Florida Field Naturalist

PUBLISHED BY THE FLORIDA ORNITHOLOGICAL SOCIETY

VOL. 39, NO. 1 MARCH 2011 PAGES 1-34

Florida Field Naturalist 39(1):1-15, 2011.

ANTHROPOGENIC FOOD IN THE DIET OF THE SACRED IBIS (*Threskiornis aethiopicus*), A NON-NATIVE WADING BIRD IN SOUTHEASTERN FLORIDA, USA

LEONARDO CALLE AND DALE E. GAWLIK
Environmental Sciences Program, Florida Atlantic University, Boca Raton, Florida 33431

Abstract.—The Sacred Ibis (*Threskiornis aethiopicus*), is native to sub-Saharan Africa. A small breeding population in southeastern Florida, USA, was established in 1992 and expanded to surrounding natural areas until 2008 when an eradication program was initiated. This study investigated the degree to which the population of Sacred Ibis in South Florida consumes food items derived from human activities which may have contributed to its population expansion. Body measurements, the first such data for this species in North America, were obtained for eight adult males and five adult females. The contents of the esophageal tract and gizzards were used to classify ibis diets (N = 22) as being of anthropogenic origin (derived from human activities) if they contained cheese, meat, paper pulp, and/or pellet meal. The diet of the Sacred Ibis was comprised of predominately anthropogenic food items (58% of the cumulative biomass). Ibises with anthropogenic food items found in their diet consumed more biomass (26.99g ± SE 5.35g) than did birds that contained only natural food items in their diet (8.74g ± SE 2.21g). Natural diets, on average, contained a significantly greater percent vegetative matter (63% ± SE 12%) than did anthropogenic diets (8% ± SE 3%). Novel organic and inorganic items found in anthropogenic diets included bacon, glass, hot dog, pellet meal, and plastic. A cluster analysis revealed that some ibises used anthropogenic food as a primary food source whereas others used it as a supplement to natural food items. This study suggests that human food resources, and the habitats that contain them, may have the ability to support this species' establishment. Further investigation, of ecologically similar species, may elucidate linkages between human food resources in urbanized areas and impacts in nearby natural habitats.

The Sacred Ibis (*Threskiornis aethiopicus*), is endemic to sub-Saharan Africa (del Hoyo et al. 1992), but as a result of anthropogenic influence (e.g., escape from captivity) it has expanded its range to include areas of France, Spain, Italy, and Taiwan (Clergeau and Yesou 2006, Agoramoorthy and Hsu 2007). In its native range, ecological attributes, such as generalist feeding (Clark 1979) and a tendency for symbiotic relationships with humans, have allowed this wading bird to subsist while experiencing habitat loss and disturbance of hydrological patterns in its natural wetland habitat. Successful use of human disturbed landscapes such as agricultural fields, parks, and refuse sites has allowed this species to flourish in areas outside of its native range.

Although many wading bird species use both urban and natural habitats, the Sacred Ibis seems particularly adept at exploiting anthropogenic (derived from human influence) resources, which may have allowed it to overcome the constraints of fluctuating food levels common to wading birds (Ciconiiformes) in wetland ecosystems (Gawlik 2002, Clergeau and Yesou 2006). In France, during 2005, refuse resources and high fecundity resulted in the establishment of a Sacred Ibis breeding population numbering in the thousands (Yesou and Clergeau 2005). A Sacred Ibis congener, the Australian White Ibis (*T. molucca*), established itself in Sydney, Australia, as a result of the successful use of botanical gardens and palm trees for nesting sites (Shaw 1999, Temby 1999). In these instances, wading birds used anthropogenic resources and impacted habitats in both urban and natural areas. Invasive species, such as the Sacred Ibis, can thus serve as a model to elucidate the linkage between urban and natural system dynamics.

