# Food Habits of Native Wild and Farm-released Juvenile Alligators

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*Abstract:* Stomach contents of 108 juvenile alligators (*Alligator mississippiensis*) were analyzed to determine if alligators hatched and raised in captivity (until 120-cm size) then released to the wild would be capable of foraging successfully for food. Seventy-eight farm-reared, post-released alligators harvested during the 1991 annual alligator hunt on Marsh Island Wildlife Refuge and 30 native wild alligators harvested of similar size class were selected and stomach contents compared. Crustaceans were the most important prey item among all alligators, with blue crabs (*Callinectes sapidus*) being the most frequently occurring item. Fish and mollusks occurred more frequently in wild alligators, whereas farm-released alligators consumed more birds and mammals. Native alligator stomachs contained significantly more ($P < 0.05$) endohelminths than farm-released alligators. Lateral fat bodies were significantly heavier ($P < 0.05$) in farm-released alligators than native wild alligators. These data suggest that alligators raised entirely in captivity (and provided food ad libitum), then released into the wild, are able to forage for food and hunt as successfully as native alligators.

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Conservation strategies involving relocation, repatriation, and translocation have become extremely controversial, particularly in reptiles. Some authors suggest these conservation methods may be successful management options (Burke 1991, Reinert 1991) while others (Dodd and Seigel 1991) do not advocate relocation, repatriation, or translocation practices for reptiles, although the feasibility and practicality of raising crocodilians in captivity for commercial and conservation purposes is well documented (Webb et al. 1987, Joanen and McNease 1990, Hutton and Webb 1992). An extensive research program on the ecology, reproductive biology, and captive propagation of American alligators was initiated in 1964 by the Louisiana Department of Wildlife and Fisheries (LDWF). The technology of egg incubation, post-hatching culture, and juvenile and adult alligator culture was researched thoroughly and refined (see review by Joanen and McNease 1987), and led to successful development of numerous alligator farms in Louisiana.

Although alligators have been shown to breed in captivity (Joanen and McNease 1987), success has been limited. Emphasis shifted to ranching programs. In Louisiana, alligator farmers/ranchers may collect eggs from privately owned wetlands, after nesting populations and habitat suitability are reviewed by LDWF personnel and egg harvest quotas are set. The alligator "rancher," as part of his contract, is obligated to return to the wild healthy alligators between 0.92 m and 1.52 m representing a calculated percentage of his annual hatch rate based on mortality/survivorship curves. This program has been described in detail elsewhere (Elsey et al. 1992).

Although food habits of wild crocodilians have been studied extensively (Magnusson et al. 1987, Wolfe et al. 1987, Platt et al. 1990, Webb et al. 1991), limited data exists on food habits of crocodilians returned to the wild from captivity or on the success rate of relocation, repatriation, and translocation efforts of crocodilians (Dodd and Siegel 1991). Also, early concern was expressed that captive released crocodilians might not thrive, possibly as a result of having to learn to hunt for food and adapt to a new environment (Blake and Loveridge 1975). Thus, the purpose of this study was to evaluate food habits of alligators raised in captivity and released to the wild.

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## Methods

Alligators were collected during the annual experimental July harvest at Marsh Island Wildlife Refuge located in southcentral Louisiana. The primary vegetative species in this brackish marsh habitat are marshhay cordgrass (*Spartina patens*) and olney bulrush (*Scirpus olneyi*) (Taylor et al. 1991).

Sub-adult and adult-sized alligators were harvested between 8 July 1991 and 18 July 1991 by baited hook and line as is standard practice. Hunters were chosen by public drawing and were asked not to use birds or fish for bait which might be interpreted later as having been consumed as prey; the most commonly used baits were chicken and beef parts. At a central check point, harvested alligators were sexed, measured for total length, and weighed, then transported to a processing plant, where after skinning the entire viscera was removed and frozen for later analysis.

Of 757 alligators harvested in 1991 on Marsh Island, 83 had been hatched in farm incubators and were raised entirely in captivity on alligator farms in Louisiana for approximately 20 months then released to the wild at Marsh Island. Stomach contents from 78 were analyzed [65 males, 13 females, average length 151 cm (range 135–165 cm), average mass 9.6 kg (range 6.4–15.9 kg)]. Thirty native wild alligators (21 males, 9 females) of similar size [153 cm average length (range 140–170 cm), 10.0 kg average mass (range 6.8–15.0 kg)] were selected for stomach content analysis for comparison. Of the harvested farm-released alligators, 73 had been released in April 1991, and 5 in August 1989.

