# AMERICAN ALLIGATOR FOOD HABITS IN NORTHCENTRAL FLORIDA

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*Abstract:* Stomachs from 350 American alligators (*Alligator mississippiensis*) collected in conjunction with 1981–83 experimental harvests on 3 lakes in northcentral Florida were examined for food habits. Common invertebrate foods of subadult alligators were giant water bugs (*Belostoma* spp.), apple snails (*Pomacea paludosa*), and crayfish (*Procambarus penninsulatus*); common terrestrial foods were round-tailed muskrats (*Neofiber alleni*) and marsh rabbits (*Sylvilagus palustris*). Larger size classes primarily consumed Florida red-bellied turtles (*Pseudemys nelsoni*), peninsular cooters (*P. floridana*), stinkpots (*Sternotherus odoratus*), gizzard shad (*Dorosoma cepedianum*), and Florida gar (*Lepisosteus platyrhincus*). When compared by sex female alligators consumed significantly ($P = 0.04$) more mammals. Reptiles (turtles) were more important ($P = 0.04$) in the diet of male alligators. No differences ($P > 0.05$) were apparent in diets between study area lakes. Alligators in Florida consumed more fish and turtles but fewer mammals than in other parts of their range. Alligator marking tags recovered from 5% of the sample suggest some juvenile mortality may be attributable to cannibalism. Fish and amphibians are probably under-represented in the sample, and turtles, snails, crayfish, birds, and mammals may be overemphasized because of differential digestion rates. Diverse wetland habitat may benefit alligators by providing a variety of foods for different size classes.

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Carcasses collected during experimental alligator hunts in Florida provided an opportunity to conduct stomach analysis and determine the role of the alligator in Florida wetlands. Because diet influences alligator growth rate, condition, and reproduction (Chabreck 1972, McNease and Joanen 1981) food habits information may be helpful in evaluating the relationship between alligators and their management in Florida. Previous studies in Florida are limited to 36 juvenile specimens (Fogarty and Albury 1968), part (11 specimens) of a regional sample (Kellog 1929), and a report on the stomach contents of a road-killed alligator (Kinsella 1982). This paper describes the late summer–early autumn diet of alligators in northcentral Florida and relates food habits to alligator size, sex, condition, location, study year, and digestion rates.

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## STUDY AREAS AND METHODS

Samples were collected within 28 km of Gainesville, Florida (29°40′N, 82°25′W), from Orange, Lochloosa, and Newnans lakes between 7 September and 14 October 1981–83. Orange and Lochloosa lakes contain extensive perimeter marshes and floating islands dominated by emergent plants and shrubs. Both are large (7,451-ha total area), shallow (3 m maximum depth), eutrophic lakes connected by Cross Creek. Newnans Lake (4,800 ha), located 11 km to the northwest, also is eutrophic, but its 21-km shoreline is bordered by wooded swamps. Its maximum depth is 4 m. Except for some residences, shorelines of study area lakes were undeveloped. The climate of northcentral Florida is humid-subtropical.

Stomachs were collected from 350 hunter-harvested alligators. Total length, sex, and location were recorded for each animal, and stomachs were frozen for storage. Alligators ranged in length from 1.3 to 3.9 m and included 219 males and 131 females. Subadult (<1.8 m) alligators comprised 26% of the sample. After thawing, stomach contents were removed and individual food items separated. Volumes were determined by water displacement to the nearest milliliter. Contents were identified to





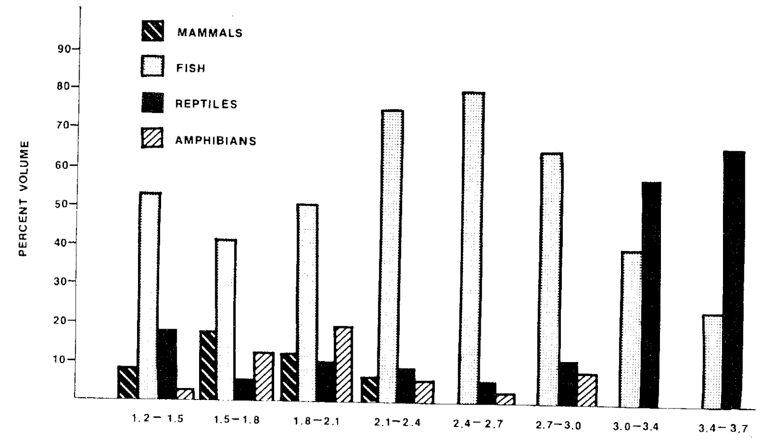


Fig. 1. Percent volumes of major food groups by different American alligator size classes. Data are from Orange, Lochloosa, and Newnans lakes, Florida, 1981–83 ($N = 350$).