It is believed that in North America the Sacred Ibis escaped from zoo aviaries and private collections following the destruction caused by Hurricane Andrew in 1992 (Constantin 2008). Sightings of the species were restricted to urban areas until 2005 when breeding birds were detected in wading bird colonies in the Arthur R. Marshall Loxahatchee National Wildlife Refuge, and other parts of the Everglades region of Florida (Herring et al. 2006). There was concern that the establishment in the Everglades by this large wading bird would put pressure on the larger bodied endangered Wood Stork (*Mycteria americana*), and the smaller bodied White Ibis (*Eudocimus albus*), through nestling predation and resource competition (Williams and Ward 2006, Herring and Gawlik 2008). A modeling study of the species in Florida suggested that there was a 73% chance the bird would become invasive if left to its population trajectory (Herring and Gawlik 2008). An eradication program was initiated by a consortium of government agencies in Florida in 2008 to avoid a case of exponential population growth of the Sacred Ibis as was seen in Europe. Twenty-seven Sacred Ibises were shot, 29 were trapped and pinioned, and two were fitted with solar powered GPS satellite transmitters and released to identify possible unknown roosting and feeding sites (Constantin 2008). The telemetered birds moved only between the Miami Metro Zoo and the Homestead landfill. Subsequently the birds were recaptured and pinioned.

Despite the capacity of the Sacred Ibis for invasiveness and potential impact on natural ecosystems, there has been no investigation into the diet of this species outside of its native range. Our objective was to determine the composition of the diet from 22 Sacred Ibis to determine if anthropogenic food items were commonly consumed and could have therefore contributed to its establishment in Florida. We classified diets of birds, collected during the eradication program, as either anthropogenic or natural based on esophageal and gizzard contents. Based on foraging distances of other wading birds (Kahl 1964, Bancroft et al. 1994, Smith 1995), we assumed that individual Sacred Ibis could use the entire landscape, both in urbanized areas and in natural wetlands. We do not make inferences about habitat use but rather aim to quantify the anthropogenic food that has been reported as supporting this non-native species' successful establishment. By doing so, we link human food resources, and the habitats that contain them, with otherwise distinct natural habitats, such as the greater Everglades. We also report the first body measurements for this species in North America.

MATERIALS AND METHODS

Twenty-two Sacred Ibis carcasses were acquired from the U.S. Department of Agriculture Wildlife Services in 2008. The birds were collected as part of an eradication program overseen by the Everglades Cooperative Invasive Species Management Area (ECISMA) and administered by U.S. Department of Agriculture Wildlife Services. All birds were collected from Miami-Dade, Broward, and Palm Beach Counties. The collection site for an individual bird was not recorded. The 22 Sacred Ibises in our sample taken over a range of 190 km in southeastern Florida (Fig. 1) represented 30% of the estimated population (N = 73) in North America.

Upon collection, the birds were immediately frozen. Within 24 hours of defrost, the contents of the esophageal tract and gizzards were sieved through a 75 μm Fisher Scientific® test sieve, washed, and collected onto filter paper with a particle retention of >20-25 μm; the contents were preserved in 70% ethanol. The total wet mass of the gut-content was obtained to the nearest 0.01 g. For this study, we assumed that the gut content of a bird was a random sample of that bird's diet.

Gut content was visually identified under 10x magnification. Food items were identified to Class, when possible (Table 1). Total biomass and food item % biomass were calculated for individual diets. These measures were summed across all birds to obtain cumulative mass and % biomass. Individual diets were classified as being of anthropogenic origin if they contained any of the following food items: cheese, meat, paper pulp, or pellet meal. Although hair, glass/porcelain, metal, plastic, synthetic fibers, and *Zea mays* (yellow corn) may be indicative of anthropogenic diets these items were not used for diet classification. *Zea mays* was not used as a metric due to difficulties of distinguishing yellow corn from naturally occurring seeds. *Zea mays* biomass was therefore included in the category "seed". Diets were classified as natural if they contained no anthropogenic food items. Anthropogenic food items can be obtained by foraging at refuse sites, landfills, or near areas of human inhabitance (e.g., handouts such as pellet meal or corn). Food items not derived from anthropogenic origin are termed natural food items. The presence of anthropogenic food items in the gut contents did not preclude the presence of natural food items.

