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The feeding habits of gafftopsail catfish *Bagre marinus* (Ariidae) in Paraiso Coast, Tabasco, Mexico

Los hábitos de alimentación del bagre *Bagre marinus* (Ariidae) en Costa Paraíso, Tabasco, México

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ABSTRACT

The gafftopsail catfish (*Bagre marinus*) is one of the species of most importance to fisheries in the Gulf of Mexico, particularly in the coastal region of Tabasco State, where it is captured abundantly almost all year round in shallow coastal zones. Although, there is neither ecological nor biological information about this species in the coastal zone of Tabasco State. This study aims to describe the feeding habits of gafftopsail catfish. Seasonal changes in the diet and its relation with reproductive period will also be discussed. Analyzes of stomachs contents of 430 individuals (97 females and 68 males for dry season, 100 females and 38 males for rainy season and 83 females and 44 males for nortes season) obtained from two commercial landings located in the Chiltepec municipality, Paraiso, Tabasco along one year (May 1996 to April 1997). The numerical percentage (%N), weight percentage (%W) and frequency occurrence indexes were calculated for the groups preys. These three indexes were comparing with the Kendall concordance coefficient, concluding that three indexes provide the same information about importance of prey inside diet, using the %F for posteriors analysis. Brachyurans were the more important preys inside the annual diet of species, reached a maximum frequency of occurrence during dry season (74.6 %F for females and 92.7 %F for males). Few seasonal changes in diet of both sexes were observed, with a progressive increase of occurrence of fishes and diminution of stomatopods and penaeid shrimps. No significant differences were finding in total diet between females and males. The variation of the proportion of fullness stomachs and fullness weight index along the year can be related with the reproductive behavior of species.

Key words: Ariidae, Feeding Habits, Life Cycle, Fisheries, Gulf of Mexico.

RESUMEN

El bagre bandera (*Bagre marinus*) es una de las especies de mayor importancia pesquera en el Golfo de México, particularmente en la región costera del Estado de Tabasco, donde es capturada en forma abundante durante casi todo el año. A pesar de esto, no existe información biológica o ecológica de esta especie para la región costera de Tabaco. El objetivo de este estudio es describir los hábitos alimenticios del bagre bandera y analizar sus cambios estacionales. Se analizaron los contenidos estomacales de 430 individuos (97 hembras y 68 machos para la estación de secas, 100 hembras y 38 machos para la estación de lluvias y 83 hembras y 44 machos para la estación de nortes); estos individuos fueron obtenidos de desembarques comerciales a lo largo de un año (mayo 1996 a abril de 1997) en dos centros de acopio localizados en el poblado de Chiltepec, Paraíso, Tabasco. Se calcularon los porcentajes numérico (%N) y de peso (%W), y la frecuencia de ocurrencia de cada grupo presa. Estos índices fueron comparados a través del coeficiente de concordancia de Kendall, comprobándose que los tres índices proveían la misma información, siendo usado la %F para el resto de los análisis. Los braquiuros fue-

ron las presas más importantes en la dieta anual de esta especie, alcanzando una frecuencia de ocurrencia máxima durante la estación de secas (74.6 %F para las hembras y 92.7 %F para los machos). Se observaron pocos cambios estacionales, destacándose un progresivo incremento en la frecuencia de ocurrencia de los peces y una disminución de los estomatópodos y camarones peneidos. No se observaron diferencias significativas entre las dietas totales de hembras y machos. La variación de la proporción de estómagos llenos y el índice de repleción estomacal a lo largo del año está relacionado al comportamiento reproductivo de la especie.

Palabras clave: Ariidae, hábitos alimenticios, ciclo de vida, pesquerías, Golfo de México.

INTRODUCTION

Family Ariidae is one of the most abundant fish group in coastal lagoons and estuaries in tropical and subtropical America (Yáñez-Arancibia & Lara-Domínguez, 1988). In the Gulf of Mexico, three species of this family are common: *Ariopsis felis L., Cathorops melanopus Günther* and *Bagre marinus* Mitchill (Kobelkowsky&Castillo-Rivera, 1995).

