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ORIGINAL ARTICLE

Possible predation by the striped weakfish *Cynoscion guatucupa* on estuary-associated fishes in an Argentinian coastal lagoon

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Abstract
Cynoscion guatucupa is one of the most important coastal fishery resources of Argentina and Uruguay, with both juveniles and adults being recorded in Mar Chiquita coastal lagoon, a shallow-water estuarine lagoon in Argentina. *Cynoscion guatucupa* enters and exits the lagoon following tidal cycles, with residence time within the lagoon lasting only for the duration of a tidal cycle. The main objectives of this study were to determine the diet composition of *Cynoscion guatucupa* captured in the lagoon, and to determine if different size-classes of this species differentially utilize available food resources during their residency within the coastal lagoon. The diet of 511 specimens of *C. guatucupa* was analysed. The most important prey item in %IRI was *Peisos petrunkevitchi*, followed by juvenile teleosts including those of *Micropogonias furnieri*, *Odontesthes argentinensis* and *Mugil platanus*. *Cynoscion guatucupa* enters the lagoon to feed on a variety of invertebrates as well as juvenile teleost fishes. Diet composition showed ontogenetic changes: smaller individuals predominantly consume crustaceans, and as size increases they begin to prey more on teleosts, with the largest fishes specializing on fish. The present study reinforces the role of estuaries for marine fishes as both feeding grounds for juveniles and adults and as refuge areas for juveniles. Furthermore, this study also highlights the importance of food habit studies for understanding the trophic ecology of fishes and estuarine food web dynamics.

Key words: *Diet composition, juvenile fish consumption, ontogenetic changes, resource use*

Introduction

Food is one of the most important factors regulating fish populations, and its availability affects fish abundance, growth, mortality and migration (Sánchez & Prenski 1996). Habitat is also an important factor influencing the feeding of a species by determining foraging opportunities, where a fish may have to choose between a habitat that provides more abundant and diverse prey and a habitat with low competition for food (Hajisamae et al. 2003). Regular or occasional displacement of individuals between open sea and estuary are common for coastal fishes (Chaves & Umbria 2003). Numerous fish species are found in estuaries and they use these systems in a variety of ways; many complete their life cycle within the estuary and yet others utilize the estuary as migratory routes or for feeding areas (Potter et al. 2013). In this context, the study of trophic ecology is useful and fundamental for understanding the functional role of the fish within ecosystems (Elliot et al. 2007). Estuarine fishes are largely characterized by flexible food habits, low tendency to specialize in their diets and typically exhibit opportunistic behaviour to exploit peaks in prey abundance. Therefore, diets of estuarine fishes may reflect both types and variability of resources available in their environment (Ley et al. 1994; Giberto et al. 2007; Mendoza Carranza & Vieira 2008).

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Striped weakfish, *Cynoscion guatucupa* (Cuvier, 1830), is one of the most important coastal fishery resources of Argentina and Uruguay (Jaureguizar et al. 2006), contributing about 17% of the total annual commercial catch of coastal fishes in this region (Ruarte et al. 2004). This species inhabits coastal waters along the southwest Atlantic coast from Río de Janeiro (22°S, Brazil) to Chubut province (43°S, Argentina) (Ruarte et al. 2004) and has been recorded in the Mar Chiquita coastal lagoon (37°32′–37°45′S; 57°19′–57°26′W), where it is regarded as an estuarine non-dependent marine fish that uses estuarine areas as a refuge from predators and also for feeding (Cousseau et al. 2001; González Castro et al. 2009). Mar Chiquita has been a UNESCO World Biosphere Reserve since 1996 (Iribarne 2001). Available literature on the fish communities of this lagoon suggests that the area is an important nursery for some marine species (Cousseau et al. 2001; Rivera Prisco et al. 2001; González Castro et al. 2009). The ingress and egress of both juveniles and adults of *C. guatucupa* in the lagoon, where they have a similar spatial distribution (Cousseau et al. 2001), is governed by daily tidal cycles (González Castro et al. 2009; Cousseau et al. 2011).

Previous studies on feeding habits of *C. guatucupa* in the Río de la Plata (Giberto 2008) and Bahía Blanca estuaries (Lopez Cazorla 1996; Sardiña & Lopez Cazorla 2005) have shown that this species feeds on a variety of small fishes and demersal invertebrates. No feeding investigations have previously been carried out for this species in the Mar Chiquita coastal lagoon. In recent years, the importance of identifying and protecting habitats used by fish species has been recognized as a critical aspect in maintaining marine resources (Monaco et al. 1998). Due to the ingress of *C. guatucupa* to the lagoon during high tide and egress at low tide, the main objective of this study is to determine whether each size-class of *C. guatucupa* differentially makes use of food resources available in the Mar Chiquita coastal lagoon. The hypothesis proposed was that *C. guatucupa* adapts its feeding strategy to take advantage of available prey during its stay in the lagoon. To test this hypothesis, both the diet composition and the feeding strategy of *C. guatucupa* have been studied.

