FOOD OF THE WHITE IBIS IN SOUTHERN FLORIDA

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Little is known about the precise food of most wading birds in southern Florida, including that of the most abundant species, the White Ibis (*Eudocimus albus*). Only two food studies of White Ibis have been conducted in Florida. Baynard (1912. Food of herons and ibises. *Wilson Bull.*, 24:167-169; 1914. The White Ibis. *Blue Bird*, 7:16-22) reported on food taken by 50 White Ibis nesting at Orange Lake, north-central Florida. Nesbitt, Hetrick, and Williams (in press. Foods of White Ibis from seven collection sites in Florida. Proc. SE Assn. Game and Fish Commissioners, 28) recently reported on stomach contents from 180 birds collected in north and central Florida.

The present paper reports on the overall food and feeding habitat preferences of the White Ibis in southern Florida. The food data reported here are based on 199 samples, including 170 regurgitation samples from nestlings and 29 stomach contents from adults, collected from 1972 to 1974. Of these, 27 stomach samples and 86 regurgitation samples were recovered from birds feeding in coastal habitats. Samples were collected from Lake Istokpoga south to Cowpens Key in Florida Bay. Regurgitation samples were collected by forcing nestlings to disgorge recent meals. Since there were no differences between food consumed by adults and that fed to young (Kushlan, Ecology of the White Ibis in southern Florida, a regional study, Ph. D. diss. University of Miami, Fla.) both regurgitation and stomach samples were combined in analysis. Samples were separated to species if possible and then dried to constant weight. Contents were expressed as percentages of total dry weight of food and percentage frequency of occurrence. The total food consumption for White Ibis in southern Florida (last two columns in Table 1) was determined by multiplying the food data obtained in coastal and in inland habitats by the percentage of the southern Florida population utilizing each habitat during nesting. The baseline used for this calculation was 1973 when about 3% of the nesting population fed in coastal habitats, and 97% fed in inland habitats.

RESULTS

Table 1 summarizes the food of White Ibis in southern Florida. Crayfish predominated in the diet at inland habitats, accounting for 52% of the weight and occurring in 82% of the samples. Fish made up 19% of the inland diet, with the Sailfin Molly [1] accounting for

[1] *Scientific names appear in Table 1.*

the greatest biomass. Dragonfly larvae, occurring in 30% of the samples, Apple Snails, water bugs, especially the Giant Water Bug (occurring in 20% of the samples), and horsefly larvae were taken in inland sites. Adult mayflies were found in only a few samples around Lake Istokpoga but comprised most of the material found in those samples. Thus mayflies are a locally important food when available. Newts and Pig Frogs were the only vertebrates other than fish commonly eaten in inland habitats.

In coastal habitats, crabs, especially Fiddler Crabs, were common prey making up 20% of the biomass. Crayfish were also taken. Relatively more fish were eaten in coastal than in inland habitats and comprised 31% of the biomass. The Sheepshead Minnow was the most important fish species. Polychaetes, spiders, isopods, prawns, Mangrove Crabs, beetles, and horsefly larvae were also important components of the diet in coastal habitats.

Considering the total diet of White Ibis in southern Florida (Table 1), crayfish were the most important prey, followed by fish. Insect material occurred in 87% of the samples but accounted for only 14% of the biomass. Dragonfly larvae, Giant Water Bugs, and Apple Snails each comprised over 3% of the diet by weight. White Ibis consumed at least 69 types of prey in southern Florida. Overall, each of 9 prey items made up at least 1% of the biomass, and each of 8 species occurred in at least 10% of the samples. Plant material accounted for 3.5% of the total biomass and occurred in 19% of the samples but may have been eaten incidentally. It is notable, however, that ibis in captivity ate such non-animal food as bread, dry dog food, corn, potatoes, and watermelon.