Along the southeast coastal zone of the Gulf of Mexico, gafftopsail catfish (*B. marinus*) is one of the species of most importance to fisheries, particularly in the coastal region of Tabasco State, where it is captured abundantly almost all year round. Gafftopsail catfishes are captured in shallow coastal zones, including estuarine lagoons and river systems (Secretaría de Pesca, 1982).

A low variation in landing volume was observed for this species in Tabasco State throughout the 1990´s (1990-1998), with an average volume of 3649 tons. During 1998, the total landing volume (4475 tons) represented approximately 72% of the total gafftopsail catfish landing in the Mexican coast of Gulf of Mexico and 56% of the national total per year (Subsecretaría de Pesca, 1998), being a very important species for regional and national fisheries of Mexico.

The great abundance of these ariids in coastal marine ecosystems of the Gulf of Mexico (Sheridan *et al*., 1984; Deegan & Thompson, 1985) and its trophic position (second and third order consumers) makes the group an important element of the trophic webs and energy flows in estuaries and coastal areas (Yáñez-Arancibia *et al*., 1985; Yáñez-Arancibia & Lara-Domínguez, 1988).

Despite the aforementioned aspects (high economical and ecological importance), there is neither ecological nor biological information about this species in the coastal zone of Tabasco State, the present study being the first scientific report to deal with the subject. This study aims to describe the feeding habits of gafftopsail catfish. Seasonal changes in the diet and its relation with reproductive period will also be discussed.

MATERIALS AND METHODS

Samples of gafftopsail catfish were obtained from two centers of commercial landings in Chiltepec Town, Paraíso County, Tabasco, from May 1996 to April 1997 (except during August and December). Fishery area is a coastal zone in front of the Chiltepec Barrier (Figure 1). The commonest catch method employed to capture this species was the bottom long line set at depths of 10 to 40m.

The species identification was based on the descriptions by Taylor & Menezes (1978) and Secretara de Pesca (1982). Randomized sampling of fishes was done. Each fish was measured (standard and total length) to the nearest mm, weighted (total and somatic weight) to the nearest g and sex was identified. The stomach was extracted, followed by preservation in 10% formaldehyde neutralized with sodium borate.

The total number of individuals sampled was 430, divided in: 97 females and 68 males in the dry season, 100 females and 38 males in the rainy season and 83 females and 44 males in the nortes season. The division of the year in three seasons was based on the criteria presented by Yáñez-Arancibia &

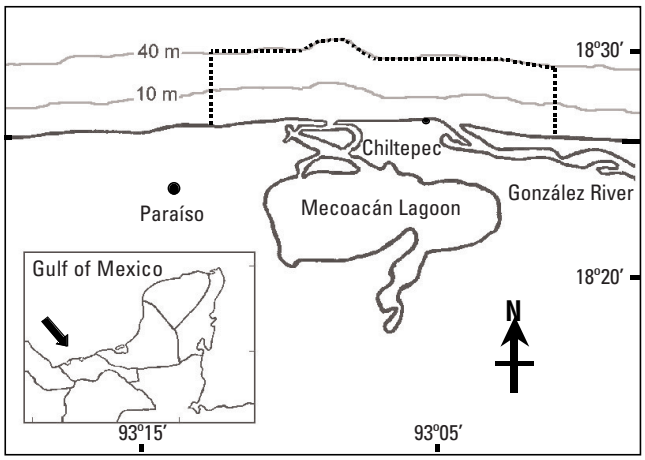

Figure 1. Localization of fishing area (dashed line). Arrow indicates the Chiltepec Barrier inside Tabasco coast.

Lara-Domínguez (1988). Standard length for females varied between 205 and 490 mm and for males between 240 and 495 mm.

The stomach contents were examined. Each item was identified to the lowest possible taxon, counted and weighed (wet weight) to the nearest 0.01 g.

