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FOOD HABITS OF JUVENILE AMERICAN ALLIGATORS IN THE UPPER LAKE PONTCHARTRAIN ESTUARY

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ABSTRACT: Food habits of juvenile (0.49-1.21 m total length) American alligators (*Alligator mississippiensis*) from an area in southeastern Louisiana were investigated. One-hundred and one stomach samples were obtained by stomach-pumping. Crustaceans (crayfish; blue crabs, *Callinectes sapidus*; grass shrimp, *Palaemonetes* sp.), insects (hemipterans, coleopterans), and small fish (least killifish, *Heterandria formosa*; mosquitofish, *Gambusia affinis*) constituted the majority of prey items taken. Fish consumption was significantly more frequent during April and May than during June through September ($P<0.025$). This differential use of prey species may be due to seasonally fluctuating water levels in the study area. Comparisons of juvenile alligator food habits revealed dietary differences between Louisiana and Florida ($P<0.001$), possibly due to the different prey available at the two areas. Prey utilization was not significantly different between larger alligators (0.9-1.2 m total length) and smaller alligators (0.3-0.9 m total length) ($P>0.25$).
[Keywords: *Alligators; juvenile; Lake Pontchartrain*]

Food habits of adult American alligators (>1.8 m total length) were described by Giles and Childs (1949), Valentine *et al.* (1972), McNease and Joanen (1977), Taylor (1986), and Wolfe *et al.* (1987) in Louisiana and by Delany and Abercrombie (1986) in Florida. These studies showed that large rodents, snakes, turtles, fish, and crustaceans were the most frequently used prey items.

Juvenile (<1.2 m total length) and sub-adult alligators (1.2-1.8 m total length) reportedly feed mainly on crustaceans, insects and fishes, but very little supporting evidence exists (Kellogg 1929, McIlhenny 1935, Giles and Childs 1949, Neill 1971, Valentine *et al.* 1972, Wolfe *et al.* 1987). Chabreck (1971) compared August food habits of 20 immature alligators under fresh and saline conditions in the coastal marshes of southwestern Louisiana. Alligators from freshwater areas preyed upon red swamp crayfish (*Procambarus clarki*) and giant water bugs (Belostomatidae), whereas in saline habitats, the principal prey items were red swamp crayfish, blue crabs (*Callinectes sapidus*), and fiddler crabs (*Uca pugnax*). Stomach contents of 36 juvenile alligators from Florida, revealed that the apple snail (*Pomacea paludosa*) was the major prey species, with crustaceans, mainly crayfish (*Cambarus* sp. "sic"), grass shrimp (*Palaemonetes intermedius*) and blue crabs, also utilized (Fogarty and Albury 1968).

Objectives of this study were to investigate the diets of juvenile American alligators from an area in southeastern Louisiana and to compare the findings with data from southwestern Louisiana and Florida. In addition, diets were analyzed from throughout the active feeding period for alligators (April-September) to determine seasonal use of prey items, since most previous food habits studies on American alligators were conducted during the late summer and fall (August-October), coinciding with the fall trapping season.

Feeding habits of different size classes were also compared. Although

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previous investigators have reported food habits of various size classes (McNease and Joanen 1977, Delany and Abercrombie 1986, Wolfe *et al.* 1987), these have largely involved adult alligators. Wolfe *et al.* (1987) synthesized the literature on alligator food habits and made broad speculations concerning size class variations, specifically involving the smaller size classes.

STUDY AREA AND METHODS

Alligators were captured by hand at night between 13 April and 24 September 1988 from an estuarine marsh and swamp area between lakes Pontchartrain and Maurepas in southeastern Louisiana (30°18'N, 90°20'W). Two extensive, state-owned wildlife management areas are situated within the study area. Joyce Wildlife Management Area (WMA) is located in southern Tangipahoa Parish and Manchac WMA is located on the northeastern corner of St. John the Baptist Parish. Currently, there is a north to south progression from freshwater swamp to intermediate salinity marsh in the study area. Dominant terrestrial vegetation includes bulltongue (*Sagittaria lancifolia*), smartweed (*Polygonum sagittatum*), deerpea (*Vigna luteola*), and grasses (*Zizaniopsis milacea, Echinochloa walteri, Panicum dichotomiflorum*, and *Leptochloa fasicularis*). Baldcypress (*Taxodium distichum*), waxmyrtle (*Myrica cerifera*), and groundselbush (*Baccharis halimifolia*) occupy elevated sites. Floating and submerged aquatic vegetation are common within shallow water areas. Climate in the area is humid subtropical. A detailed description of the study area is given by Platt (1988) and Brantley (1989).

