Revista de Biología Marina y Oceanografía 35 (1): 41-47, julio de 2000

Trophic biology contributions of the slender-spined catfish *Arius platypogon* (Günther, 1864), in San Ignacio Lagoon, Baja California Sur, Mexico

Contribución a la biología trófica del bagre cominate *Arius platypogon* (Günther, 1864), de Laguna San Ignacio, Baja California Sur, México

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Abstract.- One hundred two stomachs of the slender-spined catfish *Arius platypogon* were analyzed. The organisms were captured in San Ignacio Lagoon, Baja California Sur, Mexico, during two sampling periods (May and August 1992). The number of food components found was relatively large (23), however a few species were dominant. The slender-spined catfish has a preference for crustaceans, mainly the crab *Callinectes bellicosus* and the shrimp *Penaeus californiensis.* The diet breadth, determined with Levin's index, was low for both periods showing that *A. platypogon* can be considered a specialist predator.

Keywords: Catfish, Ariidae, food habits, Mexico.

Resumen.- Se realizó el estudio de los hábitos alimentarios de 102 bagres cominates *Arius platypogon*, capturados en Laguna San Ignacio, B.C.S, México, durante dos campañas de muestreo (mayo y agosto de 1992). El número de presas registradas fue relativamente grande (23). Sin embargo el bagre cominate tiene preferencia por los crustáceos, principalmente la jaiba *Callinectes bellicosus* y el camarón *Penaeus californiensis*. La amplitud de dieta, determinada por el índice de Levin's fue baja en los dos muestreos, resultando como consecuencia que *A. platypogon* puede ser considerado como un predador especialista.

Palabras clave: Bagre, Ariidae, hábitos alimentarios, México.

Introduction

The species of the family Ariidae (commonly called catfish) occur in all tropical and subtropical seas throughout the world. There are also several freshwater and estuarine species. Worldwide there are approximately 130 species, of which 22 species occur in the eastern central Pacific Ocean and 11 belong to the genera *Arius* (Allen & Robertson 1994, Kailola & Bussing 1995*). Arius platypogon* (Günther) inhabits sand and mud bottoms of the estuarine systems of the Mexican Pacific Ocean where it is one of the most abundant species, with ecological and economic importance indicated by its catch and wide distribution (Kailola & Bussing 1995).

Though this species is important, there are few studies on its basic biology. For the Mexican Pacific, there is only one paper by Gracia & Lozano (1980), which presents information on the food habits of *A. platypogon* in the coastal lagoon systems of the state of Guerrero, Mexico. In contrast, there are many more studies on the biology and ecology of other species of the family Ariidae (*e.g.,* DeLancey 1989, Yañez & Lara 1988, Szelistowski 1989, Vega *et al*. 1994, Blaber *et al.* 1994).

San Ignacio Lagoon is included in an ecological reserve named "La Reserva de la Biosfera de El Vizcaino", because of its importance for migratory birds and as a breeding and nursery area of the gray whale *Eschrichtius robustus* Lilljeborg. Though the lagoon is ecologically important, there is little biological information on the fish species inhabiting the lagoon. There is only one scientific publication, which makes reference to the food habits of the horn shark *Heterodontus francisci* Girard (Segura *et al.* 1997).

The objective of the present study is to contribute to the knowledge of the trophic biology of one of the most abundant species of this lagoon, and to provide new and basic knowledge on the predator-prey interactions of this important ecosystem.

Materials and Methods

Study area

San Ignacio Lagoon is on the west coast of the Baja California Peninsula, Mexico, between 26°38' and 27°00' N and 113°06' and 113°18' W (Fig. 1). It has an approximate area of 17 500 ha, and is almost 35 km long and 6 km wide (Contreras 1985). It is a shallow lagoon of temperate affinity that presents depths of 2 to 4 m in the deep area, and 20 m in the channels that connect with the Pacific Ocean (Swartz & Cummings 1978).