Because of the dependence of White Ibis on aquatic prey (Table 1), it is of interest to determine which aquatic habitats are used most often by foraging ibis. During the study we noted White Ibis feeding in such locations as muddy pools in hammocks, lawns, pastures, golf courses, expressway margins, plowed farmland, dumps, hog farms, manure piles, and holding areas for sewage sludge. Relative to the yearly energy requirements of the species, the most important feeding locations are probably those used prior to and during this period, although most habitats were used by at least small numbers of White Ibis, most birds fed in only a few habitats. Table 2 shows the percentage of foraging habitats used during the nesting season. In this table, two types of inland habitats are distinguished because of differences in usage. On the coast feeding was concentrated along the edge of mangrove-lined streams, edges of ponds, and open prairies. In the Everglades and Big Cypress feeding was concentrated in marsh prairies, particularly along the interface with sawgrass

marshes, and at the edges of ponds. Little use was made of sawgrass marsh. In the lakes area pastures and lake-edge marshes were most heavily utilized. In each area there was a tendency to use open rather than densely vegetated areas, shallow rather than deeper areas, and borders rather than the center of open areas.

DISCUSSION

To summarize, crustaceans and fish are apparently the most important prey of the White Ibis in southern Florida, together making up 73% of the diet by weight. Crayfish occurred in 80% of the samples, but fish were less commonly taken and occurred in only 16%. The Apple Snail comprised over 5% of the diet by weight. In terms of frequency of occurrence, water bugs, water beetles and dragonfly larvae were commonly eaten aquatic prey of ibis. Earthworms and snails were taken from pastures. Marine prey such as crabs, isopods, snails, and mussels were consumed along the coast.

Other studies have shown that crayfish were also the most common prey of White Ibis in other Florida locations. Crayfish made up 46% of the prey items Baynard (1912) recovered and composed about 45% of the volume of samples from both freshwater and marine sites reported by Nesbitt *et al.* (in press). The latter study also found insects and snails to be important prey, but found that fish made up 1% or less of the volume of marine and freshwater samples. They suggested that ibis may take fish only during periods of relatively low water level. This proved to be the case in the present study in which fish made up nearly 20% of the prey weight but occurred in only 16% of the samples, all of which were taken from low water conditions. Baynard's (1912) finding that snakes, which he called small moccasins, were important prey was not confirmed by either Nesbitt *et al.* (in press) or the present study.

The wide range of food utilized by White Ibis suggests that the species will consume whatever can be captured by its primarily tactile foraging methods. That some prey are much more commonly taken than others suggests that prey species differ in availability or in the ability of ibis to catch them. Most prey types fall into one of three broad categories: 1) terrestrial, ground-dwelling animals; 2) aquatic free-swimming and partially sessile animals; and 3) aquatic burrowing animals. Many prey species are slow-moving or characteristically hide in sediment or vegetation.

Ibis direct most of their foraging activity to the sediment, which in southern Florida marshes is composed of a loose aggregation of floating periphytic plants, soft flocculent organic debris, and carbonate precipitants. This floc is inhabited by fish, aquatic insects, crustaceans, and other organisms that serve as the primary prey

of ibises. Animals that remain close to submerged plants and to the stems and roots of emergent plants are also taken by probing-searching techniques used by ibis. On land, ibis usually take snails and worms dwelling among plant roots or brought to the surface by rainfall. Free-swimming organisms are apparently taken only where they occur in high densities.

The feeding ecology of the White Ibis seems, therefore, to be characterized by opportunism in the utilization of a wide range of aquatic and terrestrial prey, but constrained by a relatively simple repertoire of feeding behavior. This results in many prey species being taken, but in relatively few species making up a large percentage of the biomass consumed. Based on its wide range of acceptable prey, the ibis is certainly a generalist, but, based on the energetic contribution of various prey to the diet, it seems to be a specialist on crustaceans. Similarly, ibis use most available feeding habitats, but shallow, open aquatic habitats are the most heavily used. Such diversity of food or habitat involves both the total kinds of habitats or food utilized and the relative use made of each kind of habitat or food. The effect of these two factors can be measured together in the often-used diversity index, $H' = -\sum p_i \ln p_i$, where p_i is simply the proportion of an item in the sample. Dividing H' by the maximum H' gives an index which ranges from 0, highly specialized, to 1, highly generalized. The diversity of habitat utilization was 0.87 for coastal habitats, 0.83 for Everglades habitats, and 0.75 for lakes-region habitats, indicating a generalized pattern of habitat utilization. Food diversity was 0.66 for a coastal habitat, 0.45 for inland habitats, and 0.45 overall, suggesting that food selection is midway between generalization and specialization.