A modification of the stomach pump technique first described by Taylor *et al.* (1978) was used to remove stomach contents without killing the animal (Brantley 1989). This procedure was repeated at least twice and until only water free of stomach contents was obtained.

Taylor *et al.* (1978) verified the efficiency of the stomach-pumping process by sacrificing five juvenile saltwater crocodiles (*Crocodylus porosus*) after they had been pumped and found no food items in any of the stomachs. Verification of the process was not attempted during this study; however we are confident that in most cases all stomach contents were removed. Most of the contents were in small pieces due to the grinding action of the stomach making recovery easy but identification, enumeration and measurement difficult. Some alligators were held in captivity for periods of up to a week after stomach pumping and no ill effects were noticed. Also, none of the alligators recaptured during the study showed any apparent harm from the pumping procedure. In addition, no marked alligators were found dead after stomach pumping.

Stomach contents were preserved in 10% formalin, returned to the laboratory, transfered to 40% isopropanol after at least one week, and then analyzed. Items were examined under a dissecting microscope (7-30×) and identified to the lowest possible taxon and counted. Wet weight of each taxon was measured to the nearest 0.01 g and volume displacement of water was measured to the nearest 0.1 ml.

Total length was taken to the nearest 0.1 cm on each alligator. Field sexing of small alligators is unreliable (Joanen and McNease 1978); therefore, sex was recorded only when investigators were certain. Each alligator was marked by clipping dorsal tail scales and by attaching a Louisiana Department of Wildlife and Fisheries tag to a rear foot and was released at the capture site.

Chi-square analyses were per-

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formed to detect any seasonal, geographic, and size variability. To determine seasonal variability, stomach samples from the months of April-May, June-July, and August-September were lumped and prey items from the three major food groups (crustaceans, insects, and fish) were included. Chi-square analyses of frequency of occurrence for major food groups (crustaceans, insects and spiders, snails, and fish) compared this study with the studies of Fogarty and Albury (1968) and Chabreck (1971). Due to the seasonal variability in some food items, the alligators sampled from August were used for comparisons with the published studies, since both Fogarty and Albury (1968) and Chabreck (1971) sampled in August.

RESULTS

We captured and stomach-pumped 101 juvenile alligators. Three of the stomachs were empty of any contents. Size ranged from 0.49 m to 1.21 m total length ($\bar{X}$ = 0.88 m). The majority (56.4%) of alligators were from the 0.6-0.9 m total length size class. Stomach contents contained 77 animal and nine plant taxa. To facilitate diet analysis and comparisons, animal groupings were made on class levels.

Arthropods, especially crayfish, shrimp, crabs, giant water bugs, and beetles predominated in frequency of occurrence, percent weight, and percent volume, whereas poeciliid and cyprinodontid fishes were the major vertebrates eaten (Table 1).

Seasonal comparisons

Diet were analysed in relation to time of year to determine seasonal variability of prey items. There was no significant difference in the frequency of occurrence of prey items of alligators from the months of June-July and August-September ($Chi^2 = 1.12$, df = 2, $P>0.50$); however, these four months were significantly different when compared with April-May ($Chi^2 = 8.52$, df = 2, $P<0.025$) (Table 2). Much of the difference is due to an increased amount of fish and crustaceans in the diets during April-May.