The coast of the lagoon consists of sandy beaches, muddy lowlands, patches of rocky coast, and mangrove zones comprised of the species *Rhizophora mangle* L. (Swartz & Cummings 1978). Jones & Swartz (1984), divided this lagoon into three areas: A) Lower Lagoon, the entry that connects the lagoon with the sea. In this area, the channels are of approximately 10 m deep and up to 20 m deep near the entrance. B) Central Lagoon, extends from the lower lagoon. In this section are three channels separated by two large sand banks. C) Upper Lagoon, the inner area of the lagoon, mostly shallow, with two exposed zones (Fig. 1).

Sample processing and data analysis

Fish were collected in two sampling periods (May and August 1992), with a gill net 140 m long, 3 m wide, and with a mesh size of 9 cm. The nets were set in the three zones delimited by Jones & Swartz (1984) with the same sampling effort. The nets were set at dusk (18:00 h) and recovered at dawn (06:00 h).

The standard length (to the nearest millimeter) and total weight (to the nearest gram) of each fish determined. To reduce the digestive processes, the organisms were injected, into the abdominal cavity, with a solution of 10% formalin neutralized with sodium borate. In the laboratory, the fish were dissected and the stomachs removed.

During the analysis of the gastric contents, the different prey species were separated according to their taxonomic group and identified to the lowest possible taxon permitted by their degree of digestion. The keys of Brusca (1980), Hendrickx (1996), and Hendrickx (1997) were used for the taxonomic determination of the crustaceans. The works of Keen (1971) and Brusca (1980) were used to identify the mollusks. The fish were identified according to Fritzsche (1980), Whitehead (1985), Hastings (1995), and Heemstra (1995). The polychaetes (Annelida) were identified using Fauchald (1977).

The prey were recorded by numerical count (N), weight (W), and frequency of occurrence (F) (Hyslop 1980). The importance of each type of prey was classified in the following feeding categories: P, Preferential ($Q > 200$); S, Secondary ($Q \geq 20$); R, Rare ($Q < 20$). This followed the feeding coefficient proposed by Braga & Braga (1987).

The Index of Relative Importance (IRI) of Pinkas *et al.* (1971) was also used to corroborate the importance of each feeding component. This index frequently has been used in feeding studies because it has the capacity of identifying the food components of great importance within trophic spectrum (Hyslop 1980, Segura *et al.* 1997).

To describe the spatial and temporary variation in the composition of the trophic spectrum, the diversity index of Shannon-Wiener (Vandermer 1981) as modified by Schmitter & Castro (1996) was used to measure the diversity of prey by period and sampling location. The evenness index of Pielou (Krebs 1989) was calculated.

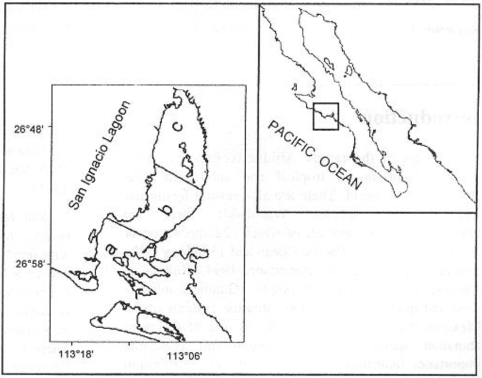

Figure 1

Study area; where a = lower lagoon; b = central lagoon and c = upper lagoon.

Area de estudio; donde a = Laguna inferior; b = Laguna central y c = Laguna superior.

Diet breadth was calculated using Levin's standardized index (Krebs 1989) according to the methodology followed by Labropoulou & Eleftheriou (1997). This index ranges from 0 to 1, low values (<0.6) indicating diet dominated by few prey items (specialist predator) and higher values (>0.6) indicating generalist diets (Krebs 1989, Labropoulou & Eleftheriou 1997).

Results

The stomachs of 102 catfish *A. platypogon,* with a mean standard length of 379.4 ± 46.9 cm (standard deviation) were analyzed. Of those stomachs sampled, 93 contained food (91 %) and 9 were empty (9 %). A total of 23 food components were identified to four taxonomic groups. Crustaceans had the largest number of species (12), followed by mollusks (5), fish (5) and annelids (1) (Table 1).

Table 1

Summary of food components in stomach of the catfish from San Ignacio Lagoon; expressed as percentage based on number (N), weight (W), frequency of occurrence (FO), index of relative importance (IRI) and feeding coefficient (Q). The number in parenthesis corresponds to the food components of the Figure 2.