Material and methods

Study area

According to Kjerfve (1994), a coastal lagoon is a shallow water body separated from the ocean by a barrier and connected with it by one or more restricted inlets, usually oriented parallel to shore. Following this definition, Mar Chiquita (Figure 1) could be classified as a coastal lagoon. It is the most austral of coastal lagoons in South America and is well known for its small size (Reta et al. 2001). This coastal lagoon has an area of 46 km^2 and is 25 km long. It is separated from the sea by a coastal line of dunes and connected via an inlet channel of about 6 km length and 200 m width. The semidiurnal tidal regime affects both depth and salinity in the lagoon. Mean depth is 1.20 m, with a maximum of 4.90 m at high tide and a minimum of 0.80 m at low tide. Salinity has a horizontal gradient that fluctuates between 0 and 36, depending on tide and wind (Reta et al. 2001). Water temperature varies monthly

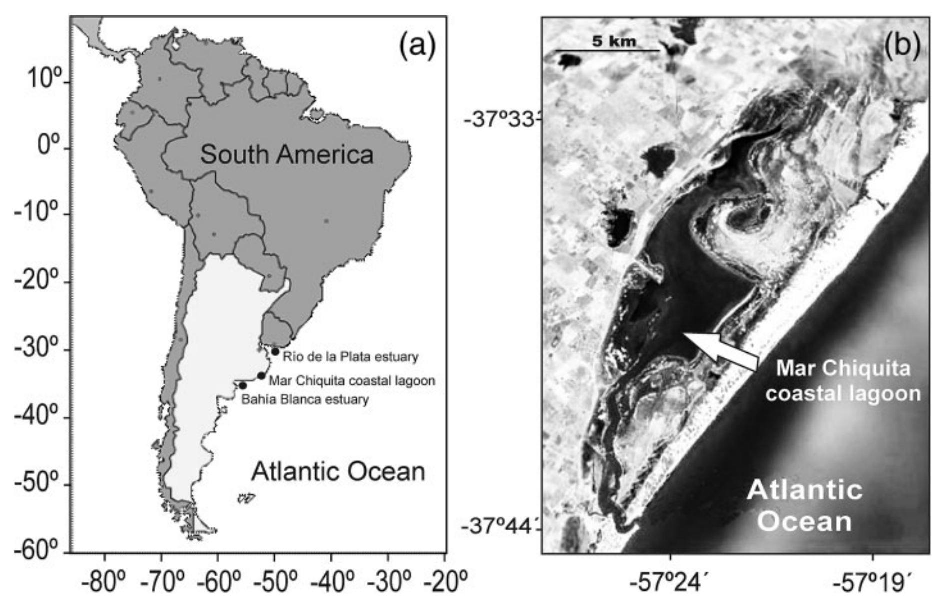

Figure 1. (a) Location of Mar Chiquita coastal lagoon, Río de la Plata and Bahía Blanca estuaries in South America; (b) aerial photograph of Mar Chiquita coastal lagoon with capture locations of *Cynoscion guatucupa*.

and two seasons can be identified: the warm season (October to March), with water temperatures between 13 and 21°C, and the cold season (April to September), with temperatures between 6 and 13°C (Cousseau et al. 2001; Reta et al. 2001).

Field sampling and laboratory procedures

Specimens of *Cynoscion guatucupa* were collected monthly between April 2008 and June 2011. Sampling was carried out in the vicinity of the mouth of the lagoon towards the sea, using 25 m long and 2 m high gill-nets with 120 mm, 68 mm and 57 mm mesh sizes to ensure the capture of a wide range of fish sizes. Samples were also taken by recreational rod-and-reel fishing at the same locality. Total length (TL), measured to the nearest millimetre, and the sex of each specimen were recorded. Stomachs of specimens were removed and stored at –20°C for subsequent laboratory analyses. In the laboratory, prey items were identified under a stereomicroscope to the lowest taxonomic level using keys, identification guides and reference collections (Boschi et al. 1992; Cousseau & Perrotta 2004). Prey items were counted and their wet weights recorded (± 0.01 g). Additionally, the standard lengths (SL) of teleosts consumed were measured to the nearest millimetre. Species that were used as bait for individuals collected by the recreational fishery were excluded from dietary analysis.

Overall diet composition

The contribution of each prey category to the diet of *Cynoscion guatucupa* was examined by its percentage in number (*%N*), percentage in wet weight (*%W*), percentage frequency of occurrence (*%O*) (Hyslop 1980), and with the Index of Relative Importance (*IRI*) (Pinkas et al. 1971): $IRI = \%O \times (\%N + \%W)$. To allow comparison with other studies, IRI was expressed as a percentage (*%IRI*) (Cortés 1997).

Prey items were assigned to one of three zoological categories for the statistical analyses: teleosts, decapods and amphipods + isopods combined. To analyse for ontogenetic shifts in diets, specimens of *C. guatucupa* were grouped into five size-classes: I, 69–149 mm TL; II, 150–280 mm TL; III, 281–399 mm TL; IV, 400–499 mm TL; and V, 500–599 mm TL, according to the length–age relationship determined for this species by Lopez Cazorla (2000). To analyse for seasonal shifts in diets, the seasons were defined as: warm (October to March) and cold (April to September). To determine sample size sufficiency, the order of stomachs sampled was randomized 100 times and the mean cumulative Shannon–Wiener diversity index was plotted as a function of stomach number (Magurran 2004). Cumulative curves were then calculated for each factor considered in the analyses of feeding variation (sex, season and size-classes). If the plot reached an asymptote, then the number of stomachs analysed was considered sufficient to comprehensively define the diet for that parameter of the feeding variation.