Statistical analyses were conducted using SAS Software, version 9.03 (SAS Institute, Inc., Cary, North Carolina). After categorizing the diets by type (e.g., anthropogenic or

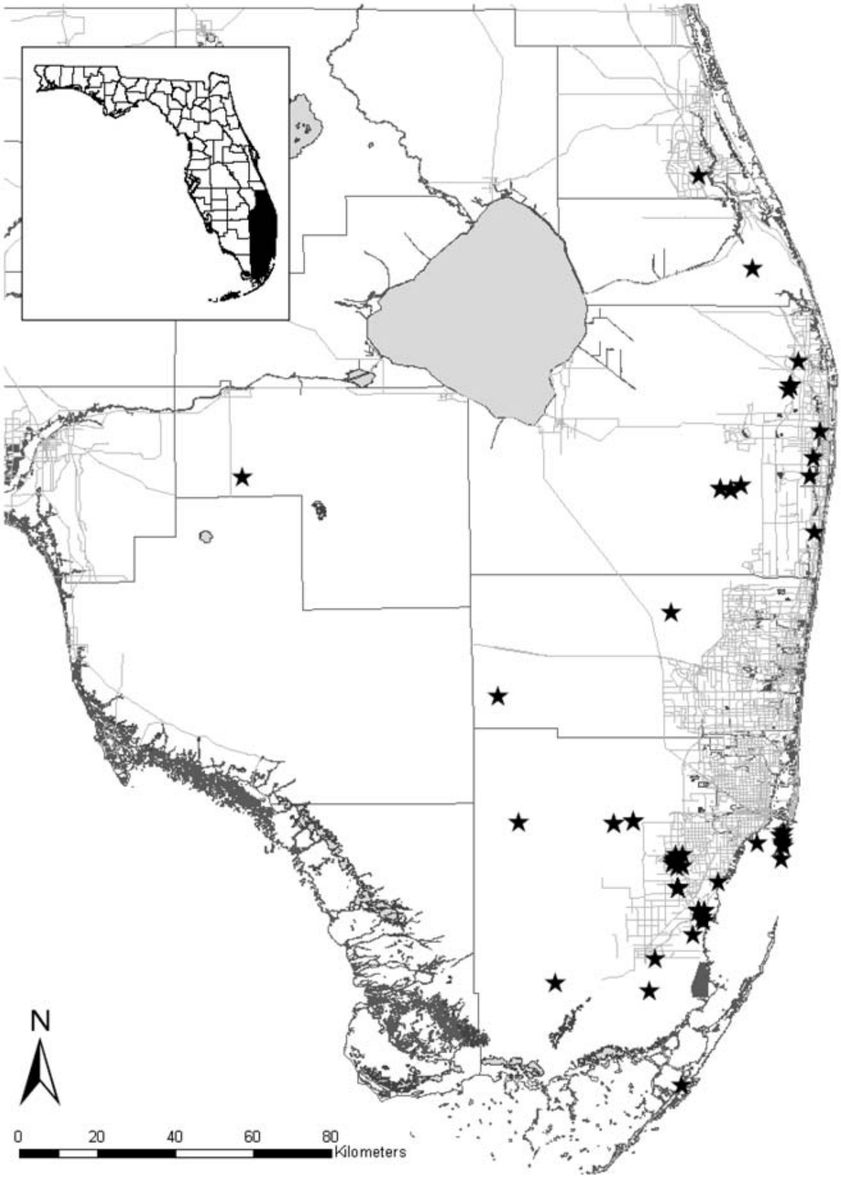

Figure 1. Distribution of Sacred Ibis observations in South Florida, denoted by black stars. Observation data obtained from the Everglades Cooperative Invasive Species Management Area.

Table 1. Pooled gut-content from 22 Sacred Ibises. Food item occurrence and total biomass (g); arranged by % biomass.