the lowest possible taxon. Analysis of variance was used to detect differences in food habits by alligator size, study area, year, and sex. Because the size of a crocodilian affects its diet (Cott 1961, Taylor 1979), it was necessary to control for length by analysis of covariance. To fulfill the necessary statistical assumptions food volumes were normalized approximately by square-root transformation. For analysis of covariance by sex the size distribution was truncated at the size of the largest female (2.7 m). We were unable to discover an objective definition of condition factors directly applicable to alligators. It is believed, however, that a crocodilian's condition or "relative fatness" somehow is indicated by the relationship between its length and weight (Taylor 1979). Therefore, for all study animals, a least squares equation was calculated giving weight as a cubic function of length:

$$\text{weight} = -154.3 + 6.173(\text{length}) - 0.085(\text{length}^2) + 0.0005063(\text{length}^3).$$

The equation's residuals were examined, assuming that animals heavier than predicted would be in relatively better condition. Because residuals were distributed approximately normally for each of the study area lakes, Z-tests were applied.

Results are presented by number of individuals, frequency of occurrence, and volumes. Results are interpreted in light of digestion rates measured with captive animals. Gizzard shad, striped mud turtles (*Kinosternon bauri*), greater siren (*Siren lacertina*), red-winged blackbirds (*Agelaius phoeniceus*), round-tailed muskrats, apple snails, and crayfish were used to determine relative digestion rates of major food groups. Over a 5-day period (2–6 Sep 1984), 3 alligators 1.1–1.6 m in length were fed volumetrically measured amounts of food similar to that found in stomachs examined. The feeding schedule was designed so that each item was ingested by an alligator 1, 3, and 5 days before examination. After 5 days, alligators were sacrificed and stomach contents segregated by species. Volumetric measurements of the remaining material were used to determine digestion rates and clarify the relative importance of foods.

## RESULTS AND DISCUSSION

Fifteen stomachs contained only plant material or debris, 4 were empty, and 331 contained food. Prey items, by volume, consisted

Table 1. Predominant contents (occurring in >1%) of 350 American alligator stomachs collected from Orange, Lochloosa, and Newnans lakes, Florida, 1981–83.