Espectro trófico, del bagre marino de laguna San Ignacio; expresado como porcentaje de los métodos numérico (N), gravimétrico (W), frecuencia de aparición (FO), índice de importancia relativa (IRI) y coeficiente de preferencia alimenticia (Q). El número en paréntesis corresponde al componente alimentario de la Figura 2.

Food components	%N	%W	% F.O	% IRI	Q
Class Crustacea					
Callinectes bellicosus (1)	12.03	39.33	40.86	59.81	473.33
Portunus xanthusii (5)	1.53	10.71	7.53	0.96	16.34
Unidentified Portunid (7)	2.54	2.39	16.12	2.27	6.09
Hepatella amica (14)	0.17	0.37	1.08	0.02	0.06
Dynomene ursula (13)	0.17	0.40	1.08	0.02	0.07
Penaeus californiensis (2)	5.93	20.20	31.28	23.00	119.83
Scycionia sp. (19)	0.17	0.28	1.08	0.01	0.04
Paracerseis sp. (9)	19.67	0.77	7.53	4.38	15.06
Cirolana sp. (18)	8.64	0.18	6.45	1.62	1.53
Hyale sp. (21)	3.90	0.08	5.38	0.61	0.30
Corophium sp. (23)	33.89	0.57	1.08	1.04	1.94
Ostracoda (22)	0.51	0.06	1.08	0.02	0.03
Phylum Mollusca					
Octopus sp. (4)	0.85	5.40	5.38	0.96	4.57
Nasarius sp. (6)	1.35	0.51	2.15	0.12	0.70
Anachis sp. (21)	2.20	0.74	1.08	0.22	1.64
Ensis californiensis (12)	1.36	2.63	5.38	0.61	3.57
Mollusk remains (15)	0.16	1.35	7.53	0.51	1.37
Phylum Annelida					
Polychaeta (16)	1.18	0.30	3.23	0.14	0.35
Class Osteichthyes					
Sardinops caeruleus (17)	0.68	8.34	5.38	0.97	5.65
Syngnathus californiensis (3)	1.02	0.79	5.38	0.28	0.81
Paralabrax maculatofasciatus (8)	0.34	2.36	2.15	0.17	0.80
Blenniidae (11)	0.34	0.23	2.15	0.02	0.08
Fish remains (24)					
Number of stomach analyzed (102)					
Percent of stomach contained food (91.1%)					
Total	100	100	169.64	100	655

Based on the values obtained for the feeding coefficient (Q), the food components were grouped into three categories: A) Preferential prey, which included in this category the crab *Callinectes bellicosus* Stimpson; B) Secondary prey, which included the shrimp *Penaeus californiensis* Holmes, and C) Rare prey, which included the rest of the identified food components (*e.g.*, *Portunus xanthusii* Stimpson, *Scycionia* sp., *Paracerseis* sp., *Corophium* sp. and *Hyale* sp.) (Fig. 2).

According to the index of relative importance (IRI), the prey *C. bellicosus and P. californiensis* provided nearly 83 % of the total importance within the trophic spectrum *of A. platypogon* (Table 1). For seasonal variation, the changes observed were important. During May 1992 (spring), the IRI showed that the predominant prey species were *C. bellicosus* (40 %) and *P. californiensis* (27%) (Fig. 3). However none of the identified food components reached the preferential level in prey hierarchy, according to the feeding coefficient (Q). Most of the prey were classified as rare or occasional, except for *C. bellicosus* and *P. californiensis*, which remained classified as preferential and secondary prey.

During August 1992 (summer), the stomach contents showed a change in the food habits. The analysis again showed *C. bellicosus* to have the highest value in IRI, but now with 63 %, followed by *P. californiensis* with 20 % (Fig. 3). The frequency and the considerable number of *C. bellicosus* in this month increased its importance within the trophic spectrum of *A. platypogon* and consequently it became a preferential prey.