For the quantitative analysis of diet items were grouped into higher level taxonomic categories and three descriptive parameters were used: numeric percentage (%N), the number of individuals in each food category recorded for all stomachs and the total expressed as a proportion (percentage) of the total individuals in all food categories; weight percentage (%W), the wet weight of one type of prey in proportion to the total wet weight of all preys present in all stomachs, expressed as percentage; and the percent of frequency of occurrence (%F), the number of stomach containing one or more individual of each prey category in proportion to the total number of stomachs, expressed as percentage (Hyslop, 1980; Cortés, 1997).

In order to simplify the statistical comparisons among the diets of gafftopsail catfish groups, Kendall concordance coefficient (W) was used to test if the three indexes used (%N, %W and %F) showed or not the same information (Zar, 1984). Diet differences to prey group level, between pairs of seasons (dry vs rainy and rainy vs nortes) and between sexes were tested applying the Chi-square test (Sokal & Rohlf, 1981; Crown, 1982).

The proportion of stomach fullness (stomachs with food) was expressed as a percentage. To make its comparison between seasons and sexes Chi-square goodness of fit test was employed (Zar, 1984; Castro & Guerra 1990).

Fullness weight index was expressed as a percentage, dividing the total wet weight of the food items by the somatic weight of the fish. Two-factors ANOVA model were used to test differences among months and sexes. An arcsine transformation of the original data was applied (Zar, 1984). Prior to their use in the ANOVA model, data were tested for normality (Kolmogorov-Smirnov test) and homogeneity of variances (Cochran test) (Underwood, 1997).

RESULTS

The diet of the gafftopsail catfish consisted of 30 identified prey species. These species were included in five groups: stomatopoda (three species), penaeidae (six species), brachyura (six species), actinopterygii (six species) and "other groups" (nine species). The last group included several species that occurred at low densities and sparsely throughout the year; consequently this prey group was not included in the statistical comparisons. Only two genus of prey were found during the three seasons in both females and males stomach contents; these were: Squilla sp and Callinectes sp, mostly S. empusa and C. similis. The presence of other prey species was not constant throughout the year (Table 1).

The Kendall concordance coefficient shows that the three indices provide similar information about the diet of males and females during the dry and rainy season. On the other hand, for the nortes season in both males and females, these indices showed relative low values of concordance ($p < 0.05$) (Table 1). As it was considered that the three indices provide very similar information, the percentage of frequency occurrence was chosen for description and statistical comparisons of the diet of each sex.

In general, the brachyurans were the most important prey in the diet of both sexes in all seasons. In females its maximum frequency of occurrence (74.6%) was observed during the dry season and the minimum (58.2%) during the rainy season. In males the brachyurans reached their maximum frequency of occurrence (92.7%) also during the dry season, and the minimum (55.6%) during the nortes season (Table 1).

In females the diminution of the frequency of occurrence of the stomatopoda group was notorious from the dry (39.7%) to the rainy (20.9%) and nortes (20.8%) seasons, significant differences were found ($p < 0.05$). In the same way, the frequency of occurrence of penaeid shrimps showed a significant diminution from the dry to rainy seasons ($p < 0.01$), while the group was absent in the nortes season. Despite these changes in individual prey groups, the results of the total diet comparison suggest that the diet of females of gafftopsail catfish does not change significantly in different seasons (Table 1).

In males a similar pattern was found, stomatopods presented a progressive diminution in occurrence, the principal variation was between the rainy (25.0%) and the nortes (11.1%) seasons ($p < 0.05$). Penaeid shrimps were only present in dry season. Brachyurans showed a significant reduction ($p < 0.01$) in occurrence from the dry season (92.7%) to the rainy season (58.3%). A significant difference ($p < 0.01$) was detected in the total diet of males of gafftopsail catfish between the dry and rainy season (Table 1).

No significant differences were found in total diet between females and males of gafftopsail catfish throughout the seasons. However, during the rainy season, a significant difference between sexes ($p < 0.01$), was detected only in the prey group "fishes", as result of the major occurrence of this prey in males (41.7 %) in contrast with females (19.9%).

Table 1. Species prey composition of gafftopsail catfish *Bagre marinus* diet by sex among seasons, significance levels of the frecuency of ocurrence prey comparison among seasons by sex and results of the Chi-square test for fiet of gafftopsail catfish *Bagre marinus* in Chiltepec Barrier. %N= numerical percentage, %W= weight percentage, %F= percentage of frecuency occurrence.