| Item | *N* items | % frequency | Vol displaced (ml) | % vol of food |
|---|---|---|---|---|
| Vertebrates (total) | 551 | 88.0 | 50,975 | 99.2 |
| Fish (total) | 241 | 55.1 | 29,405 | 57.2 |
| Gizzard shad | 35 | 8.9 | 7,748 | 15.1 |
| Florida gar | 30 | 7.7 | 6,453 | 12.6 |
| Chain pickerel (*Esox niger*) | 15 | 3.4 | 4,354 | 8.5 |
| Largemouth bass (*Micropterus salmoides*) | 12 | 2.9 | 3,622 | 7.0 |
| Sunfish (*Lepomis* spp.) | 5 | 1.4 | 328 | 0.6 |
| Bowfin | 13 | 3.7 | 773 | 1.5 |
| Brown bullhead (*Ictalurus nebulosus*) | 5 | 1.4 | 458 | 0.9 |
| Mosquitofish (*Gambusa affinis*) | 4 | 1.1 | 2 | tr[a] |
| Undetermined | 108 | 28.9 | 4,624 | 9.0 |
| Reptiles (total) | 202 | 40.0 | 11,962 | 23.3 |
| Florida red-bellied turtle | 40 | 8.3 | 7,764 | 15.1 |
| Peninsula cooter | 26 | 5.7 | 2,032 | 3.9 |
| Stinkpot | 75 | 18.9 | 400 | 0.8 |
| Striped mud turtle | 26 | 5.7 | 387 | 0.1 |
| Water snake (*Nerodia* spp.) | 9 | 2.6 | 734 | 1.4 |
| Crayfish snake (*Regina alleni*) | 4 | 1.1 | 91 | 0.2 |
| Amphibians (total) | 35 | 8.6 | 3,575 | 6.9 |
| Greater siren | 35 | 8.6 | 3,575 | 6.9 |
| Birds (total) | 32 | 9.1 | 3,456 | 6.7 |
| American coot (*Fulica americana*) | 5 | 1.4 | 865 | 1.7 |
| Undetermined | 17 | 4.9 | 599 | 1.2 |
| Mammals (total) | 41 | 11.7 | 2,679 | 5.0 |
| Round-tailed muskrat | 29 | 7.7 | 893 | 1.7 |
| Invertebrates (total) | 1,364 | 65.4 | 391 | 0.8 |
| Snails (total) | 1,126 | 55.7 | 248 | 0.5 |
| Apple snail | 861 | 55.4 | 221 | 0.4 |
| Freshwater snail (*Campeloma* spp.) | 6 | 1.1 | 4 | tr |
| Crustaceans (total) | 52 | 9.7 | 6 | 0.1 |
| Crayfish | 6 | 1.7 | 40 | tr |
| Grass shrimp (*Palaemonetes intermedius*) | 27 | 2.6 | 7 | tr |
| Undetermined | 17 | 4.9 | 26 | tr |
| Insects (total) | 177 | 16.8 | 2 | tr |
| Giant water bug | 19 | 5.1 | 12 | tr |
| Predaceous diving beetle (Dytiscidae) | 12 | 2.6 | 6 | tr |
| Water scavenger beetle (Hydrophilidae) | 7 | 1.4 | 4 | tr |
| Hermit flower beetle (*Osmoderma eremicola*) | 5 | 1.4 | 4 | tr |
| Green June bug (*Cotinus nitida*) | 5 | 1.4 | 2 | tr |
| Cone-headed grasshopper (Copiphorinae) | 22 | 1.7 | 1 | tr |
| Spiders (total) | 4 | 1.1 | 3 | tr |
| Fishing spider (*Dolomedes triton*) | 4 | 1.1 | 3 | tr |
| Total food | 1,915 | 94.6 | 51,366 | 100.0 |
| Plant material | | 90.6 | 18,483 | |
| Debris | | 69.1 | 6,215 | |
| Empty | | 1.1 | 0 | |
| Total contents | | | 76,064 | |

[a] tr = <0.1% of total food volume.

of invertebrate (0.8%), fish (57.2%), amphibian (6.9%), reptile (23.3%), bird (6.7%), and mammal (5.0%) species (Table 1). Taxonomic groupings were represented differently among size classes (Fig. 1). Stomach capacity and volume of contents increased with alligator size (Table 2).

No differences ($P > 0.05$) were discovered in food habits (mean percent volume of food items) when examined by study area lakes (Table 3). Compared by year, fish ($P < 0.01$) and total food ($P < 0.05$) consumption were higher in 1983. This probably was due to earlier hunt dates and warmer weather for that year. New-



Table 2. American alligator length, stomach capacity, and volume of stomach contents. Data are from Orange, Lochloosa, and Newnans lakes, Florida, 1981–83.

| Total length (m) | *N* | $\bar{x}$ stomach capacity (ml) | $\bar{x}$ contents (ml) | |
|---|---|---|---|---|
| | | | Food | Nonfood |
| 1.2–1.5 | 46 | 165.1 | 39.3 | 6.4 |
| 1.5–1.8 | 52 | 289.4 | 82.3 | 20.4 |
| 1.8–2.1 | 70 | 564.7 | 102.1 | 32.4 |
| 2.1–2.4 | 59 | 831.5 | 167.4 | 56.8 |
| 2.4–2.7 | 49 | 1,346.7 | 202.6 | 88.5 |
| 2.7–3.0 | 25 | 1,469.8 | 197.0 | 141.2 |
| 3.0–3.4 | 27 | 2,446.4 | 241.3 | 191.8 |
| 3.4–3.7 | 19 | 2,207.4 | 274.4 | 170.0 |
| >3.7 | 3 | 2,656.6 | 557.6 | 483.9 |