Geographic comparisons

Diets of juvenile alligators were markedly different in Louisiana and Florida ($Chi^2 = 59.85$, df = 3, $P<0.001$). Our analyses revealed a highly significant difference in the occurrence of snails between Louisiana and Florida ($Chi^2 = 28.77$, df = 3, $P<0.001$) and a highly significant difference in the occurrence of insects and spiders between Louisiana and Florida ($Chi^2 = 33.85$, df = 3, $P<0.001$).

Table 1. Major stomach contents (>5.0% occurrence) recovered from 101 juvenile American alligators from southeastern Louisiana, April-September, 1988 (number of stomachs with food = 98; weight and volume data from 83 stomachs).

Taxon	% frequency	% weight	% volume
CRUSTACEA	74.5	35.6	37.9
Decapoda	71.4	33.1	36.3
Palaemonidae	19.4	9.1	9.5
Palaemonetes sp.	19.4	9.1	9.5
Cambaridae	58.2	16.9	18.1
Procambarus clarki	14.3	12.2	13.3
Callinectes sapidus	20.4	7.0	8.7
INSECTA	91.8	19.1	17.4
Coleoptera	81.6	8.2	7.3
Hydrophilidae	16.3	1.7	1.5
Diptera	7.1	tr[a]	tr
Hemiptera	65.3	6.0	4.9
Belostomatidae	54.1	4.7	4.0
Nepidae	18.4	0.5	0.4
Corixidae	6.1	0.1	tr
Odonata	6.1	0.3	0.4
Orthoptera	9.2	1.5	1.4
GASTROPODA	5.1	0.2	0.2
ARANEAE	10.2	0.6	0.5
OSTEICHTHYES	41.8	16.7	16.7
Cyprinodontidae	6.1	3.1	3.3
Poeciliidae	31.6	6.8	6.7
Heterandria formosa	27.6	4.5	4.5
Gambusia affinis	14.3	2.2	2.1
REPTILIA	5.1	1.1	1.0
Total animal	100.0	90.8	91.5
Total plant	81.6	7.8	7.5
Miscellaneous	12.9	1.4	1.0

[a]tr = <0.1%

Table 2. Chi-square values of frequency of occurrence of crustaceans, insects, and fish in the diets of juvenile alligators in southeastern Louisiana, April-September, 1988.

Monthly comparison	Chi^2	df	P
April - May *vs.* June - July	6.04	2	<0.05
April - May *vs.* August - September	8.80	2	<0.025
June - July *vs.* August - September	1.12	2	>0.50
April - May *vs.* June - July and August - September	8.52	2	<0.025
Total	15.96	6	<0.025

No significant differences were noted in the occurrence of major food groups between the present study and the study of Chabreck (1971) in southwest Louisiana ($Chi^2 = 2.68$, $df = 2$, $P>0.25$).

Size comparisons

Size-class comparisons were performed between alligators less than 0.9 m total length with those greater than 0.9 m (Table 3). The frequency of occurrence for seven food groups was analysed by Chi-square. Amphibians, reptiles, birds, and mammals were lumped into a terrestrial vertebrate group due to small cell sizes in these groups. The frequency of occurrence of the food groups was not significantly different between the two size classes ($Chi^2 = 6.97$, $df = 6$, $P>0.25$).

Table 3. Size class comparisons of % frequency of occurrence for major food groups of juvenile and sub-adult alligators in southeastern Louisiana, April - September, 1988.

	0.3-0.9 m TL (N = 63)	0.9-1.2 m TL (N = 35)
CRUSTACEA	66.7	88.6
INSECTA	93.7	88.6
GASTROPODA	4.8	5.7
ARANEAE	12.7	8.6
OSTEICHTHYES	38.1	48.6
TERRESTRIAL VERTEBRATES	14.3	5.7
VEGETATION	76.2	91.4
TOTAL	$Chi^2 = 6.97$, $df = 6$, $P>0.25$	

DISCUSSION

Analysis of crocodilian diets should include only fresh material to reduce bias due to the differential digestion of prey items (Garnett 1985). The use of the stomach pumping method reduced such bias as stomach contents were removed and quickly preserved to inhibit digestive enzymes. This insured the availability of the freshest material possible. In many cases live fish and insects were flushed from the stomach.