Lateral fat bodies were removed from alligator viscera and weighed to the nearest 0.05 g. Stomach contents were separated as to individual prey species and each weighed to the nearest 0.05 g. Volumes of prey items were determined by water displacement. Items occurring in trace amounts ($<0.05$ g; i.e., insect parts) were non-detectable on the scale used and were assigned a value of 0.01 g in calculation of total prey mass and averages. Volumetric measurements closely paralleled mass as other investigators have noted (Chabreck 1971, McNease and Joanen 1977) and thus were not used in analyses. If present, roundworms were enumerated and placed in ethanol for preservation and later identification. Vegetation and debris were weighed and measured as above, but not considered prey items. Prey items were ranked by frequency occurrence (excluding empty stomachs), by the average mass of that prey type, and as to what percent of the total prey mass that item constituted. A $z$-test was used to compare differences in percent frequency occurrence of prey item types, and $t$-tests were used to compare average prey item mass and percent of individual prey items of total prey mass between native and farm-released alligators.

## Results and Discussion

All alligators examined in this study were of normal body habitus, none appeared malnourished or emaciated. There were no differences in mass and body conditions between the 2 groups (Elsey et al. 1992).

Of the 108 stomachs examined, 101 (93.5%) contained prey items. No difference ($P > 0.05$) in the percentage of empty stomachs was present between farm-released (7.7%) and native wild alligators (3.3%). These results are consistent with earlier studies in southern Louisiana which showed 3.0%–15.4% of wild alligator stomachs examined being empty (Kellogg 1929, Arthur 1931, O'Neil 1949, Giles and Childs 1949, Platt et al. 1990). Taylor (1986) studied food habits in the cypress lake habitat in north Louisiana and noted 31.5% of wild alligator stomachs had no prey items; and Sloan (unpubl. data) found 31.2% empty stomachs in a large sample of wild adult alligators from Marsh Island. Surprisingly, the majority of alligators with empty stomachs included in Sloan's data were taken during the summer. It is unclear if differing digestion rates, metabolic rates, or feeding frequency alter gastric emptying time in alligators or whether these factors are responsible for the varying proportions of empty stomachs seen.

Crustaceans were by far the most frequently consumed prey item by both groups. Only 1 farm-released alligator stomach did not contain some type crustacean, and all native alligators had crustaceans among prey consumed (Table 1). Blue crabs were the most frequently occurring prey item in both groups (88.9% farm-released, 75.9% native wild) and accounted for approximately 70% of the total prey weight in each group. Crawfish (*Procambarus clarkii*) remains were observed in 37.9% of the wild alligators and 30.6% of the farm-released alligators. Crabs other than *Callinectes* were more frequently seen in farm-released alligators (Table 1) and constituted a significantly higher percentage ($P < 0.05$) of the total prey consumed (22.9% vs. 5.7%). Although fiddler crabs (*Uca* sp.) have been reported in several studies, mud or wood crabs (*Sesarma reticulatum*) have been documented only once in alligator stomachs and occurred in only 5% of 157 stomachs examined (Kellogg 1929). To our knowledge, the xanthid crab (*Rhithropanopeus harrisii*) has not been described previously in alligator stomach contents, yet were found in 16.7% of the farm-released alligators. Grass shrimp (*Palaemonetes*) occurred more frequently (although not significantly so) in native alligators (31.0%) than in farm-released alligators (22.2%). Likewise, previous studies have documented that crustaceans are frequently seen in alligator stomach contents and are considered to be an important prey item, especially in smaller alligators (Kellogg 1929, Arthur 1931, O'Neil 1949, Giles and Childs 1949, Fogarty and Albury 1967, Chabreck 1971, Valentine et al. 1972, McNease and Joanen 1977, Wolfe et al. 1987, Platt et al. 1990, Delany 1990, Sloan unpubl. data).