Food Item	Occurrence	Biomass (g)	% Biomass
Pellet meal[b]	5	112.28	26.15
Meat[b]	8	77.59	18.07
Seed	17	66.32	15.44
Vegetative matter	22	59.91	13.95
Paper pulp[b]	2	31.74	7.39
Cheese[b]	1	27.6	6.43
Diplopoda	7	13.52	3.15
Coleoptera	17	12.78	2.98
Vegetable/fruit	8	10.48	2.44
Insect larvae	10	9.75	2.27
Malacostraca	3	2.37	0.55
Mollusc	12	1.88	0.44
Insect imago	11	1.58	0.37
Osteichthye	2	1.04	0.24
Small vertebrate	2	0.58	0.14
Rock/pebble	13	0	0.00
Seed (*Zea mays*)[a]	10	0	0.00
Glass/porcelain	10	0	00
Hair	6	0	0.00
Plastic	3	0	0.00
Medium vertebrate	6	0	0.00
Metal	3	0	0.00
Synthetic fibers	2	0	0.00
TOTAL		429.42	100.00

[a]*Zea mays* total biomass is included in category "seed".
[b]Anthropogenic food item.

natural), Kruskal-Wallis tests were conducted using the GLM procedure in the SAS Software to investigate differences in: 1) gut-content biomass per individual between anthropogenic and natural diets and 2) the total biomass of categorized food item (see Appendix A) overlaps between diet types.

In order to determine if our a priori categorization was justified and perhaps identify additional groupings based on diets, we performed agglomerative hierarchical clustering on the diets of individual birds using the CLUSTER technique in the Primer 6 Software (Clarke and Gorley 2006). To give weight to each diet in the analysis, we analyzed the percent contribution of a food item's biomass to its corresponding individual total diet biomass; we also applied a square-root transformation in order to give weight to the low- and intermediary dietary contributors and to down weight otherwise dominant single food items in the diet (Clarke 1993). Dendrograms were then constructed from a resemblance matrix of Bray-Curtis Similarities obtained using the average distance between sample similarities.

A Pesola® Medio-line 2500 g precision scale, with 20 g divisions, was used to obtain body mass (g). SPI ® 2000 150 mm dial calipers are used to obtain measurements of exposed culmen, bill length from gape, and tarsus to the nearest 0.1 mm. An Alvin & Bloomfield 46 cm stainless steel ruler, with a perpendicular stop at zero, was used to record the wing chord. Body measurements were taken as described by Pyle (2008). The right wing and right leg were used for all measurements of wing chord and tarsus, re-

Table 2. Descriptive statistics for the diet analysis. A 90% C.I. for the difference of mean gut-content biomass per individual between diet types is 18.25 g ± 11.52 g (H = 8.44, d.f. = 1, p < 0.01).

	n	Mean gut-content biomass (g) / individual (SE, CV)
Anthropogenic	13	26.99 g (5.30, 70.8)
Natural	9	8.74 g (2.21, 76.0)

spectively, in order to account for any variation between left and right appendages. Individuals were classified as adult or juvenile based on data from plumage characteristics (e.g., presence of neck feathers, gray/brown coloration of plumage tips, molt) as well as general morphology (Clark and Clark 1979). The sex of birds was determined using DNA analysis provided by Zoogen® Inc.

Results

Of the 22 specimens, 13 were identified as having consumed anthropogenic food items and 9 as having consumed only natural food items (Table 2). The food item categories that define an anthropogenic diet (e.g., cheese, meat, paper pulp, pellet meal) comprised 58% of the cumulative gut-content biomass for all Sacred Ibises (Table 2).

Pellet meal was found in only five individuals, although it accounted for 26% of the total biomass (Table 2). The most frequently occurring food item category was vegetative matter, followed by seed, and Coleoptera (Table 2). The "seed" category was preferentially distributed in anthropogenic diets (64% of total seed biomass); however, it is possible that the inclusion of *Zea mays*, an anthropogenic food item in the "seed" category, may have inflated the biomass of natural diets which contain seed. Inorganic items (e.g., glass, plastic, metal) present in the diets may have been inadvertently ingested with organic food items. Although medium vertebrate bones (possibly chicken femora), as well as cartilage, were found in six individuals, these items were not included in the analysis.

A comparison of gut content biomass between diet types showed a larger range (Fig. 2) and mean (Table 2; $H = 8.05$, d.f. = 1, $p < 0.01$) for birds with anthropogenic food items found in their diet than birds with only natural food items in their diet. Natural diets, on average, contained a significantly greater percent vegetative matter (63% ± SE 12%) than anthropogenic diets (8% ± SE 3%) ($H = 8.44$, d.f. = 1, $p < 0.01$). The amount of other food items did not differ significantly between diet types ($p > 0.05$).