Variation in prey consumption

Variation in the consumption of each prey category was evaluated by sex, total length (TL) and season using a generalized linear model (GLM; Crawley 2005). Models were built based on the number of prey consumed in each category as the response variable, and with sex, TL or season as the independent variables. Therefore, models with combinations of sex + TL, sex + season and season + TL as independent variables were fitted. Models with count data have a negative binomial error distribution and a log link when too many zeros are present and the variance is much greater than the mean (Zuur et al. 2009). For each model, the Akaike Information Criterion (AIC) was calculated and the model with the lowest AIC was selected as the best model (Zuur et al. 2009). Akaike's weight (w) was calculated to obtain the relative likelihood of each model fitted given the data (Johnson & Omland, 2004). Akaike's weights are normalized across the set of candidate models to the sum of one and are interpreted as probabilities. A model whose w approaches 1 is unambiguously supported by the data (Johnson & Omland 2004). If w did not provide strong support for any model fitted, model averaging was computed to measure the effects of the variable, explaining most of the variation (Symonds & Moussalli 2011). All statistical analyses were conducted with the R statistical software, version 2.14.2.

Feeding strategy

The feeding strategy for each size-class of *Cynoscion guatucupa* and the importance of each prey category in the diet were identified by plotting the percentage prey-specific abundance (*%P*) of each prey category against *%O* (Amundsen et al. 1996). *P*, the relative abundance among prey species found in the stomachs, was calculated as the number of prey consumed in category i divided by the total number of prey in the stomachs that contained the prey category i, expressed as a percentage. Prey points located on the upper right of the diagram would be indicative of specialization of the predator population. In contrast, all prey points located along or below the diagonal from the upper left to the lower right would reflect a generalized feeding strategy of the predator population. Furthermore, the distribution of points along the diagonal from the lower left to the upper right corner provides a measure of prey importance, with dominant prey at the upper and rare prey at the lower end (Amundsen et al. 1996).

Results

Diet composition

A total of 541 specimens of *Cynoscion guatucupa* ranging from 66 to 565 mm TL were captured. Of these, 511 ranging in size from 69 to 565 mm TL contained food in their stomachs and these were used for the diet analyses. Of individuals with stomach contents, 42.8% corresponded to size-class I, 10% to class II, 17.6% to class III, 18.8% to class IV and 10.8% to class V. The length frequency distributions were similar between both seasons and both sexes (Figure 2); and cumulative curves of diversity reached an asymptote for all individual groups, indicating that the sample sizes were sufficient to describe and compare the diets (Figure 3).

The diet of *C. guatucupa* for all specimens examined was composed of 17 different prey items: seven teleost, three decapod, two amphipod, two isopod, two mollusc and one polychaete species. Overall, the decapods *Peisos petrunkevitchi* Burkenroad, 1945 and *Artemesia longinaris* Spence Bate, 1888 were the most important prey of *C. guatucupa*. These species showed the highest values of %IRI (72.41% and 2.82%, respectively), followed by the teleosts *Micropogonias furnieri* (Desmarest, 1823) (10.72%), *Odontesthes argentinensis* (Valenciennes, 1835) (6.77%) and *Mugil platanus* Günther, 1880 (2.39%). Amphipods, isopods, molluscs and polychaetes were less important (%IRI < 1; Table I) in the diet composition. The sergestid *P. petrunkevitchi* dominated the diet both in terms of numbers of individuals and frequency of occurrence, while *M. furnieri*, *M. platanus* and *O. argentinensis* were the most important fish prey items in terms of biomass, representing 53.56% of the total diet (Table I). The size range of teleosts consumed by *C. guatucupa* varied from 8 to 105 mm SL (mean ± SD was 46 ± 25 mm; n = 119).

Diet shifts

The number of all prey items consumed by *Cynoscion guatucupa* was independent of sex (Table II). The consumption of both decapods and teleosts increased with increasing length of *C. guatucupa* and consumption of these prey items was independent of season (Figure 4). However, this increasing trend in decapod consumption was driven by only four individuals over 400 mm TL. These four individuals contained high numbers of this prey item (Figure 4b). Estimated models excluding information from these four fish showed a constant trend between the