nans Lake alligators were in better condition ($Z = 7.8$, df $= 2$, $P < 0.01$) than those from Orange and Lochloosa lakes; the latter areas did not differ ($P > 0.05$). Diet composition, species volumes, and stomach capacities were not different ($P > 0.05$). Chabreck (1972) related alligator condition to stomach capacity and level of food intake. In this study condition differences are unexplained but do not appear to be due to the quantity or quality (species) of food ingested.

## Stomach Contents

*Fish*.—Fish were the most important food by percent volume ($P < 0.05$) but ranked 2nd to snails in percent frequency of occurrence. Fish are probably the most available and abundant prey for alligators and are probably under-represented because of their rapid digestion (Table 4). Fish were a major component in the diet of all size classes but were less important for large (>3 m) alligators (Fig. 1). The pattern of fish occurrence by alligator size follows a trend similar to that observed in Nile crocodiles (*Crocodilus niloticus*) (Cott 1961). Other studies of alligators have found fish to be important but usually secondary to crustaceans (Giles and Childs 1949, Chabreck 1972, Valentine et al. 1972) and mammals (McIlhenny 1935, McNease and Joanen 1977).

Nongame fish, mostly gar, gizzard shad, and bowfin (*Amia calva*), occurred in 24% of the stomachs and accounted for 51% of fish volume. Identifiable game and commercially valuable fish species constituted 33% of the total fish volume and occurred in 11% of the stomachs. Apparently, alligators utilize these fish groups in proportion to their availability because fish group proportions from alligator stomachs are

Table 3. Analysis of covariance, controlling for the effect of American alligator length, for selected food groups and total food volumes, by year, sex, and study area lake. Data are from Orange, Lochloosa, and Newnans lakes, Florida, 1981–83.

| Food group | Factor | df | *F* | *P* |
|---|---|---|---|---|
| Fish | year | 2 | 7.24 | 0.01 |
| | sex | 1 | 2.14 | 0.15 |
| | lake | 2 | 1.38 | 0.25 |
| Reptiles | year | 2 | 1.02 | 0.36 |
| | sex | 1 | 4.33 | 0.04 |
| | lake | 2 | 0.47 | 0.62 |
| Mammals | year | 2 | 0.37 | 0.69 |
| | sex | 1 | 4.17 | 0.04 |
| | lake | 2 | 0.02 | 0.98 |
| Total food | year | 2 | 2.86 | 0.05 |
| | sex | 1 | 0.05 | 0.82 |
| | lake | 2 | 1.29 | 0.28 |

consistent with blocknet fish survey data (J. T. Krummrich, unpubl. reps., Fla. Game and Fresh Water Fish Comm., Lake City, 1979, 1981).

*Reptiles*.—Reptiles ranked 2nd by percent volume and, except for fish and snails, were more prevalent ($P < 0.05$) than any other food. Compared by sex, reptiles were more important ($P = 0.04$) in the diet of male alligators. Turtles were the most common reptile and most important food for large (>3 m) alligators. Turtles, however, probably are over-represented in the sample. In digestion trials, epidermal scutes persisted after 5 days of digestion, and similar remains were found in 64% of those stomachs containing turtles. Unlike other studies (Giles and Childs 1949, McNease and Joanen 1977), turtles were more prevalent than snakes, which were found in only 4% of the stomachs and accounted for 8% of the total volume of reptiles. Nine alligator eggs were found in the stomach of a 2.2-m female alligator, and 20

Table 4. Percent volume remaining, at different times post-ingestion, for 3 American alligators fed measured amounts of various food items, Florida, September 1984. Total volume (ml) at time of feeding (1, 3, and 5 days before examination) is in parentheses.