Body measurements (Appendix A), were obtained from eight adult male and five adult female Sacred Ibises. Body mass, bill length, tarsus, and wing chord measurements are all larger in males than females. The range of body measurements in this sample set fell within the

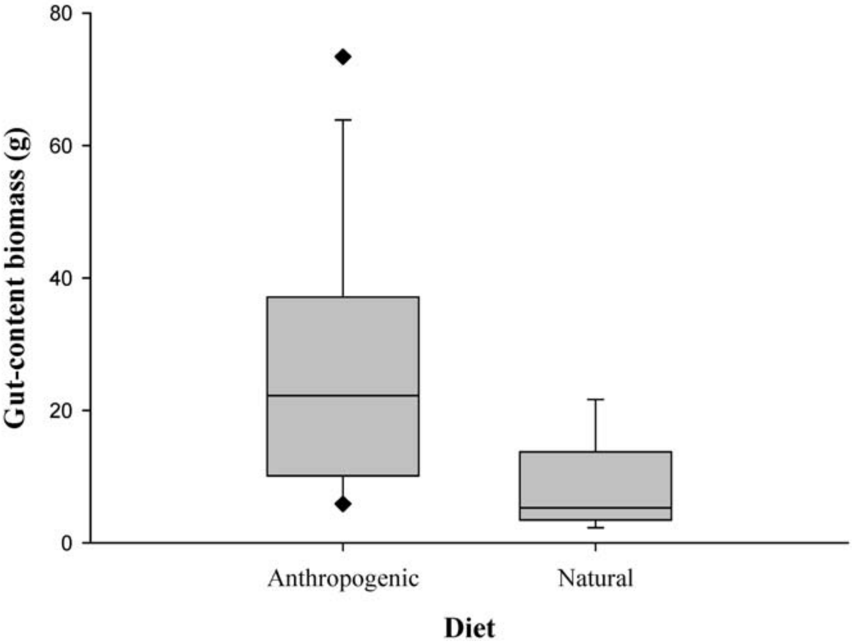

Figure 2. Individual gut-content biomass (g) per anthropogenic (n = 13) or natural diet (n = 9). Whiskers represent the 90th and 10th percentile; outliers are represented by a diamond. The range of gut-content biomass for anthropogenic diets (5.89 g-93.97 g) is larger than natural diets (2.29 g-21.65 g).

range of body measurements reported in the literature for various regions of sub-Saharan Africa (Lowe and Richards 1991). Ten of 13 adults exhibited characteristics associated with breeding (Clark and Clark 1979, del Hoyo et al. 1992), such as a red eye-ring and red coloration on the flesh of the underwing. The characters most accepted to signify breeding, such as a yellow coloration of the auxiliaries and secondary upper coverts, as well as a copper coloration of the tarsus, were present on three males and four females.The cluster technique identified five clusters with 40% similarity (Fig. 3). Diets classified a priori as natural diets clustered tightly (seven of nine diets clustered at 60% similarity) while a priori defined anthropogenic diets formed scattered clusters (Fig. 3) at 40% similarity. Investigation of the anthropogenic diet-clusters revealed that the diets of several birds were dominated by one food item, either anthropogenic or natural food, which accounted for greater than 50% of the individual's total diet biomass. For other individual birds (diet of birds 13, 17, 18, and 22 in Fig. 3), the percent contribution of anthropogenic food to the individual's total diet biomass was less than 50%. While cluster analysis did not affect our a priori

