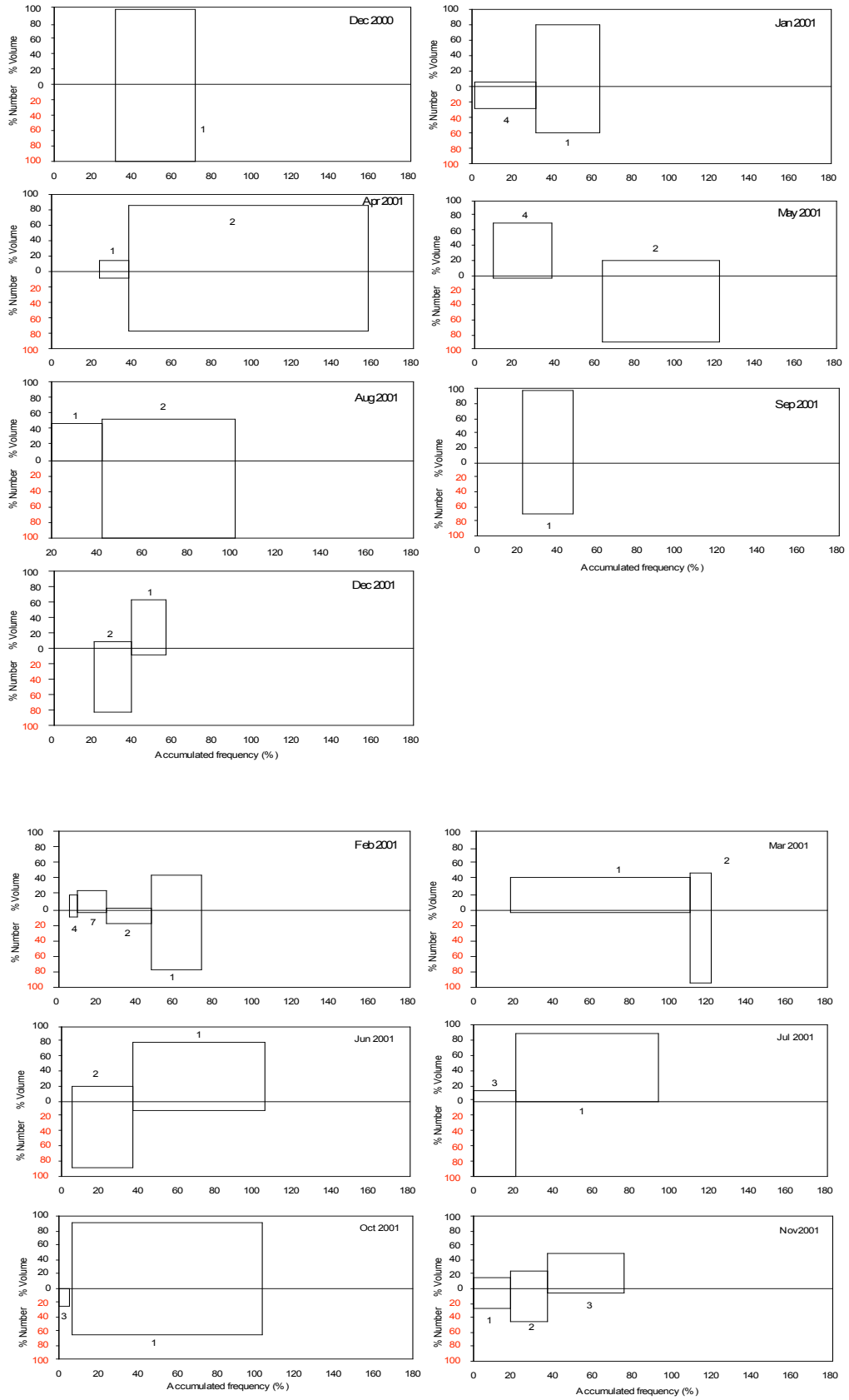


**Fig. (5).** Monthly $IRI_V$. Average numbers: 1 Fish, 2 Crustaceans, 3 Crustacean larvae, 4 Mollusks, 5 Cnidarians, 6 Chaetognata, 7 Organic matter, in the diet of *C. caballus*.