| Item | Days of digestion | | |
|---|---|---|---|
| | 1 | 3 | 5 |
| Fish | 0.5 (100.0) | 0.0 (40.0) | 0.0 (55.0) |
| Turtle | 89.1 (32.0) | 3.1 (35.0) | 2.9 (49.0) |
| Amphibian | 0.0 (35.0) | 0.0 (40.0) | 0.0 (50.0) |
| Bird | 93.8 (80.0) | 30.0 (70.0) | 4.4 (80.0) |
| Mammal | 59.0 (290.0) | 34.0 (308.0) | 8.6 (145.0) |
| Snail | 40.0 (5.0) | 12.5 (4.0) | 1.8 (11.0) |
| Crayfish | 70.0 (8.5) | 13.0 (5.5) | 7.6 (13.0) |

numbered, monel, alligator marking tags were in 18 stomachs. All stomachs containing tags were from large alligators (11 males and 7 females, $\bar{x}$ length = 2.4 m), and it is probable that the presence of tags represents cannibalism. According to Nichols et al. (1976), cannibalism may be a major density dependent factor acting on alligators, with rates of 2–6% estimated for some populations.

Published reports of alligator cannibalism are rare; however, it is common among Nile crocodiles (Cott 1961). Also, Giles and Childs (1949) reported an entire 45-cm alligator and the remains of 2 alligator feet and Valentine et al. (1972) found 1 alligator foreleg in alligator stomachs they examined.

*Amphibians.*—The only amphibian found was the greater siren. Because of rapid digestion, its importance is probably under-represented. After only 1 day there was no evidence of amphibian remains in the digestion rate study. Frogs (*Rana* spp.) are abundant in study area lakes but were not found in any stomachs.

*Birds.*—Compared with other prey, birds were a less important food item and included 6 species. Their importance may be enhanced as evidenced by the persistence of feathers in the digestion rate study.

*Mammals.*—Compared by size and sex, mammals were more important in the diet of subadult and female (Table 3) alligators. The round-tailed muskrat was the most common of 6 species found, constituting 35% by volume of all mammals, and occurred in 29 stomachs. Kinsella (1982) found 6 round-tailed muskrats in the stomach of a 2-m-long road-killed alligator. Muskrats (*Ondatra zibethicus*) and nutria (*Myocastor coypus*) are important prey in coastal Louisiana (McIlhenny 1935, Chabreck 1972, Valentine et al. 1972, McNease and Joanen 1977) but do not occur in northcentral Florida. Hair persisted in the digestion rate study, indicating that mammals may be over-represented. Nutritional studies (McNeese and Joanen 1981) of captive alligators indicate that a diet of mammals may increase reproductive potential and improve condition.

*Invertebrates.*—Invertebrates accounted for <1.0% by volume of all food but, nevertheless, comprised the most prevalent food group. Apple snail remains (usually only the operculum) occurred equally in all alligator size classes. Only 23 stomachs (6%) contained snail parts with attached soft tissue. Operculums persisted after 5 days in the digestion rate study and were undoubtedly over-represented. Fogarty and Albury (1968) found *Pomacea* spp. to be the major food for juvenile alligators in south Florida. Compared by size class, crustaceans and insects were more common in the diet of subadult alligators. According to Neill (1971:237–238) insects are overemphasized as crocodilian prey because of secondary ingestion and a slower digestion rate. Jackson and Campbell (1974) demonstrated this but suggested that insect ingestion by juvenile crocodilians is common. The proportion of prey acquired by secondary ingestion probably is insignificant (Webb et al. 1982). Terrestrial insect species found in this study are common at the vegetation-water interface (J. F. Butler, pers. commun.) and are probably ingested when subadult alligators forage along the shoreline. Clams and spiders were infrequent and of minor importance.

*Nonfood Items.*—Stomachs from large alligators contained a large amount of nonfood items. Plant material was found in 90% of the stomachs. Stones were found in 36% of the stomachs and accounted for 4% by volume of the total contents. Man-made objects constituted 2% of the volume. Parasitic worms (*Dujardinascaris waltoni* and *Brevimulticecum tenuicolle*) occurred in 82% of the stomachs.