The kind of prey taken by a predator depends on the interaction between the morphology and behavior of the predator and the size, behavior, and density of potential prey. The relatively stereotyped and primarily tactile feeding behavior of the White Ibis would seemingly be selective for slow-moving, sedentary, moderately sized animals, and such prey do make up most of the prey types taken in southern Florida. But mobile animals, such as fish and prawns, represent an important part of the diet in areas where their density is high. Although generalized in its use of habitat, the White Ibis relies heavily on only a few of the many types it consumes.

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Table 1.--Food of White Ibis in southern Florida.

	Inland Feeding Sites		Coastal Feeding Sites		Total	
	Weight %	Frequency %	Weight %	Frequency %	Weight %	Frequency %
Polychaete, Nereidae			1.15	9.3	.03	.28
Leech, *Placobdella* sp.	.01	p[1]			.01	p
Earthworm, *Lumbricus* sp.	.23	1.8			.22	1.7
Spiders, Arachnida			1.02	9.3	.03	p
Isopod, *Ligia* sp.			2.92	7.0	.17	p
Prawn, *Palaemonetes paludosus*	.09	5.3	4.41	22.1	.22	5.8
Crayfish, *Procambarus alleni*	52.22	82.3	11.18	20.9	50.99	80.4
Fiddler crabs, *Uca* sp.			19.96	16.3	1.16	p
Mangrove crab, *Sesarma* sp.			.79	2.3	.05	p
Land crab, *Cardisoma guanhumi*			.52	1.2	.02	p
Mangrove Crab, *Aratus pisonii*	.03	1.8	.52	1.2	.05	1.8
Unidentified crabs			2.38	14.0	.07	p
Millipedes, Diplopoda	.03	p	.07	3.5	.03	p
Mayfly, Ephemeroptera	1.48	1.8			1.44	1.7
Dragonfly, Odonata	3.97	30.1	1.00	17.4	3.88	29.2
Mole cricket, Gryllidae	.04	p			.04	p
Field cricket, Gryllidae	.05	p	.04	1.2	.05	p
Cockroach, *Periplanita americana*			.54	2.3	.02	p
Pigmy grasshopper, Tetrigidae	.08	p			.08	p
Cone-headed grasshopper *Neoconocephalus* sp.	.02	p			.02	p
Earwig, Dermaptera	t[2]	p			t	p
Water bug, *Belostoma lutarium*	.26	14.2	.15	7.0	.26	14.0
Giant Water Bug, *Lethocerus americanus*	3.37	20.4	.78	10.5	3.29	20.1
Water boatman, *Corixidae* sp.	.03	1.8			.03	1.7
Water scorpion, *Ranatra buenoi*	t	p			t	p
Creeping water bug, *Pelocoris* sp.	.16	13.3	.01	1.2	.16	12.9
Unidentified bugs	.30	p	t	2.3	.29	p
Dung bettles, Carabidae	t	1.8	1.32	1.2	.05	1.8

Table 1.--Food of White Ibis in southern Florida (Continued)

	Inland Feeding Sites		Coastal Feeding Sites		Total	
	Weight %	Frequency %	Weight %	Frequency %	Weight %	Frequency %
Predacious diving beetle, Dytiscus (adult)	.64	6.9	.26	3.5	.63	7.9
(larvae)	.39	8.0	.04	1.2	.02	7.8
Whirligig beetle. Gyrinidae	.02	.9			.02	p
Water scavenger beetle, Tropisternus lateralis	.32	4.4	.44	5.8	.32	4.4
Water scavenger beetle, Hydrophilus insularis	t	p	t	1.2	t	1.0
Water scavenger beetle, Enochrus perplexus	t	p	.13	1.2	t	1.0
Water scavenger beetle, Neohydrophilus castus	t	p	.19	2.3	t	1.0
Scarab beetles, Scarabidae	t	p			t	p
Ground beetle, Oodes amaroides	t	1.8			t	1.7
Ground beetle, Platynus floridanus	t	p			t	p
Ground beetle, Dynascetus morater	t	p	.15	1.2	t	1.0
Unidentified beetles	.05	9.7	1.39	19.8	.09	10.0
Noctuid larvae, Noctuidae	t	p			t	p
Horsefly larvae, Tabanus sp.	1.30	1.8	2.43	14.0	1.33	2.2
Deerfly, larvae, Chrysops flavidus	.45	p			.44	p
Marshfly, Dictyapictipes sp.			.19	1.2	t	p
Rat-tail maggot, Tubifera sp.			.22	7.0	t	p
Ant, Formicidae	t	p			t	p
Unidentified insect	1.72	10.6	1.20	4.7	1.70	10.4
Apple Snail, Pomacea paludosa	5.28	8.0	t	1.2	5.12	7.8
Pond Snail, Polygyra, sp.	.02	p			.02	p
Orb snail, Helisoma sp.	.86	6.9			.83	6.8
Olivella, Olivella sp.			t	1.2	t	p
Cerith, Cerithidea sp.			t	1.2	t	p
Land snail, Helix sp.	t	p			t	p
Unidentified snail	.96	4.4	t	8.1	.93	5.1
Freshwater clam, Pelecepoda	t	p	.06	3.5	t	1.1
Freshwater mussel, Unionidae	t	p			t	p
Saltwater mussel, Mytilidae			.02	1.2	t	p
Yellow Bullhead, Ictalurus natalis	t	p			t	p
Sheepshead Minnow, Cyprinodon variegatus			5.03	10.5	.15	p