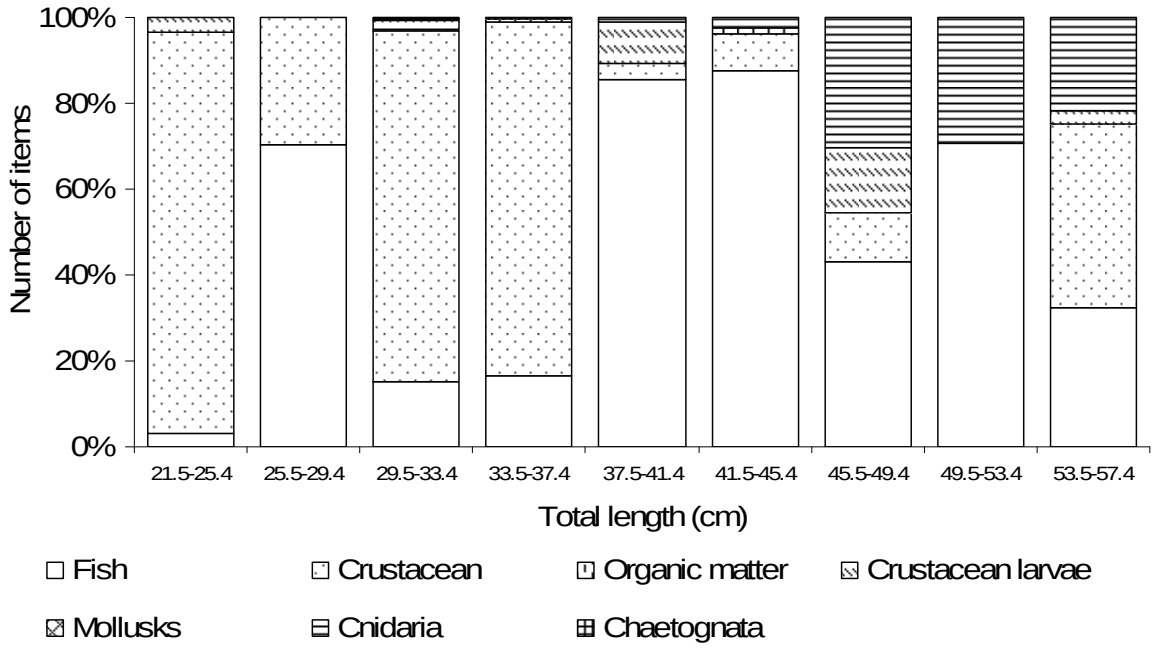


**Fig. (6).** Numeric index (%N) for different lengths and prey groups of *Caranx caballus*.

individuals (21.5 - 25.4cm and 29.5 - 33.4cm) fed mainly on crustaceans and the main food of those measuring 25.5 to 29.4cm were fish. Medium sized organisms fed mainly on crustaceans (82.45%) and on fish. Larger organisms fed mainly on fish and those measuring 53.5 to 57.4 cm, included other items like cnidarians, larvae and crustacean adults (Fig. **6**).

Nevertheless the gravimetric index showed that small individuals (21.5 - 33.4cm and 25.5 to 29.4cm) fed mainly on fish. Individuals measuring 29.5 to 33.4cm showed preference for crustaceans and fish. Medium sized specimens (33.5 - 45.4cm) and larger individuals (45.5 - 53.4cm) fed on fish mainly. Those measuring 53.5 to 57.4cm, showed a preference for crustaceans and cnidarians (Fig. **7**). As they grow their diet is more varied.

Results of the volumetric index showed similar trends as the percentage by weight: a preference for fish in all sized individuals, although those from 21.5 to 25.4cm and 53.5 to