## Variation Among Habitats

Alligators ingested a wide variety of foods and seemed to take advantage of locally abundant prey species. Variation in diet may be related to habitat occupied, prey species encountered, prey vulnerability, prey size suitability, and alligator size. Subadult alligators consumed more invertebrates and terrestrial prey than did larger size classes and utilized a greater variety of species. Adult female alligators nesting near the shoreline or in marshes also are presented with more opportunities to consume terrestrial prey; i.e., mammals. Large alligators, particularly males, spend more time in open water (Goodwin and Marion 1979) and primarily consumed fish and turtles. This differential use of invertebrates and vertebrates as well as terrestrial and aquatic prey is consistent with other studies (Giles and Childs 1949, Cott 1961, Fogarty and Albury 1968, McNease and Joanen 1977, Taylor 1979, Webb et al. 1982). Alligators in northcentral Florida consumed more fish and turtles but fewer mammals than in other parts of their range.



Alligators are versatile, opportunistic predators that utilize a variety of prey species. Different food habits of various alligator size classes indicate that a diverse wetland habitat, providing many kinds of foods (in addition to other biological requirements) may be essential. Additional samples from juveniles and other seasons and regions may be useful in evaluating apparent differences in growth rates, mortality, reproductive success, and condition among Florida's alligator populations. These data also may be useful in determining the indirect effects of alligator harvest on other wildlife.

## LITERATURE CITED

CHABRECK, R. H. 1972. The foods and feeding habits of alligators from fresh and saline environments in Louisiana. Proc. Annu. Conf. Southeast. Assoc. Game and Fish Comm. 25:117–124.

COTT, H. B. 1961. Scientific results of an inquiry into the ecology and economic status of the Nile crocodile (*Crocodylus niloticus*) in Uganda and Northern Rhodesia. Trans. Zool. Soc. London 29: 211–357.

FOGARTY, M. J., AND J. D. ALBURY. 1968. Late summer food of young alligators in Florida. Proc. Annu. Conf. Southeast. Assoc. Game and Fish Comm. 21:220–222.

GILES, L. W., AND V. L. CHILDS. 1949. Alligator management on the Sabine National Wildlife Refuge. J. Wildl. Manage. 13:16–28.

GOODWIN, T. M., AND W. R. MARION. 1979. Seasonal activity ranges and habitat preferences of adult alligators in a north-central Florida lake. J. Herpetol. 13:157–164.

JACKSON, J. F., AND K. E. CAMPBELL. 1974. The feeding habits of crocodilians: validity of the evidence from stomach contents. J. Herpetol. 8:378–381.

KELLOG, A. R. 1929. Habits and economic importance of alligators. U.S. Dep. Agric. Tech. Bull. 147. 36pp.

KINSELLA, J. M. 1982. Alligator predation on round-tailed muskrats. Fla. Field Nat. 10:78.

MCILHENNY, E. A. 1935. The alligator's life history. The Christopher Publ. House, Boston, Mass. 117pp.

MCNEASE, L., AND T. JOANEN. 1977. Alligator diets in relation to marsh salinity. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 31: 26–40.

———, AND ———. 1981. Nutrition of alligators. Proc. Annu. Alligator Prod. Conf. 1:15–28.

NEILL, W. T. 1971. The last of the ruling reptiles: alligators, crocodiles, and their kin. Columbia Univ. Press, Ithaca, N.Y. 486pp.

NICHOLS, J. D., L. VIEMAN, R. H. CHABRECK, AND B. FENDERSON. 1976. Simulation of a commercially harvested alligator population in Louisiana. Louisiana State Univ. Agric. Exp. Stn. Bull. 691. 59pp.

TAYLOR, J. A. 1979. The foods and feeding habits of subadult *Crocodylus porosus* (Schneider) in Northern Australia. Aust. Wildl. Res. 6:347–359.

VALENTINE, J. M., J. R. WALTHER, K. M. MCCARTNEY, AND L. M. IVY. 1972. Alligator diets on the Sabine National Wildlife Refuge, Louisiana. J. Wildl. Manage. 36:809–815.

WEBB, G. J. W., S. C. MANOLIS, AND R. BUCKWORTH. 1982. *Crocodylus johnstoni* in the McKinlay River Area, N.T.I. variation in the diet, and a new method of assessing the relative importance of prey. Aust. J. Zool. 30:877–899.

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