	Females										
	Season										
	Dry				**Rainy**				**Nortes**		
Prey taxon	**%N**	**%W**	**%F**		**%N**	**%W**	**%F**		**%N**	**%W**	**%F**
Stomatopoda	**17.71**	**18.45**	**39.68**	*	**20.24**	**9.42**	**20.90**	ns	**18.42**	**14.03**	**20.83**
Squilla sp	10.29	8.61	23.81		19.05	7.33	20.90		13.16	7.05	16.67
Squilla empusa	3.43	6.46	9.52		1.19	2.09	1.49		5.26	6.98	8.33
Squilla cydaea	4.00	3.38	9.52								
Penaeidae	**18.29**	**4.69**	**22.22**	**	**7.14**	**1.37**	**7.46**				
Trachipenaeus sp	4.57	0.94	4.76								
Sicyonia dorsalis	4.57	1.56	7.94		2.38	0.53	2.99				
Trachipenaeus constrictus	1.14	0.09	1.59		1.19	0.09	1.49				
Penaeids rest	8.00	2.10	11.11		3.57	0.74	2.99				
Brachyura	**48.57**	**69.25**	**74.60**	ns	**47.62**	**59.41**	**58.21**	ns	**36.84**	**41.80**	**58.33**
Callinectes sp	12.57	11.03	23.81		16.67	11.72	20.90		7.89	7.13	12.50
C. similis	30.86	54.01	49.21		8.33	25.42	10.45		5.26	11.95	8.33
C. rathbunae	3.43	3.80	7.94		1.19	5.61	1.49				
C. sapidus					1.19	4.88	1.49				
Illiacantha intermedia	0.57	0.16	1.59								
Brachyuran rest	1.14	0.26	3.17		20.24	11.78	23.88		23.68	22.72	37.50
Actinopterygii	**10.86**	**6.41**	**22.22**	ns	**17.86**	**28.17**	**19.40**	ns	**44.74**	**44.17**	**33.33**
Trichiurus lepturus	0.57	1.73	1.59		1.19	0.31	1.49		23.68	20.95	4.17
Megalops atlanticus scales					3.57	0.44	1.49		5.26	0.88	4.17
Myropsis punctatus											
Sphoeroides sp											
fish rest	10.29	4.68	20.63		13.10	27.43	16.42		15.79	22.34	25.00
Other groups	**4.57**	**1.20**	**7.94**		**7.14**	**1.63**	**8.96**				
Porifera	0.57	0.11	1.59								
Lolliguncula sp	0.57	0.89	1.59		4.76	1.13	5.97				
Mysidae	2.29	0.12	3.17								
Mysidopsis bahia	1.14	0.07	1.59								
Euceramus praelongus					1.19	0.40	1.49				
Odonata					1.19	0.09	1.49				
W		**0.87**				**0.92**				**0.77**	
X^2				**4.9**				**2.8**			
d.f.				**3**				**2**			
p				**n.s.**				**n.s.**			