In other habitats, and with larger alligators, different species may predominate, probably due to availability. For example, for a cypress lake habitat in north Louisiana, Taylor (1986) found that turtles, mammals, and fish were more important prey items (by frequency and mass) than crustaceans. Delany and Abercrombie (1986) found crustaceans to be of lesser importance (by frequency and volume) than fish, snails, reptiles, and mammals in their study of alligator food habits in north central Florida. They also provided data that differential rate of digestion can cause some prey items that are resistant to digestion to be overrepresented (mammals, birds, crustaceans) and prey consumed that is rapidly digested to be underrepresented (amphibians and fish). Similar concerns with validity of interpreting stomach contents of crocodilians have been discussed previously (Jackson and Campbell 1974, Garnett 1985).

Fish were seen in 31.0% of native alligator stomachs and in 23.6% of farm-released, and fish comprised a greater percentage ($P < 0.05$) of total prey content for wild alligators (26.9%) than for farm-released alligators (11.2%). Fish were likely underrepresented due to the rapid digestion of soft, fish body parts (Delany and Abercrombie 1986), and subsequent difficulty with identification. The most commonly seen fish were *Fundulus* sp., rainwater killifish (*Lucania parva*), and silversides (*Menidia* sp.). Fish have been noted as important prey items for alligators in most previously mentioned studies, in varying amounts ranging from 10.0%–55.1%