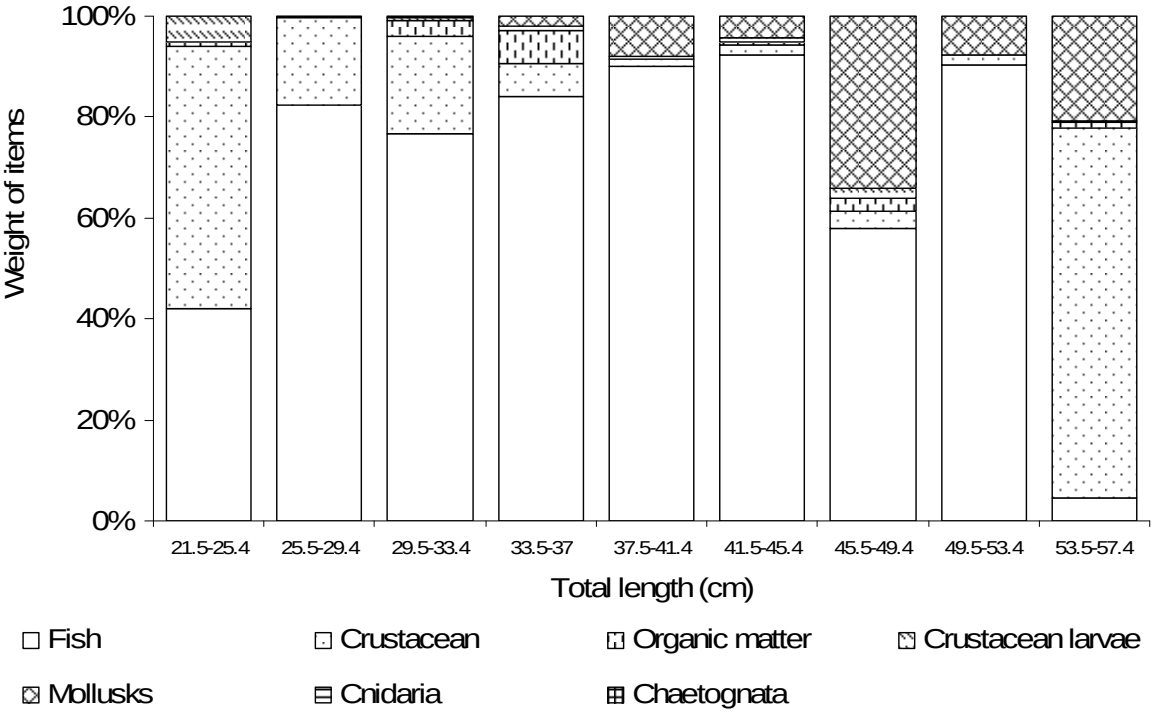


**Fig. (7).** Gravimetric index (%W) for different lengths and prey groups of *Caranx caballus*, during one year.

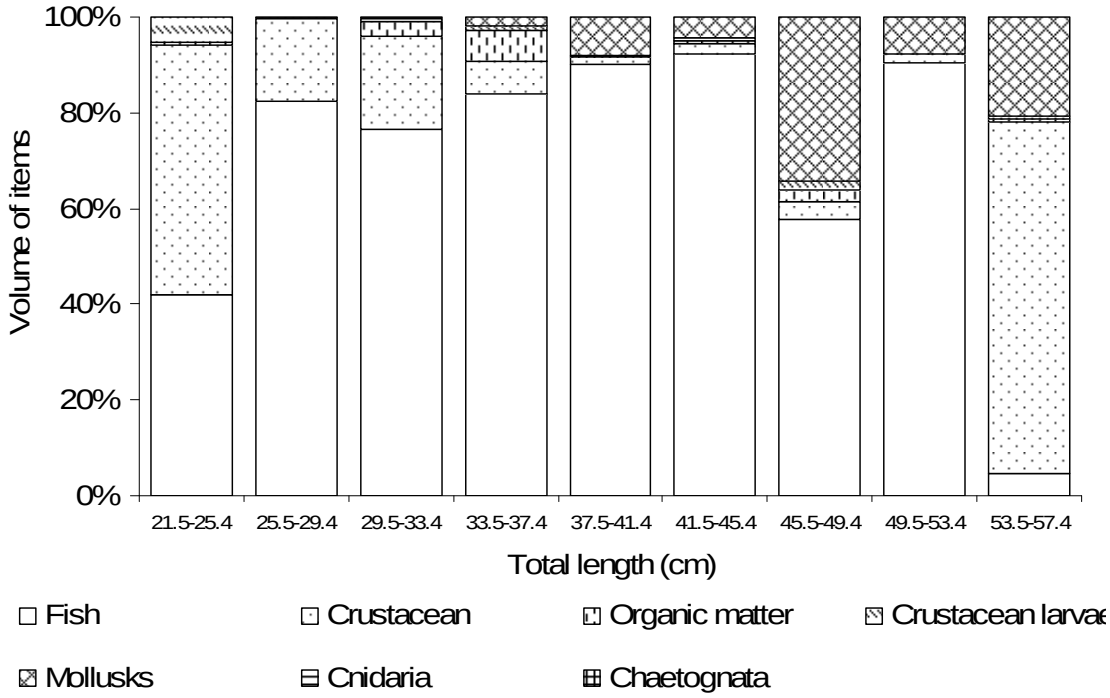


**Fig. (8).** Volumetric index (%V) for different lengths and prey groups of *Caranx caballus*, during one year.

57.4cm showed preference for crustaceans. These last ones also consumed cnidarians in smaller proportion (Fig. **8**).