	Males										
	Season										
	Dry				Rainy				Nortes		
	%N	%W	%F		%N	%W	%F		%N	%W	%F
Stomatopoda	**13.45**	**16.91**	**31.71**	**ns**	**15**	**6.499**	**25**	*****	**7.41**	**3.59**	**11.11**
Squilla sp	5.04	2.56	14.63		15.00	6.50	25.00		7.41	3.59	11.11
Squilla empusa	3.36	6.44	7.32								
Squilla cydaea	5.04	7.92	9.76								
Penaeidae	**21.01**	**8.46**	**29.27**								
Sicyonia sp	0.84	0.12	2.44								
Sicyonia dorsalis	1.68	0.78	4.88								
Penaeus sp	5.88	3.70	9.76								
Penaeus duorarum	0.84	1.72	2.44								
Penaeids rest	11.76	2.15	12.20								
Brachyura	**49.58**	**67.89**	**92.68**	******	**55.00**	**48.59**	**58.33**	**ns**	**40.74**	**24.83**	**55.56**
Callinectes sp	19.33	19.73	39.02		40.00	28.23	41.67		3.70	1.68	5.56
C. similis	24.37	40.05	39.02		5.00	7.37	8.33				
C. rathbunae	2.52	2.05	4.88								
C. sapidus	2.52	1.17	7.32								
Portunus gibbesii	0.84	4.90	2.44								
Brachyuran rest					10.00	13.00	16.67		37.04	23.14	50.00
Actinopterygii	**11.76**	**5.88**	**14.63**	******	**25.00**	**39.57**	**41.67**	**ns**	**51.85**	**71.59**	**38.89**
Anchoa sp	0.84	0.38	2.44								
Anchoa hepsetus	1.68	0.43	2.44								
Trichiurus lepturus	0.84	0.38	2.44								
Myropsis punctatus									3.70	7.08	5.56
Sphoeroides sp									3.70	18.57	5.56
fish rest	8.40	4.70	7.32		25.00	39.57	41.67		44.44	45.94	27.78
Other groups	**4.20**	**0.84**	**12.20**		**5.00**	**5.33**	**8.33**				
Prosobranchia	1.68	0.08	4.88								
Lolliguncula sp	0.84	0.04	2.44		5.00	5.33	8.33				
Albunea paretii	0.84	0.19	2.44								
Coleoptera	0.84	0.54	2.44								
W		**0.95**				**1.00**				**0.77**	
X^2				**20.9**				**3.9**			
d.f.				**2**				**2**			
p				******				**ns**			

ns: not significant differences, *: $p < 0.05$, ** $p < 0.01$.

The proportion of stomach fullness showed a similar tendency in females and males. The maximum values for females (79.1 %) and males (66.6 %) occurred during November, the rainy season (Figure 2). The minimum proportion of stomach fullness for females (12.1 %) and males (23.0 %) was during January corresponding to the nortes season (Figure 2). Only during September significant differences were registered in the proportion of stomach fullness between females and males ($p < 0.01$).

In the case of the fullness weight index, the maximum value for females (2.9 %) occurred in February and the minimum (0.5 %) in September. For males the maximum value for the fullness weight index (2.8 %) occurred in January and the minimum (0.5 %) in July (Figure 2). The ANOVA multiple comparisons revealed significant differences in the fullness weight index in different months ($p < 0.01$). No significant differences between sexes and interaction between months and sex were detected (Table 2).

DISCUSSIÓN

The high and constant presence of crustaceans, mainly brachyurans, throughout the seasons characterizes the diet of gafftopsail catfish. Presence of fishes was constant too, however with lesser importance. Stomach content analyses

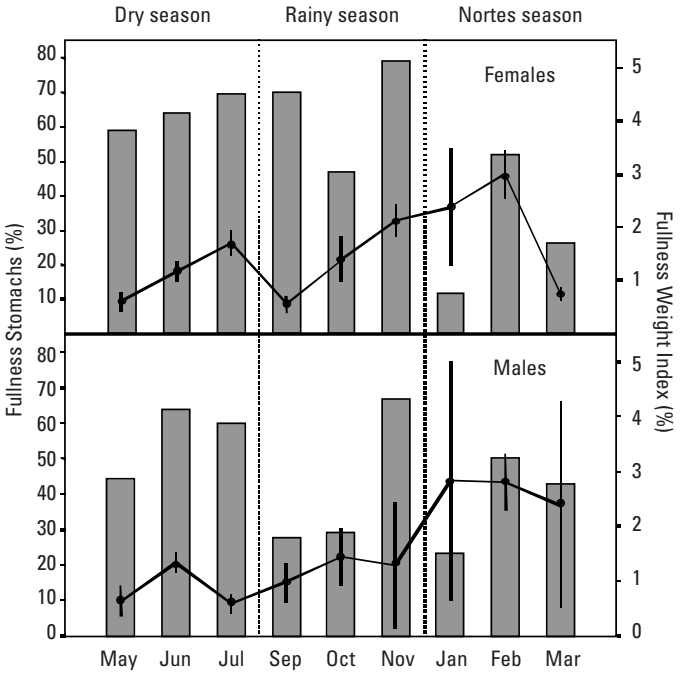

Figure 2. Variation of the monthly fullness stomach proportion (gray bars) and monthly average and standard deviation of fullness weight index (hard line) in females and males of gafftopsail catfish Bagre marinus.