Crustaceans, especially crabs, crayfish, and shrimp, ranked first in dietary importance for juvenile alligators in this study. Chabreck (1971) found that crayfish were utilized heavily by immature alligators in freshwater marshes, whereas blue crabs were frequently taken in more saline marshes. Other studies have also found crustaceans to be a major component of immature alligator diets (Giles and Childs 1949, Fogarty and Albury 1968, McNease and Joanen 1977, Delany and Abercrombie 1986).

In some of the stomachs analysed, only small chitinous fragments were found, usually from coleopteran elytra. Occasionally whole insects, including live specimens, were recovered. These insects were mostly aquatic species, but exclusively terrestrial species of beetles, bugs, crickets, grasshoppers, caterpillars, and flies were also recovered. Terrestrial insects were probably consumed while alligators were foraging at the land/water interface or when insects had fallen into the water.

Insect remains in crocodilian stomachs have been the source of much controversy. Neill (1971) and Jackson *et al.* (1974) suggested that the portions of insect exoskeletons found in crocodilians were obtained secondarily from the stomachs of anurans consumed as prey. A recent study on adult alligator food

habits stated that insects were mostly ingested accidentally or secondarily (Wolfe *et al.* 1987). Jackson *et al.* (1974) demonstrated that the chitinous exoskeleton of arthropods was much more resistant to digestion than vertebrate muscle or bone and remained in the stomach for a longer period of time. Delany and Abercrombie (1986), noted that crayfish particles remained in the stomach for a considerable time, but mammalian hair and bird feathers had longer retention times. Garnett (1985) suggested that the presence of chitinous particles in the stomach of crocodilians was due to the lack of gastric chitinase which facilitates digestion of chitin, and concluded that vertebrate bone would be easily digested whereas chitin would be resistant. Garnett (1985) also noted that these chitinous particles may act as gastroliths to facilitate digestion for small crocodilians, much as stones do for larger animals.

This study indicates that insect material found in the stomach contents was ingested primarily and not secondarily. During the study only four anurans were recovered from two stomachs. All were juvenile green treefrogs (*Hyla cinerea*). There was no evidence of other anuran remains despite the abundance of bullfrogs (*Rana catesbeiana*), pigfrogs (*Rana grylio*), cricket frogs (*Acris crepitans*), narrow-mouthed toads (*Gastrophryne carolinensis*), as well as green treefrogs in the study area.

The size of the arthropods recovered also suggested they represented primary consumption. The whole vertebrates that were recovered (fish, frogs and snakes) were similar in size to the arthropods and any acquisition of prey items from these vertebrates would be doubtful. Finally, intact living insects were recovered from some stomachs indicating recent, primary consumption by the alligator.

Fish recovered during this study belonged to the families Cyprinodontidae and Poeciliidae, both common in coastal marsh habitats. Least killifish (*Heterandria formosa*) and mosquitofish (*Gambusia affinis*) occurred most frequently in stomach contents. These two species are among the most abundant fish species on the Manchac WMA (Hastings 1987). Other studies also indicate that small fish are an important food source for juvenile alligators. Valentine *et al.*(1972) ranked small fish second in importance to crustaceans in juvenile alligator diets and Fogarty and Albury (1968) and Chabreck (1971) found fish occurring in 33% and 10% of the stomachs they examined, respectively.

Reptiles recorded from this study included two specimens of the Gulf Coast ribbon snake (*Thamnophis proximus*) and two specimens of glossy water snake (*Regina rigida*). Tail scutes of an alligator were recovered from one individual (1.04 m total length). Alligator cannibalism has been reported previously by Giles and Childs (1949), Valentine *et al.* (1972) and Delany and Abercrombie (1986). Birds and mammals were recovered infrequently and may be overrepresented in the diet due to slow digestion rates and long retention times (Delany and Abercrombie 1986).