**Table 1** Prey items in juvenile alligator stomachs from Marsh Island Refuge, July 1991.

| | % frequency occurrence | | $\bar{x}$ prey item mass (g) | | % of total for prey type | |
|---|---|---|---|---|---|---|
| | Released | Native | Released | Native | Released | Native |
| Total Crustaceans | 98.6 | 100.0 | 4.5 ± 1.0 | 8.0 ± 2.5 | 48.2 ± 3.7 | 44.7 ± 5.9 |
| Blue Crab | 88.9 | 75.9 | 9.8 ± 1.6 | 14.4 ± 5.3 | 72.8 ± 4.2 | 68.1 ± 7.3 |
| Crawfish | 30.6 | 37.9 | 4.9 ± 2.2 | 4.0 ± 2.1 | 25.6 ± 7.0 | 35.7 ± 13.4 |
| Crabs, other | 27.8 | 24.1 | 1.7 ± 0.5 | 0.8 ± 0.3 | 22.9 ± 7.2[a] | 5.7 ± 2.1 |
| Xanthid Crab | 16.7 | 10.3 | 1.6 ± 0.5 | 0.3 ± 0.2 | 14.3 ± 5.7 | 3.3 ± 1.4 |
| Purple Marsh Crab | 6.9 | 10.3 | 2.2 ± 0.6 | 1.1 ± 0.6 | 46.1 ± 16.9 | 8.6 ± 4.3 |
| Fiddler (*Uca* sp.) | 2.7 | 0 | 0.1 ± 0.1 | 0 | 5.1 ± 4.9 | 0 |
| *U. longisignalis* | 4.2 | 3.4 | 1.5 ± 1.3 | 1.4 | 18.1 ± 15.0 | 7.8 |
| Unidentified | 0 | 3.4 | 0 | 0.2 | 0 | 0.1 |
| Grass Shrimp | 22.2 | 31.0 | 1.5 ± 0.9 | 2.9 ± 1.6 | 14.0 ± 5.2 | 28.9 ± 13.3 |
| *Penaeus* sp. | 1.4 | 0 | 0.4 | 0 | 25.0 | 0 |
| Total Fish | 23.6 | 31.0 | 1.1 ± 0.4[a] | 5.3 ± 1.5 | 11.2 ± 3.5[b] | 26.9 ± 7.5 |
| Gulf Killifish | 1.4 | 3.5 | 1.4 | 14.0 | 17.3 | 12.4 |
| *Fundulus* sp. | 1.4 | 6.9 | 1.0 | 2.0 ± 0.6 | 16.1 | 12.2 ± 2.3 |
| Silversides | 0 | 3.5 | 0 | 1.7 | 0 | 3.4 |
| Rainwater Killifish | 2.8 | 0 | 0.1 ± 0.1 | 0 | 1.0 ± 0.6 | 0 |
| Unidentified | 19.4 | 31.0 | 1.2 ± 0.5 | 5.5 ± 1.9 | 11.9 ± 4.3[a] | 34.4 ± 9.7 |
| Total Mollusks | 6.9[a] | 20.7 | 0.5 ± 0.3 | 0.7 ± 0.3 | 7.0 ± 3.8 | 6.9 ± 2.9 |
| Rangia | 0 | 3.5 | 0 | 1.0 | 0 | 2.9 |
| Snails | 2.8 | 0 | 1.0 ± 0.8 | 0 | 6.1 ± 5.7 | 0 |
| Unidentified | 4.2 | 17.2 | 0.3 ± 0.2 | 0.7 ± 0.3 | 7.7 ± 6.0 | 7.6 ± 3.4 |
| Total Insects | 27.8 | 13.8 | 0.1 ± 0.03 | 0.2 ± 0.1 | 9.2 ± 5.0 | 18.4 ± 17.3 |
| Coleoptera | 12.5 | 10.3 | 0.1 ± 0.03 | 0.4 ± 0.2 | 1.1 ± 0.6 | 30.7 ± 28.4 |
| Dragonfly | 1.4 | 0 | 0.01 | 0 | 0.1 | 0 |
| Pupae | 6.9 | 0 | 0.3 ± 0.2 | 0 | 20.3 ± 15.8 | 0 |
| Unidentified | 13.9 | 6.9 | 0.01 ± 0.004 | 0.03 ± 0.02 | 11.8 ± 9.8 | 0.1 ± 0.01 |
| Spiders | 1.4 | 3.5 | 0.5 | 0.1 | 1.6 | 0.3 |
| Birds, Unidentified | 8.3 | 6.9 | 21.0 ± 10.4 | 0.2 ± 0.2 | 69.6 ± 15.3 | 23.0 ± 23.0 |
| Total Reptiles | 0 | 6.9 | 0 | 0.3 ± 0.1 | 0 | 6.1 ± 0.6 |
| Snake | 0 | 3.5 | 0 | 0.2 | 0 | 6.7 |
| Unidentified bone | 0 | 3.5 | 0 | 0.4 | 0 | 5.5 |
| Amphibian, Unidentified frog | 0 | 3.5 | 0 | 1.5 | 0 | 50.0 |
| Total Mammals | 12.5 | 6.9 | 26.7 ± 19.9 | 101.7 ± 101.6 | 34.9 ± 13.2 | 58.3 ± 41.6 |
| Nutria | 6.9 | 3.5 | 8.1 ± 4.9 | 203.3 | 33.6 ± 20.9 | 99.9 |
| Muskrat | 5.5 | 0 | 56.7 ± 55.6 | 0 | 29.9 ± 22.6 | 0 |
| Mink | 1.4 | 0 | 25.5 | 0 | 91.4 | 0 |
| Rabbit | 1.4 | 0 | 0.7 | 0 | 4.5 | 0 |
| Unidentified | 0 | 3.5 | 0 | 0.01 | 0 | 16.7 |

[a]Significant at $P < 0.05$
[b]Significant at $P < 0.10$

frequency of occurrence (Arthur 1931, Delany and Abercrombie 1986), and 0.3%–57.2% composition by volume (Fogarty and Albury 1967, Delany and Abercrombie 1986).

Mollusks occurred more frequently ($P < 0.05$) in stomachs of native alligators (20.7%) than in farm-released alligators (6.9%) but accounted for a similar low percentage of the total prey mass in both groups (Table 1). Giles and Childs (1949) and McNease and Joanen (1977) also observed mollusks to be of minor importance to alligators as prey. Fogarty and Albury (1968) found the apple snail (*Pomacea paludosa*) in > 65% of alligator stomach contents by volume and frequency occurrence in Florida; however, their study involved a limited sample size and area, with all 36 alligators being caught from a single canal on the same night.

Insects were more frequently observed (although not significantly greater) in farm-released alligators than native wild, but the small size of insect remains contributed little mass to the total amount of prey taken (Table 1). Most previously mentioned studies list insects as occurring in alligator stomachs in varying amounts, and insects have been shown to be more important in the diet of small (122–183 cm) alligators, and even more so for those < 122 cm (Giles and Childs 1949, Chabreck 1971, Wolfe 1987, Delany 1990, Platt et al. 1990, Hayes 1992). Garnett (1985) suggested crocodilians may lack gastric chitinase, leading to persistence of chitinous elytra in crocodilian stomachs, causing insects to be overrepresented in crocodilian diet analyses. These chitinous particles may act as gastroliths in crocodilians not ingesting stones as gastroliths (Garnett 1985). Spiders occurred infrequently in both groups and were of little importance as prey.