The diet of males and females were very similar in the percentage in number of individuals, where crustaceans were dominant preys (88.36% in males and 84.94% in females). As percentage by weight of individuals, the most abundant prey was fish (61.16% in males and 79.21% in females). The percentage by volume showed preference towards fish (males 60.04% and females 76.60%). Finally, %IRI showed that the group of fish and crustaceans are very important in the diet (Fig. **9**).

The diversity of the diet spectrum, also considered as the trophic amplitude niche showed different degrees of specialization in the feeding habits throughout the year, lower than 0.05 in the percentage of number, weight and volume (Table **2**).

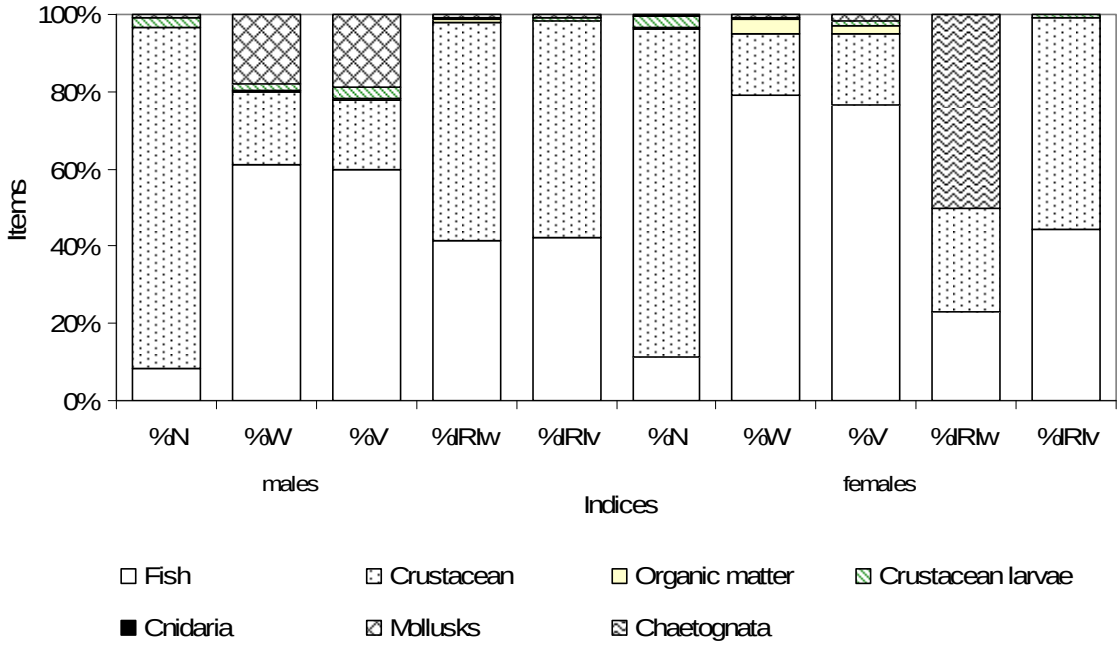


**Fig. (9).** Numeric index (%N), gravimetric index (%W), volumetric index (%V), index of relative importance (%IRI) used for males and females of *Caranx caballus* and their prey groups during one year.

**Table 2. Monthly Sample Trophic Diversity According to Number, Weight and Volume of the Prey of *Caranx caballus***

| Months | Number | Weight | Volume |
|---|---|---|---|
| December (2000) | 0.00 | 0.03 | 0.05 |
| January | 0.02 | 0.01 | 0.01 |
| February | 0.02 | 0.07 | 0.09 |
| March | 0.00 | 0.09 | 0.08 |
| April | 0.02 | 0.08 | 0.10 |
| May | 0.02 | 0.03 | 0.03 |
| June | 0.01 | 0.03 | 0.04 |
| July | 0.00 | 0.01 | 0.01 |
| August | 0.02 | 0.12 | 0.10 |
| September | 0.05 | 0.02 | 0.02 |
| October | 0.03 | 0.02 | 0.04 |
| November | 0.05 | 0.09 | 0.09 |
| December (2001) | 0.00 | 0.06 | 0.05 |

Results of the Alimentary Index (AI) showed that fish is the preferred item of the diet in the seven groups of lengths, with percentage of volume (55.10%) and of weight (58.81%). Crustaceans were frequent food with 11.25% and 10.78% respectively. The rest of the groups are accidental food, with a percentage smaller than 10% (Table **3**), that is, an item that wasn't searched for.