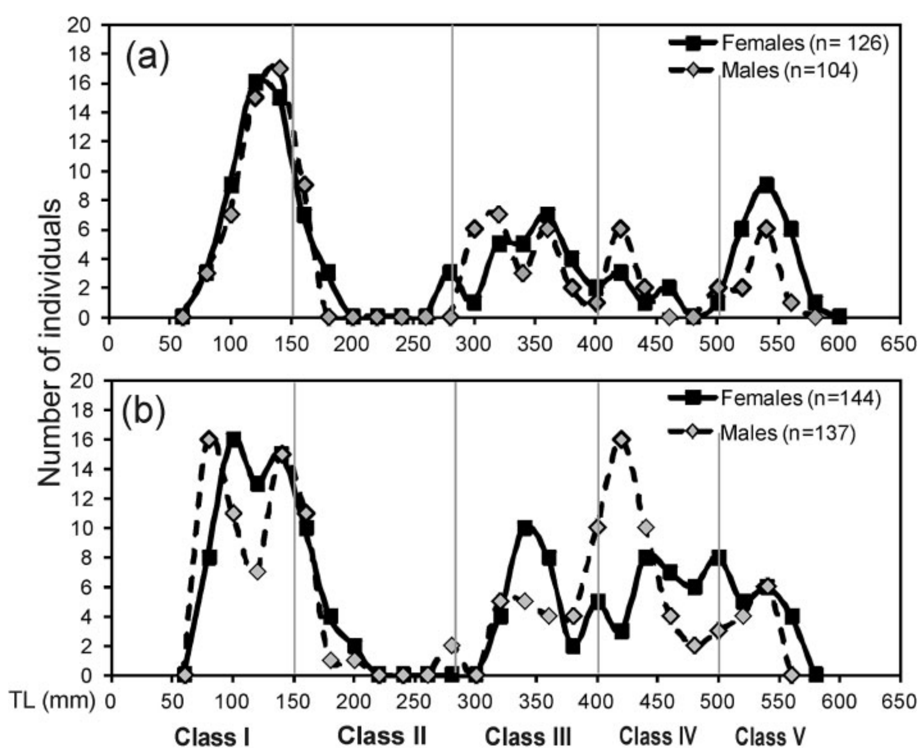

Figure 2. Length–frequency distributions by sex of 511 *Cynoscion guatucupa* with stomach contents, collected in Mar Chiquita coastal lagoon during (a) cold and (b) warm seasons. Vertical lines: size-class limits.

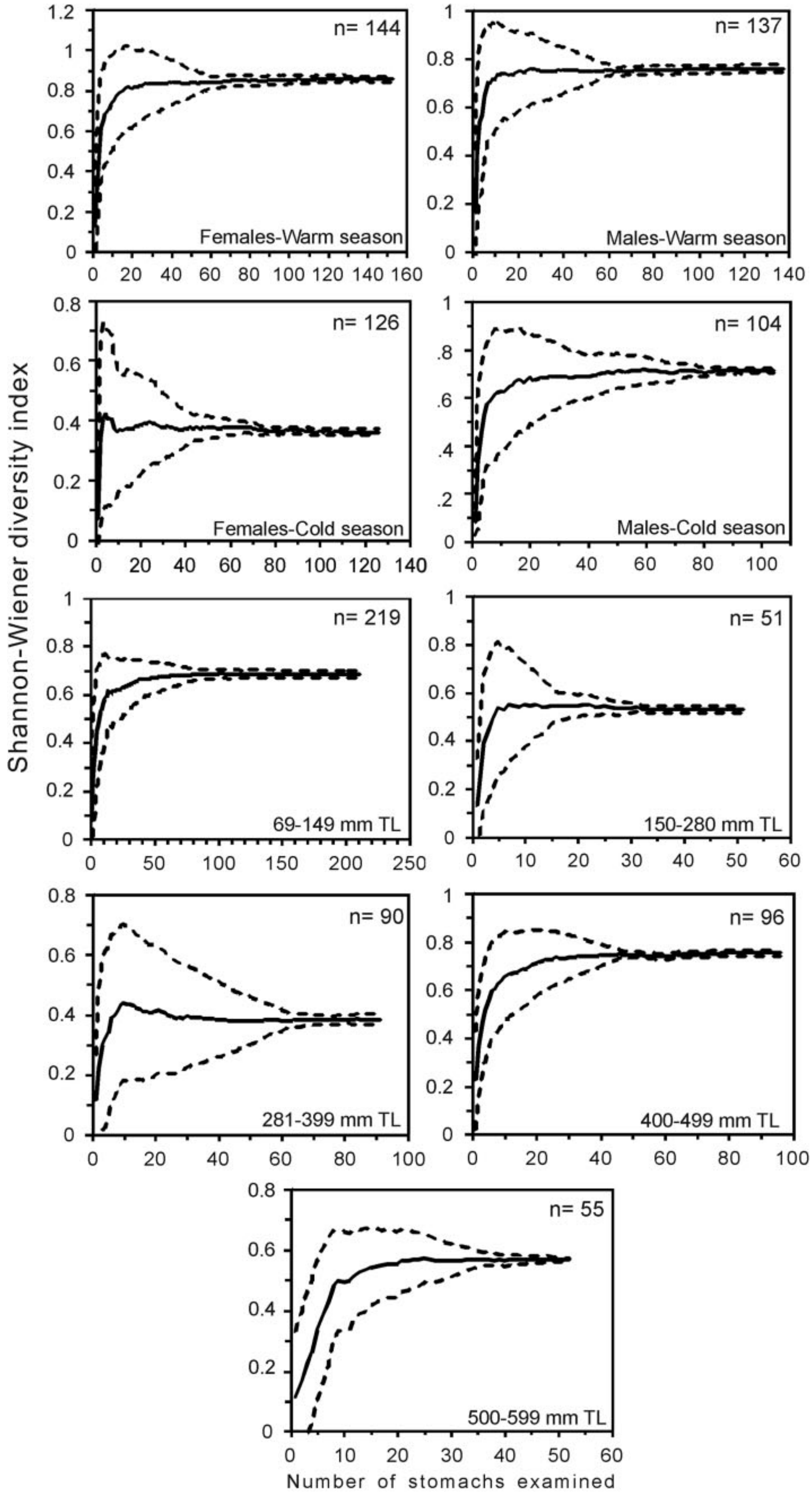

Figure 3. Cumulative Shannon–Wiener diversity index of prey items for each subgroup of *Cynoscion guatucupa* considered in the analysis; mean (continuous line) ± standard deviation (dashed lines).