Birds occurred more frequently, with a higher average mass of prey, and as a higher percentage of total prey items taken in farm-released alligators than native alligators, although these differences were not statistically significant (Table 1). Limited digested remains precluded definite bird identification, although 2 birds consumed by farm-released alligators were thought to be from the rail family. Most prior studies showed birds were taken infrequently by adult alligators, and in some cases no birds were consumed by juvenile alligators (Arthur 1931, Fogarty and Albury 1967, Platt et al. 1990). One notable exception is McIlhenny's study (1934) on Avery Island; stomachs of 24 alligators contained remains of 136 herons, probably due to the abundance of birds at this location.

Reptiles did not occur in farm-released alligators and rarely in native alligators. One kingsnake (*Lampropeltis* sp.) tail and 1 unidentified dermal bone thought to be reptilian in origin were present. Previous papers have documented reptiles (especially turtles and snakes) occurring in alligator stomach contents ranging from 9%–57% frequency (McNease and Joanen 1977, Delany and Abercrombie 1986, Taylor 1986), but they were generally of minor importance by mass. Alligator eggshells or alligator parts have been reported previously in alligator stomach contents; possibly as a result of cannibalism or consumption of carrion (Kellogg 1929, Giles and Childs 1949, Valentine 1972, McNease and Joanen 1977, Delany and Abercrombie 1986, Taylor 1986, Rootes 1989, Platt et al. 1990, Sloan unpubl. data). There was no evidence of cannibalism in our study. Alligator teeth occurred in 3 stomachs (2 native and 1 farm-released) and were thought to have been cases of the alligator swallowing its own tooth.

One inner eggshell membrane (of undetermined origin) occurred in a native alligator. The mass was 0.3 g, and the eggshell membrane was 3 cm x 2 cm in length and was judged to be too small to be from an alligator, too large to be from a turtle egg, yet thicker than a normal bird inner eggshell membrane.

Only 1 amphibian was noted in our study; skeletal remains of an unidentified frog were seen in a native alligator. Several authors have noted how infrequently frogs are taken by alligators, despite abundant populations and prey availability (Giles and Childs 1949, McNease and Joanen 1977). However, Delany and Abercrombie (1986) found amphibians were the fastest prey item digested and thus would be underrepresented in analyses of alligator stomach contents.

Mammals occurred more frequently in farm-released alligators (12.5%) than native alligators (6.9%), although not significantly so. Species taken included nutria (*Myocastor coypus*), muskrat (*Ondatra zibethicus*), mink (*Mustela vison*), and rabbit (*Sylvilagus* sp.). The average prey mass was slightly, falsely elevated as the largest alligator in our study (170 cm, vs. 152 cm average) was a native alligator that ate what we believed to be a gravid nutria. This was based on 203.3 g nutria remains that included 2 large toenails and 14 small toenails. Mammals are generally not utilized as prey items by alligators until the sub-adult period is reached (Giles and Childs 1949, Valentine et al. 1972, Wolfe et al. 1987, Platt et al. 1990, Sloan unpubl. data). Brantley (1989) suggested that an ontogenetic change in skull shape may enable sub-adult alligators to capture larger prey items and allow larger alligators to utilize energetically worthwhile food items including fish, reptiles, birds, and mammals (Dodson 1975, Hines and Abercrombie 1987, Platt et al. 1990). Likewise, other crocodilians exhibit a shift in prey size with increasing predator size, possibly being more energetically advantageous (Webb et al. 1991).

The total prey mass and total mass of stomach contents were not different ($P > 0.05$) between the farm-released alligators and native alligators. Also, the 5 alligators that had been released from captivity in August 1989 had stomach contents comparable to those released in April of 1991. There was no difference in the species diversity taken by either group; farm-released alligators consumed 2.6 ± 0.2 different prey types per stomach as compared to 2.8 ± 0.3 for native animals.