**Table 3. Alimentary Index (AI) of the Prey of *Caranx caballus*, According to the Percentage of Volume and Weight**

| Groups | % Volume | % Weight |
|---|---|---|
| Fishes | 84.60 | 84.27 |
| Crustacea | 13.93 | 14.32 |
| Crustacean larvae | 0.36 | 0.22 |
| Mollusca | 0.76 | 0.69 |
| Cnidaria | 0.00 | 0.00 |
| Chaetognatha | $2.56x10^{-6}$ | 0.00 |
| Organic mater | 0.35 | 0.51 |

## DISCUSSION

Feeding spectrum of *C. caballus* in the coast of Colima includes 42 prey types, which is a larger number compared with other carangids studied in Brazil [27], in India [28], in the Mediterranean [29] and in Colombia [7]. In contrast in Florida, Louisiana and Texas, Soloman & Naughton [6] reported more than 150 different preys. Other authors [30] suggest the diet is a result or describes the species habitat, and the diversity of the prey can infer competition and overlap in diets of the species in the area.

The preys identified belong to five taxonomic groups: fishes (important in weight throughout the annual cycle and weight by the individuals' length), crustaceans (important in number for the annual cycle); mollusks, cnidarians and chaetognaths, present in some seasons. We separated two extra groups for the analysis: "Crustacean larvae" and "Organic matter" because they give more information as a separate item.

Apparently the difference in the diets of *C. caballus* and others are related to the variation abundance and availability of the prey. Soloman & Naughton [6] reported for Florida, Louisiana and Texas, 28 families and 50 species of fish emphasizing that clupeids are most consumed and species of the families Engraulidae, Clupeidae and euphausids predominated in stomach contents of *C. caballus*.

The prey preference of *C. caballus* does not differ much from other carangids being basically fishes. Engraulids were described as a family of fish present in the stomachs of *Oligoplites saurus* and *C. caballus* [6]. They also reported the presence of zoea and megalops in their stomachs, and differ in the hymenopteran and dipteran insects. Crustaceans and mollusks were also reported, but differ in the presence of insects and insect larvae in their diet [27], probably owing to the differences in the influence of coastal rivers and/or latitude. In his study, Santos-Martínez [31] agrees with this paper, according to the percentage in number, weight and volume of prey, with the feeding spectrum where fish, crustaceans and insects are present. Differences found in the feeding throughout the year are due to changes of natural occurrence of prey in the sampling area, whereas along years there are no changes. On the other hand, nutritional habits can change in a same species depending of the locality [32], feeding conditions, availability and seasonality of sex. This variation was reported for other species of the same family, such as *Caranx hippos* [5] and *C. ruber* [33]. Similarities in the feeding at different sizes of *O. saurus* and *O. palometa* were also found [7, 29].

Results of this study show that the variation between the analyses of IRI elaborated with weight and volume is minimum; they only vary in small feeding items. Without doubt the preference, by far, is for fishes, followed by crustaceans and mollusks in smaller proportions. Smaller organisms tended to feed more on fishes, perhaps because it offers better quality of protein, very important in young specimens, to grow faster and avoid being a prey themselves.

The diversity of the diet spectrum or amplitude of the trophic niche of *C. caballus* showed that it is specialized, with preference for fish throughout the year, in all its lengths and in both males and females. It was also found that there were other organisms as supplement of a basic diet.

*C. caballus* has a defined alimentary index reported in other studies of Carangidae family, whose diet is similar; its preferential food is fish, frequently crustaceans and occasionally crustacean larvae, mollusks, cnidarians, chaetognaths and organic matter, which vary in other carangids according to the study area.

## CONFLICT OF INTEREST

None declared.

## ACKNOWLEDGEMENT

None declared.

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