Table I. Diet composition of *Cynoscion guatucupa* in Mar Chiquita coastal lagoon expressed as percentage frequency of occurrence (%*O*), percentage by number (%*N*), percentage by wet weight (%*W*), the index of relative importance (IRI) and percent IRI (%IRI).

Prey items	%*O*	%*N*	%*W*	IRI	%IRI
ANNELIDA	2.34	0.32	0.05	0.87	0.01
Polychaeta	2.59	0.32	0.05	0.96	0.02
CRUSTACEA	60.55	88.04	21.80	6650.62	65.37
Decapoda	51.95	75.24	21.18	5009.38	58.01
Penaeidae					
Artemesia longinaris Spence Bate, 1888	15.77	4.74	3.91	136.48	2.82
Solenoceridae					
Pleoticus muelleri (Spence Bate, 1888)	5.18	1.93	5.22	37.06	0.77
Sergestidae					
Peisos petrunkevitchi Burkenroad, 1945	43.41	68.56	12.05	3499.73	72.41
Amphipoda	8.01	9.71	0.41	81.04	0.94
Hyalidae					
Hyale grandicornis Krøyer, 1845	3.89	2.93	0.28	12.51	0.26
Melitidae					
Melita palmata (Montagu, 1804)	4.97	6.77	0.13	34.28	0.71
Isopoda	6.45	3.10	0.21	21.28	0.25
Sphaeromatidae					
Sphaeroma serratum (Fabricius, 1787)	1.94	1.09	0.03	2.18	0.05
Idoteidae					
Idotea balthica (Pallas, 1772)	5.83	2.01	0.17	12.73	0.28
CEPHALOPODA	0.98	0.12	1.72	1.80	0.02
Octopodidae					
Octopus tehuelchus d'Orbigny, 1834	0.65	0.08	1.65	1.12	0.02
Loliginidae					
Doryteuthis gahi (d'Orbigny, 1835)	0.43	0.04	0.07	0.05	<0.01
TELEOSTEI	40.04	11.52	76.43	3521.18	34.61
Engraulidae					
Anchoa marinii Hildebrand, 1943	4.32	0.80	5.68	28.01	0.58
Engraulis anchoita Hubbs & Marini, 1935	1.08	0.20	0.92	1.21	0.03
Clupeidae					
Brevoortia aurea (Spix & Agassiz, 1829)	1.73	0.28	3.28	6.16	0.13
Mugilidae					
Mugil platanus (Günther, 1880)	8.42	1.23	12.51	115.73	2.39
Atherinopsidae					
Odontesthes argentinensis (Valenciennes, 1835)	14.04	2.93	20.38	327.33	6.77
Sciaenidae					
Cynoscion guatucupa (Cuvier, 1830)	4.32	0.76	8.99	42.11	0.87
Micropogonias furnieri (Desmarest, 1823)	20.95	4.06	20.67	518.17	10.72
Unidentified teleosts	11.02	1.25	3.99	57.70	1.19

number of decapods consumed and the predator's length (see Decapods** in Table II). Amphipod and isopod consumption decreased with increasing size of *C. guatucupa* and consumption values were 2.218 times lower in the cold season compared with those from the warm season (Figure 5).

The diets of *C. guatucupa* showed considerable variation in the principal prey categories consumed over the different size-classes analysed (Figure 6). The highest importance of decapod consumption was recorded for size-classes I and II. Size-class III consumed decapods and teleosts in similar

Table II. Best models explaining the number of prey consumed in each category by *Cynoscion guatucupa*.

Prey category	Intercept	Coefficients	*P*-value	AIC	*w*
Teleosts	−3.280 (0.178)	0.010 (< 0.001) TL	< 0.001	1161.5	0.936
Decapods*	1.246 (0.167)	0.003 (< 0.001) TL	< 0.001	2455.9	0.633
Decapods**	1.709 (0.175)	−0.0009 (< 0.0001) TL	0.078	1697.9	0.573
Amphipods + Isopods	2.174 (0.397)	−2.218 (0.388) Cold − 0.006 (0.001) TL	< 0.001	827.5	0.750

TL, total length (mm); Cold, cold season; AIC, Akaike Information Criterion; *w*, Akaike's weight; standard error in brackets; *estimated model for total number of samples; **estimated model without fish over 400 mm TL with high numbers of decapods consumed. The coefficients of the models are relative to the warm season.