Only small changes by areas were found in the diet of *A. platypogon* because the prey *C. bellicosus* and P. *californiensis* had a similar contribution in the three sampling locations during the two seasons. Only in summer close to the entrance of the lagoon, we found that *Anachis* spp. and *C. bellicosus* are the most important prey in this season (Fig 4).

The ecological attributes of diversity and evenness, showed a decrease during the summer (August), as a consequence of the dominance of *C. bellicosus* within the prey spectrum in this season. Also, important differences were seen in the trend of these attributes among seasons. In the spring (May)

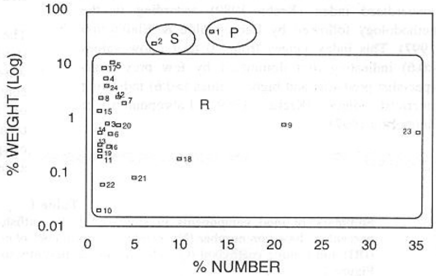

Figure 2

The importance of prey items in the trophic spectrum of catfish, determined by feeding coefficient analysis (Q); where P = preferential prey; S = secondary prey; R = rare preys; 1 = *Callinectes bellicosus*; *Penaeus californiensis*; 3, 4.......n = other preys.

Caracterización del espectro trófico del bagre marino, con base al análisis del coeficiente de preferencia alimenticia (Q); donde P = presas preferentes; S= presas secundarias; R= presas raras; 1= *Callinectes bellicosus*; *Penaeus californiensis*; 3, 4.......n = otras presas

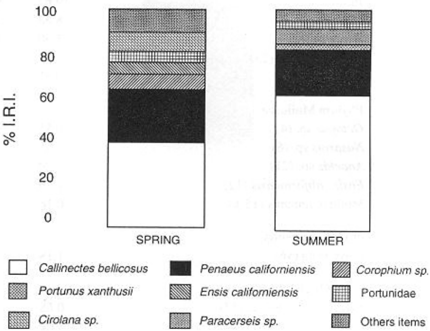

Figure 3

Seasonal variation of the trophic spectrum of catfish, determined by index of relative importance (IRI).

Variación estacional del espectro trófico del bagre marino, de acuerdo al índice de importancia relativa (IRI).

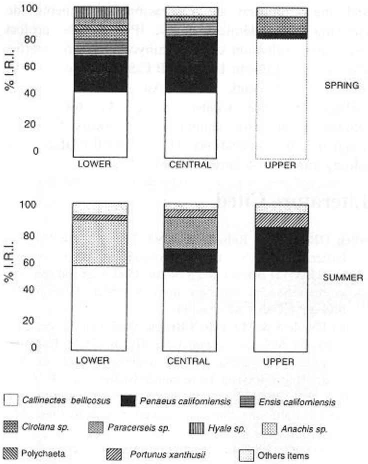

Figure 4

Spatial variation of the trophic spectrum of catfish, determined by index of relative importance (IRI).

Variación espacial del espectro trófico del bagre marino, de acuerdo al índice de importancia relativa (IRI).

Table 2

Comparisons of seasonal and temporal variations of the ecological attributes of the trophic spectrum of catfish from San Ignacio Lagoon.

Comparación de las variaciones estacionales y temporales de los atributos ecológicos del espectro trófico del bagre marino de laguna San Ignacio.

Ecological Atributes	General	Lower	Central	Upper
Spring (May-92)				
Richness (S)	13	7	6	6
Shanon-Wiener diversity index (HQ)	1.55	1.31	1.09	0.38
Maximum diversity (HQ')	2.56	1.95	1.79	1.79
Evenness (J)	0.61	0.67	0.61	0.21
Diet breadth (Bi)	0.17	0.34	0.31	0.04
Summer (August-92)				
Richness (S)	23	7	10	16
Shanon-Wiener diversity index (HQ)	0.89	0.59	1.04	1.13
Maximum diversity (HQ')	3.09	1.95	2.30	2.77
Evenness (J)	0.29	0.31	0.45	0.41
Diet breadth (Bi)	0.03	0.09	0.13	0.09

there was a negative trend (less diverse and even) toward upper area of the lagoon. In the summer, this condition is the opposite (Table 2).