We rarely observed non-food items in alligator stomachs, only noting a single instance of monofilament fishing line in a native alligator and a piece of glass in a farm-released alligator stomach. Numerous lead, iron, and other unidentifiable metal fragments of negligible mass (<0.01 g) were noted in both groups and possibly ingested incidentally or secondarily. Five stones were seen in 1 native alligator stomach and several oyster shells noted in another native alligator stomach. These may have been ingested accidentally or to serve as gastroliths to facilitate digestion (Kennedy and Brockman 1965, Sokol 1971). Cott (1961) suggested that Nile crocodiles (*Crocodylus niloticus*) ingest stones to act as ballast to lie submerged in strong current or to contribute extra mass to assist the crocodile in holding prey under water; however, Sokol (1971) suggests these theories seem unlikely.

Vegetation occurred in 93%–95% of stomachs of both groups. Most prior papers also list vegetation frequently occurring in stomach contents. Early naturalists (Kellogg 1929) supposed vegetation served to keep the stomach distended while alligators were hibernating and reduced the quantity of food required to fill the stomach. Platt et al. (1990) suggested that seeds were sought by small alligators as gastroliths due to scarcity of stones in the study area. Plant material has been shown to have no biological importance in crocodilian diets (Coulson and Hernandez 1983), and vegetation is most likely ingested incidentally while burrowing or lunging to capture prey (Giles and Childs 1949, McNease and Joanen 1977, Platt et al. 1990).

Roundworms occurred more frequently ($P < 0.05$) in native alligators than farm-released (83.3% vs. 47.4%), and were present in significantly larger numbers per stomach in native than in farm-released alligators (13.1 ± 3.8 wild; 2.1 ± 0.5 farm-released, $P < 0.05$). The literature varies widely on the occurrence of roundworms; many studies did not discuss the presence of nor mention the absence of roundworms. Kellogg (1929) noted only a single nematode in 157 stomachs, and Valentine et al. (1972) noted 3 in 309 stomachs. Much higher frequencies were observed by Delany and Abercrombie (1986, 82%), Sloan (unpubl. data, 64%), and Platt et al. (1990, 44%). We assume these roundworms are not pathologic, and it is unclear why they are more frequent and numerous in native than farm-released alligators.

Lateral fat bodies were significantly heavier ($P < 0.05$) in farm-released alligators (10.1 ± 0.7 g) than native alligators (4.1 ± 0.5 g). This may be a sign of good body condition and well-being. Farm-released alligators were well fed daily and were maintained in heated sheds prior to release to the marsh. This may have given them an inherent advantage over the native alligators, and they possibly were able to use the fat reserve while initially adapting to the wild environment and learning to forage for food. The lateral fat bodies in the 5 alligators that were released in August 1989 were much smaller (range 1.4–4.9 g) than those of the other farm-released alligators which were more comparable to the native alligator fat bodies. Preliminary data indicates farm-reared alligators released to the wild have growth rates equal to or superior to native wild alligators, even after overwintering (Elsey et al. 1992). Recent work on food conversion rates of wild crocodilians showed that to maintain similar growth rates, wild juvenile saltwater crocodiles require food equivalent to only 4% of their body mass per week, whereas captive counterparts require 4 times that much due to less efficient food conversion rates (Webb et al. 1991). Similar quantitative data on food conversion rates of wild alligators is lacking.

In summary, released and native alligators had generally similar food habits, with no differences in total prey mass, total mass of stomach contents, or number of empty stomachs. We therefore conclude that alligators raised entirely in captivity (and provided food ad libitum) then released into the wild are able to forage for food and hunt as successfully as native wild alligators. The presence of heavier lateral fat bodies, superior or equal growth rates, and similar body condition factors seen in released alligators (Elsey et al. 1992) also indicated alligators thrive after release into the wild. Farm-released juvenile alligators may be more "advanced" in their feeding habits than wild juvenile alligators as they were more likely to consume large prey items (nutria, muskrat, birds) normally not taken by native alligators until the adult size class is reached. Our findings in this preliminary study support the practices of restocking and relocation of alligators in suitable habitat types as useful management techniques as farm-released alligators appear to easily adapt to a new environment.

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