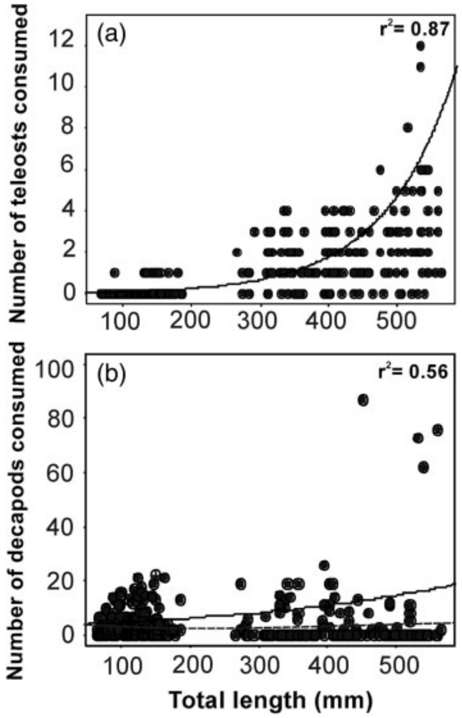

Figure 4. Number of (a) teleosts and (b) decapods consumed as a function of total length of *Cynoscion guatucupa*. Solid line: estimated model based on total number of samples (r^2 in graphic); dashed line: estimated model without fish over 400 mm TL that had consumed high numbers of decapods.

proportions, whereas teleosts were the most important prey category in the largest size-classes of *C. guatucupa* (Figure 6).

Within the Mar Chiquita coastal lagoon, *C. guatucupa* showed a specialist feeding strategy. Although decapods and teleosts were the dominant prey categories, a clear variation between size-classes was observed. Abundance and occurrence of decapods decreased while teleosts increased with the increase in size-class (Figure 7).

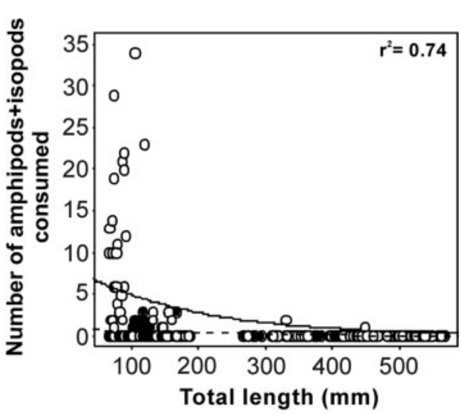

Figure 5. Number of amphipods + isopods consumed as a function of season and total length of *Cynoscion guatucupa*; solid line and open circles: warm season; dashed line and solid circles: cold season.

Discussion

Striped weakfish *Cynoscion guatucupa* in the Mar Chiquita coastal lagoon is a carnivorous fish that consumes both pelagic and demersal prey species. The sergestid shrimp, *Peisos petrunkevitchi*, was identified as the main prey of *C. guatucupa*, both in the current study and in that conducted on this species in the Bahía Blanca estuary (Lopez Cazorla 1996). This shrimp has a permanent presence in coastal waters of the southwestern Atlantic (Boschi et al. 1992; Scelzo et al. 2002) where it is frequently preyed upon by both fishes and other crustaceans (Boschi 2004). However, this species has not previously been reported in Mar Chiquita. Therefore, this sergestid, consumed mainly by classes I, II and III of *C. guatucupa*, was likely ingested by fishes when they were outside of the lagoon.

Previous reports of feeding behaviour for *C. guatucupa* in coastal waters of the Southwest Atlantic Ocean indicate that this species feeds on pelagic fishes, mainly *Engraulis anchoita* Hubbs & Marini, 1935 and *Anchoa marinii* Hildebrand, 1943 (Cordo 1986; Lucena et al. 2000; Giberto 2008). On the other hand, in the Bahía Blanca estuary *C. guatucupa* preyed mainly on *Ramnogaster arcuata* (Jenyns, 1842), *Micropogonias furnieri* (Desmarest, 1823) and *C. guatucupa* (Lopez Cazorla 1996). In Mar Chiquita, the most important teleosts found in stomachs of *C. guatucupa* were the demersal fish *M. furnieri* and the pelagic fishes *Mugil platanus* and *Odontesthes argentinensis*. Such expansion of prey types consumed in the lagoon may be related to the fact that, as the lagoon is a shallow water body (Reta et al. 2001), no stratification of the water column is observed, which contrasts markedly to what happens in the open sea.

This study revealed ontogenetic shifts in the diet of *C. guatucupa*, and these shifts were similar to those reported for this species in the Southwest Atlantic Ocean (Ciechomski & Ehrlich 1977; Lopez Cazorla 1996) and for other congeneric species, such as *Cynoscion regalis* (Bloch & Scneider, 1801) (Merriner 1975) off the southeastern coast of the United States and *Cynoscion nannus* Castro Aguirre & Arvizu Martinez, 1976 (Raymundo Huizar et al. 2005) from off the coast of Mexico. Specimens smaller than 280 mm TL (classes I and II) fed upon teleosts in a proportion no higher than 11% of the total diet, whereas the relative importance of these prey species increased significantly and was close to 100% in the largest individuals (class V). Size-related diet shifts in a species could be related to different energy requirements due to sexual maturity in larger fishes, or they may result via passive mechanisms not directly linked to age or life stages, such as differences in predator