Plant material occurred frequently in the stomach contents. Although reported from other studies, vegetation has been discounted as having no biological importance in crocodilian diets (Coulson and Hernandez 1983). Most plant material was probably ingested accidentally during prey capture. Seeds, especially those from baldcypress and deerpea, occurred regularly and may be readily sought as gastroliths by small alligators because of the scarcity of stones in the study area. Small stones were flushed from a few stomachs, but due to the alluvial origin of soils in the study area, few stones are available for ingestion.

Sokol (1971) stated that stones found in crocodilian stomachs function as gastroliths, macerating food items to facilitate more rapid digestion.

Seasonal comparisons

Seasonal variation was noted in frequency of occurrence of recovered food items. Fish utilization was higher during the months of April-May and subsequently declined during the remaining months of the study. This pattern of utilization may be due to prey availability. Observations of small fish in the study area indicate a dispersal into marsh habitats when water levels are relatively high, and a concentration into ditches and canals when water levels are low. Therefore, during low water levels alligators should find fish more available. However, during lower water levels in late summer and early fall there was no concomittant increase in fish utilization. The availability of additional plant cover at this time may provide refuges for small fish, resulting in lower vulnerability to alligator predation.

Crustaceans are present year-round in the study area. The area consists of low-salinity habitats, with both freshwater and brackish water organisms present, including red swamp crayfish and blue crabs. The results indicate that crustacean usage was highest during spring, and late summer and fall. There was a slight decrease in usage in summer which could be due to water level fluctuation at that time resulting in decreased crustacean availability. Huner (1975) demonstrated that red swamp crayfish will remain active if water levels are high in summer, but during low-water conditions will burrow into the substrate until the water table is reached.

Insects were recovered more frequently during the summer and it was during these months that terrestrial insects appeared in the diet. Terrestrial vertebrates also began appearing in the diet during June and continued to be found through September.

Geographic comparisons

Comparisons with published literature on juvenile alligator food habits (Fogarty and Albury 1968, Chabreck 1971) reveal dietary differences between alligators in Louisiana and Florida. These differences are due mostly to the presence of the apple snail in the diet of Florida alligators. Insects and spiders were recovered significantly more frequently from alligators in Louisiana. Although Chabreck's (1971) samples were taken from somewhat larger alligators, their food habits were not significantly different from the alligators examined in this study. Chabreck (1971) and the present study found that most of the diet is comprised of crustaceans and insects.

Size comparisons

Size class comparisons revealed no differences in the utilization of prey items between larger juveniles (>0.9 m total length) and smaller individuals. Other alligator food habits studies have shown a progression from invertebrate to vertebrate prey utilization as the animal grows larger (McNease and Joanen 1977, Delany and Abercrombie 1986, Wolfe *et al.* 1987). This shift in prey utilization occurs during the sub-adult period (1.2--1.8 m total length) where an ontogenetic change in skull shape may be an adaptation for capturing and feeding upon large prey items (Brantley 1989). Growth curves of American alligators reinforce the theory of an ontogenetic skull change and its relation to feeding in sub-adult animals, as a renewed rate of growth may be the result of exploiting an abundant, energetically worthwhile food source such as fish, reptiles, birds, and mammals (Dodson 1975, Hines and Abercrombie 1987).

IMPLICATIONS FOR MANAGEMENT

Wetland management practices for juvenile alligators should be designed to create environmental conditions favorable for an increase in prey populations of crustaceans, insects and small fish. This may be achieved by manipulation of water levels and establishment of aquatic vegetation.

Water levels subject to extreme fluctuations may be stabilized by the construction of weirs. Impounded areas should be managed under a regime of spring and summer drawdowns. These drawdowns will promote the growth of vegetation on exposed areas providing food for prey species when reflooded. Such a regime should maximize production of prey species such as crayfish during a time of year when juvenile alligators are active. Additionally, while crayfish may burrow into the substrate during drawdowns, other prey species will be concentrated in the remaining pools, thereby increasing their availability to alligators.

The growth of submerged and floating vegetation should be encouraged in management areas. This vegetation will provide foraging habitat and cover for juvenile alligators. In these areas the use of herbicides should be severely curtailed and employed only when navigation is threatened.

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