Table 2. Results of multiple ANOVA on the fulless weught index among seasons and sex in the gafftopsail catfish *Bagre marinus* in Chiltepec Barrier.

Source of variation	MS	DF	F	p
Month	7.92	8	5.49	0.00
Sex	0.28	1	0.19	0.66
Interaction	2.20	8	1.52	0.15
Error	1.44	209		

for this species in Términos Lagoon, Southern Gulf of Mexico, showed that its diet is composed of a great variety of crustaceans groups and that fishes were also important (Yáñez-Arancibia & Lara-Dominguez 1988). In the same way, feeding studies published on others catfishes like *Galeichthys caerulescens* Günther (Yáñez-Arancibia et al., 1976), *Netuma platypogon* Günther (Gracia & Lozano, 1980), *Cathorops spixii* Agassis (Arias & Bashirullah, 1984), *G. feliceps* Valenciennes, *G. ater* Castelnau (Tilney & Hecht, 1990), *Ariopsis felis* and *C. melanopus* (Lara-Domínguez *et al.*, 1981, Yáñez-Arancibia & Lara-Domínguez, 1988; Vega, 1990; Kobelkowsky & Castillo-Rivera, 1995), showed that crustaceans dominate in the diet, followed by small fishes. On the other hand, Kobelkowsky & Castillo-Rivera (1995) report an inverse situation for gafftopsail catfish, where the fishes were the most important food item, followed by crustaceans. The above demonstrates a great constancy in the feeding habits of the ariids species, which are important second order and occasionally third order consumers (Yáñez-Aracibia & Lara-Domínguez, 1988).

The availability of food related to seasons and localities determinates variations in feeding habits (Hughes, 1980; Yáñez-Arancibia & Lara-Domínguez, 1988) nevertheless, in the gafftopsail catfish no evident seasonal changes in the diet were observed. The situation above can be related to a constant availability of prey, however, without quantitative data about prey abundance, the above assumption remains speculative. On the other hand, the disappearance or decrease of prey in males in the rainy season and in both sexes in the nortes season, is more related to a reduction in full stomachs number than to a real variation in diet. Relative lack of variation of diet in different seasons was observed in other species of catfishes such as *C. melanupus* (Lara-Domínguez *et al.*, 1981), *G. feliceps*, *G. ater* (Tilney & Hecht, 1990) and the armored catfishes like *Hoplosternum littorale* Hancock, *H. thoracatum* Cuvier & Velenciennes and *Callichthys callichthys* L. (Mol, 1995).

Differences in diet composition between males and females were not observed, but differences between sexes

were clear when the percentage of fullness stomachs and the fullness weight index were analyzed. These changes are possible related to a reproductive behavior reported for gafftopsail catfish (Yáñez-Arancibia & Sánches-Gil, 1986; Palazón *et al*., 1994).

In females the minimum value of fullness weight index can be associated with a reproductive period (July to September), registered for Tabasco coast (Yáñez-Arancibia & Sánches-Gil, 1986; pers. obs.). Despite this decrease in fullness weight index, the number of stomachs with food were high. These processes are explained by a diminution in the size of stomach and intestinal diameter in the reproductive period, due to gonads growth and fat accumulation (Kobelkowsky & Castillo-Rivera, 1995).

In males it could be observed that during the rainy season in September and October a decrease in the number of individuals captured and fullness stomachs occurred. This pattern is possibly related to the reproductive behavior, since this species presents oral incubation (Lara-Domínguez *et al*., 1981; Palazón *et al*., 1994; Kobelkowsky & Castillo-Rivera, 1995). A progressive increase in fullness weight index can be attributed to the recruitment of males that have already finished the period of oral incubation. The increment in the proportion of stomach fullness in both females and males during January probably indicates the end of the reproductive period.

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