Table 1.--Food of White Ibis in southern Florida (Continued)

	Inland Feeding Sites		Coastal Feeding Sites		Total	
	Weight %	Frequency %	Weight %	Frequency %	Weight %	Frequency %
Golden Topminnow, *Fundulus chrysotus*	.22	p			.21	p
Marsh Killifish *Fundulus confluentus*	.17	p	.33	10.5	.17	1.2
Flagfish, *Jordanella floridae*	.16	p	.17	2.3	.16	p
Redfin Killifish, *Lucania goodei*	t	p			t	p
Rivulus, *Rivulus marmoratus*			.15	1.2	t	p
Least Killifish, *Heterandria formosa*	t	p	.15	3.5	t	p
Mosquitofish, *Gambusia affinis*	.47	2.7	1.49	7.0	.50	2.8
Sailfin Molly, *Poecilia latipinna*	.99	6.2	3.80	16.3	1.08	6.0
Blue-spotted Sunfish, *Enneacanthus gloriosus*	.83	p			.80	p
Warmouth, *Lepomis gulosus*	t	p			t	p
Unidentified fish	16.42	15.0	25.83	47.7	16.70	16.0
Pig Frog, *Rana grylio*	.77	8.0	t	1.2	.75	7.8
Peninsular Newt, *Diemyctylus viridescens*	1.28	9.7	.71	4.7	1.26	9.5
Siren, *Siren intermedia*	.02	p			.02	p
Two-toed Amphiuma, *Amphiuma means*	.03	p			.03	p
Green Anole, *Anolis carolinensis*			.65	2.3	.02	.07
Brown Water Snake, *Natrix taxispilota*	t	p			t	p
Plant	.29	19.5	.39	7.4	.28	19.4
Unidentified	3.45	15.0	5.81	30.2	3.53	15.4

[1]p = less than 1% of samples

[2]t = less than .01% of biomass

Table 2.--Habitat selection by foraging ibises during the nesting season. Data expressed as the percentage of the number of flocks observed on aerial surveys in each of three geographic areas

Coastal habitats

Habitat	% Occurrence
Dwarf mangroves	
dense	0%
open	3%
Mangrove-lined streams	
in streams	0%
at edge	21%
under mangroves	9%
Mangrove-lined ponds	
in pond	6%
at edge	19%
under mangroves	6%
Coastal marshes	0%
Marl prairies	19%
Tidal swamps	
at edge	7%
under mangroves	7%
Tidal shoals	2%
Total # of flocks	108

Interior habitats — Everglades-Big Cypress

Habitat	% Occurrence
Sawgrass marshes	
dense	0%
open	4%
Marsh prairies	
center	20%
edge	27%
Sawgrass-lined ponds	
center	1%
edge	28%
Willow-lined ponds	
center	4%
edge	11%
Canal-edge marshes	5%
Tree islands	0%
Total # of flocks	75

Interior habitats — Lakes region

Habitat	% Occurrence
Marsh prairies	
center	6%
edge	16%
Pastures	56%
Ditches	3%
Lake-edge marshes	19%
Total # of flocks	63

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