For diet breadth, there are a large number of food components, however the clear dominance of the prey species *C. bellicosus* and *P. californiensis* determined that the estimates obtained by Levin's index were very low for both seasons (0.17 in spring and 0.03 in summer). As consequence, *A. platypogon* must be considered a specialist predator (Table 2).

Discussion

The presence of a considerable number of food components within the trophic spectrum of *A. platypogon* (23 in total) indicates they are widely available to this predator within this coastal lagoon. In spite of consuming a large number of species, this predator is selective on the diverse prey of the benthic environment (more than 90% originates from this habitat). Evidence of the high degree of food specialization of this species is the large consumption of the prey species *C. bellicosus* and *P. californiensis*.

Several authors have indicated that fish are important regulators of the structure of benthic communities. Minello & Zimmerman (1984) mentioned that many species of fish strongly impact certain populations of crustaceans, some of which have commercial importance. In the particular case of *A. platypogon*, Gracia & Lozano (1980) argue that this fish plays an important role in the recruitment of certain crustaceans such as lobster larvae of *Panurilus gracilis* Bouvier and *P. inflatus* Streets, acting as one of the predators that in part limit the number of lobsters off the coasts of Guerrero, Mexico. The high incidence of the crustaceans *C. bellicosus* and *P. californiensis* in the stomach of *A. platypogon* in San Ignacio Lagoon may indicate that this predator affects the recruitment periods and abundance of these prey species of high commercial value in the area.

Minello & Zimmerman (1984), Minello *et al.* (1987), Minello *et al.* (1989) and Salini *et al.* (1990) found that the presence of peneid shrimp and other crustaceans in the gastric contents of teleostean fish in coastal areas (costal lagoons, estuaries, and marsh) means that predation is an important component in the natural mortality of these important crustaceans. However few studies have been done to determine the amount of this predation on shrimp (Pauly & Palomares 1987). In some locations, some effort to understand the effect of predation on shrimp recruitment in commercial fisheries has been made (Divita *et al.* 1983, Sheridan *et al.* 1984) however no estimates of the loss of shrimp and other crustaceans by predation have been made.

Results close to our study were found by Lara *et al.* (1981), Yañez & Lara (1988), and Vega *et al.* (1994). They concluded benthic resources are the most important food components for this type of predator and thus play an important role affecting energy flow through the ecosystems. Many species of crustaceans use the coastal lagoons for reproduction, breeding, and feeding, and several fish species take advantage of this situation (Day *et al.* 1989).

Some authors mention that temporary and spatial changes in prey are very frequent in fishes, due mainly to changes in availability and quality of habitat and food resources (Winemiller 1990). The persistence of certain important food components in the seasonal trophic spectrum of *A. platypogon*, during both spring and summer 1992, could be indicative of the high productivity of San Ignacio Lagoon, which is a characteristic of coastal lagoons (Vega 1990).

A higher diversity of food resources was recorded toward the upper area of the lagoon, as indicated by the positive values of the ecological attributes (specific richness, diversity, and evenness) used to describe the trophic spectrum. This supports the hypothesis that *A. platypogon* finds optimum feeding conditions in this area, where they are most abundant. In addition to the food components found in the stomachs of *A. platypogon,* there were items that becauses of their nature (remains of the fishing camp) were not considered as real components of diet of this predator. Among these were some remains of fish and structures of other species which if digested could supplement the energetic needs of this species. This feeding behavior does not necessarily indicate that *A. platypogon* is an omnivorous species; it may be more opportunist, which could be advantageous in competing with other species of fish within San Ignacio Lagoon. Having alternative sources of food could reduce competition for a given prey resource.

Acknowledgements

The institutional and financial support for this study was provided by the Instituto Politécnico Nacional (IPN) and the Comisión de Operación y Fomento de Actividades Académicas of the IPN, for the project "Seasonal evaluation of the ichthyofauna and marine algae of San Ignacio Lagoon, B.C.S., Mexico", (DEPI 923591). We thank David Au of the Southwest Fisheries Science Center in U.S.A., for critical comments and two anonymous reviewers for their comments and suggestions. Thanks to Ellis Glazier for editing this English language text.

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Recibido en mayo de 1999 y aceptado en enero de 2000