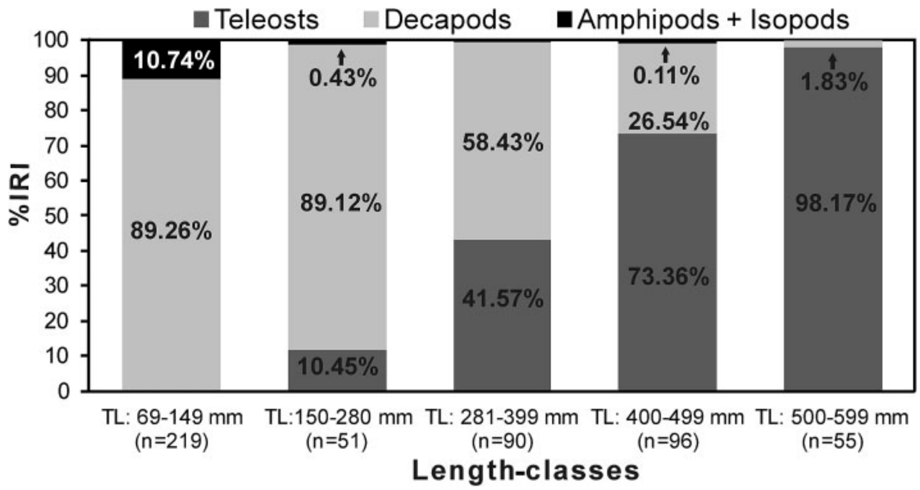

Figure 6. Accumulated percentage of relative importance indices for each prey category for five size-classes of *Cynoscion guatucupa*; TL: total length range of size-classes.

movement velocity or spatial or temporal habitat variations in food resource (Raymundo Huizar et al. 2005). Size-related changes in the diet composition of *C. guatucupa* may also be attributed to habitat use, morphological constraints and the availability of prey items in the environment (Sardiña & Lopez Cazorla 2005).

Seasonal variations recorded in amphipod and isopod consumption could be due to changes in abundance and availability of these prey species in the environment. Similar seasonal changes in food consumption have previously been reported for *C. guatucupa* in the Bahía Blanca estuary (Lopez Cazorla 1996) and in coastal waters off southern Brazil (Lucena et al. 2000). The abundance of the amphipod *Melita palmata* (Montagu, 1804) in the diet of size-class I of *C. guatucupa* during the warm season is positively linked with the seasonal abundance of this species in the lagoon. This amphipod has the highest densities in the Mar Chiquita lagoon in summer, during its reproductive season, while during the rest of the year, abundance of this species decreases when adults disappear from this system (Obenat et al. 2006). This could indicate that this prey item, although of relative unimportance in the diet of class I individuals, is eaten by *C. guatucupa* while they occur within the lagoon, whereas the most important prey item *P. petrunkevitchi* is consumed in the adjacent coastal waters.

All fish species consumed by *C. guatucupa* were juveniles smaller than the size at first sexual maturity reported for these species: *M. furnieri* 340 mm (Cousseau & Perrota 2004), *M. platanus* 436 mm (González Castro et al. 2011) and *O. argentinensis* 161 mm (Moresco & Benvenuti 2006). These fish species, as well as *C. guatucupa*, are represented in Mar Chiquita by both adult and juvenile specimens. The presence of juveniles and adults of these species emphasizes the role of the Mar Chiquita coastal lagoon both as a nursery site for juveniles as well as a foraging ground for adults (Cousseau et al. 2001). Within the lagoon, abundances of juvenile fishes are high (González Castro et al. 2009). Because of the shallow nature of the lagoon and the high population densities of juvenile fishes, the encounter rates for predators with fish prey are likely to be very high. Many estuarine fishes consume almost any suitably sized prey that they encounter and thus, these predators should be regarded as opportunists (Elliot et al. 2007).

Predation on juvenile fishes that utilize the coastal lagoon as a nursery area is not limited to large predatory fishes. Other possibilities include predation by juvenile conspecifics, crustaceans and birds (Paterson & Whitfield 2000). Cannibalism in *C. guatucupa*, shown in this study, has been reported for this species in other Argentinean and Brazilian regions (Cordo 1986; Lopez Cazorla 1996; Lucena et al. 2000; Giberto 2008).

The results presented here do not support previous hypotheses that these estuarine habitats function as refuges from predators for juvenile fishes occurring within these systems (Able 2005). However, further studies are required on aspects such as temporal/spatial habitat use and trophic interactions within the fish assemblage.

Given the total diversity of potential prey species occurring within the Mar Chiquita lagoon, the feeding strategy demonstrated by *C. guatucupa* within this system indicated a much more restricted diet than potential prey available. In contrast, the feeding strategy employed by *C. guatucupa* allows them to take advantage of the organisms that are present in high abundance within this system. This strategy

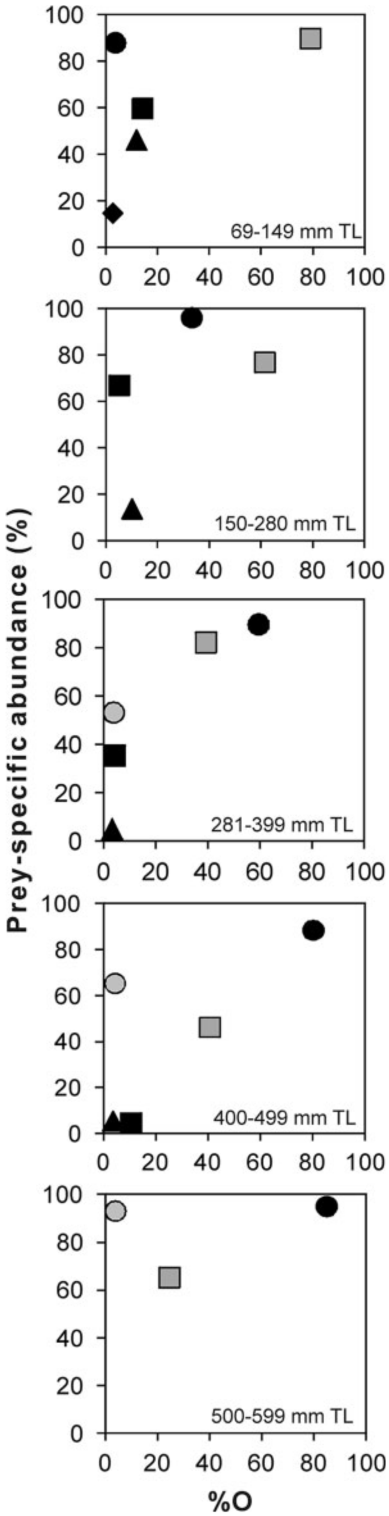

Figure 7. Percentage prey-specific abundance plotted against percentage frequency of occurrence (*%O*) for five size-classes of *Cynoscion guatucupa*; ● Teleosts; ■ Decapods; ▲ Isopods; ■ Amphipods; ● Cephalopods; ◆ Polychaetes.

could thus be regarded as one of an opportunist predator. Estuarine fishes are usually characterized by a generalist feeding behaviour, whereby they adapt their feeding strategy and show plasticity to exploit peaks in prey abundance (Mendoza Carranza & Vieira 2008). This type of plasticity is also found in *C. guatucupa* in southern Brazil (Lucena et al. 2000) and in other sciaenids, including *M. furnieri* (Giberto et al. 2007; Mendoza Carranza & Vieira 2008) and *Pogonias cromis* (Linnaeus, 1766), in the Mar Chiquita coastal lagoon (Blasina et al. 2010).

Given the importance of *C. guatucupa* as part of the demersal fish assemblages in estuarine areas, observations on both trophic spectrum and feeding strategy in this and other species are very important for determining the ecological role of these species in the community and are also important in designing management and conservation programs designed to protect populations of these species. Coastal sciaenids commonly inhabit both open sea and estuaries (Chao & Musick 1977; Vieira & Musick 1994), and differences in the diet depend on the environment where the fish are feeding (Ley et al. 1994). The dietary composition of *C. guatucupa*, in the present study, reflected seasonal changes in abundance, distribution and availability of prey in the Mar Chiquita coastal lagoon. It appears likely that this species makes daily feeding migrations, probably in the direction of the tide, to feed on species that occur in high abundance within the lagoon. Potter et al. (2013) consider that the marine fish species found in estuaries are subdivided into three categories: marine straggler, marine estuarine-opportunist and marine estuarine-dependent. Given that *C. guatucupa* regularly enters estuaries in high numbers but also uses coastal marine waters as alternative nursery areas (Cousseau & Perrotta 2004; Ruarte et al. 2004), the results presented here provide strong evidence that it should be regarded as a marine estuarine-opportunist fish. However, the use that *C. guatucupa* makes of this coastal lagoon may change through different size-classes. About 90% of prey items of both class I and II individuals were mainly marine, as their prey, although of marine origin, have not been recorded in the lagoon. In this case the habitat use may be associated with a refuge site for juveniles (Able 2005; Elliot et al. 2007). In classes III, IV and V, the estuarine prey items are more important in the diet (42%, 73% and 98%, respectively), and provide evidence that the adult individuals make use of the lagoon as a feeding ground. This observation agrees with that of Cousseau et al. (2001), who regarded *C. guatucupa* as an estuarine non-dependent marine fish that uses estuarine areas for refuge and feeding, emphasizing the importance of estuaries for juvenile and adult marine fishes. In addition, our results agree with the behaviour reported for this species in other southwestern Atlantic estuaries (Lopez Cazorla 1996, 2000; Sardiña & Lopez Cazorla 2005; Jaureguizar et al. 2006; Villwock de Miranda & Haimovici 2007).

Fish are among the most mobile consumers and have a recognized potential to affect the structure and function of aquatic food webs (Chaves & Umbria 2003; Haertel Borer et al. 2004; Sheaves 2005, 2009). A variety of small-scale movements, such as the migration of predators into the mouth of estuaries to feed, link the coastal and estuarine waters from a feeding perspective (Baker & Sheaves 2005). The energy obtained in one foraging area can then be transferred to another environment (Kneib 2000), with excretion being the most direct route by which animals provide nutrients to the aquatic ecosystem (Deegan 1993). Due to the entry and exit into and out of the Mar Chiquita coastal lagoon during daily tidal cycles, together with the foraging activity of *C. guatucupa* during its residence within the lagoon, this species plays an important role in nutrient cycling, acting as a carrier of energy between coastal and lagoonal environments.

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