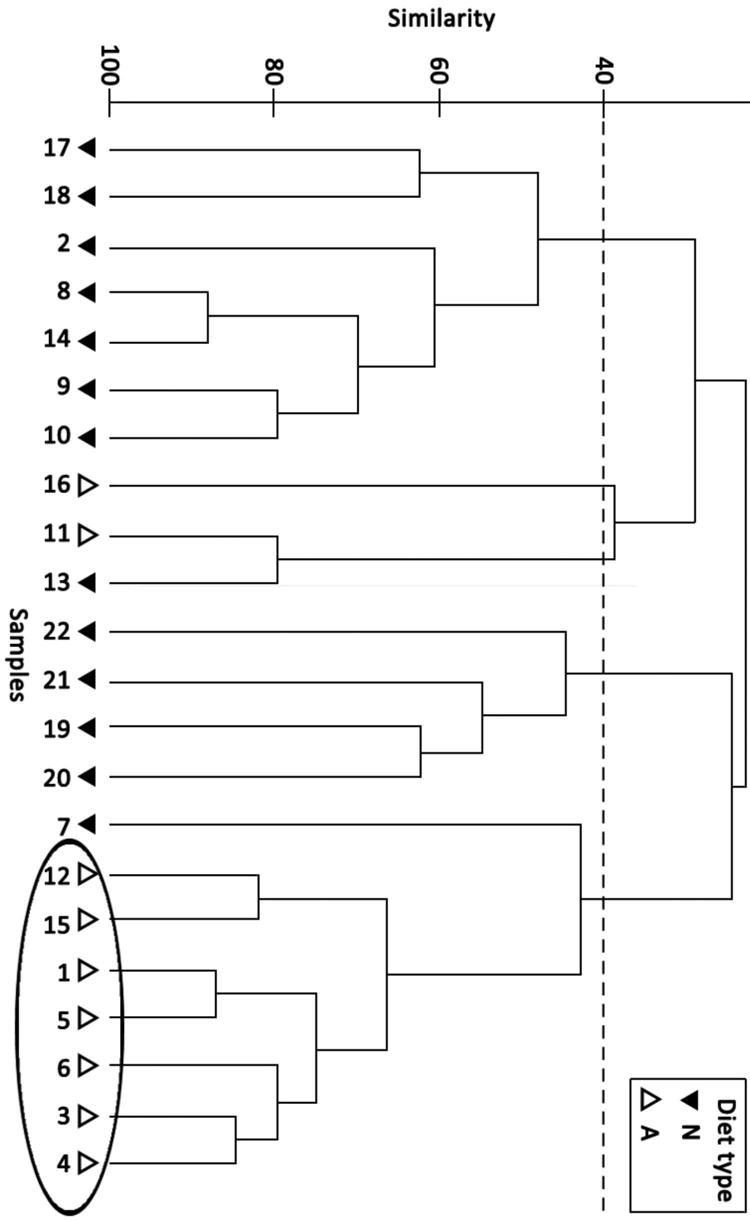

Figure 3. Dendrogram from hierarchical cluster analysis. Bray-Curtis Similarity Index is used for clustering. Samples are standardized to individual totals, and a square-root transformation is applied to the data-set to give weight to all dietary contributors. Solid triangles denote diets with all natural food items whereas outlined triangles denote diets with anthropogenic food items. The ellipse highlights the tight clustering of anthropogenic diets.

categorization of diets, it did reveal a gradient of anthropogenic food biomass in the diets.

The DNA analysis identified 11 females, from which there were 5 adults and 6 juveniles based on the plumage characters. Eleven birds were males, of which 8 were adults and 3 were juveniles. Our sample size did not allow for characterization of sex or age differences in diet.

DISCUSSION

The results of this study underscored the Sacred Ibis's exploitative relationship with humans and its generalist foraging strategy. The large number of birds with anthropogenic food in their diet confirmed that this species is capable of exploiting human landscapes to become established. Some birds consumed primarily anthropogenic food whereas others used it only as a supplement to natural food items. It is not clear whether this species prefers anthropogenic food or whether it simply serves as a buffer when natural food items are scarce.

While this study has categorized ibis into distinct diet types, we may have potentially underestimated the biomass of anthropogenic food consumed by the Sacred Ibis. Kopij et al. (1996) found that Sacred Ibises in South Africa were consuming "natural food" items, imagos of Coleoptera and larvae of Diptera (family Calliphoridae), from anthropogenic sites. These items increased in the diet from 1976 to 1996, which the authors attributed to greater use of anthropogenic foraging areas. It is unknown whether Coleoptera collected from the gut of Sacred Ibises in our study, were obtained in natural habitat or, were actually acquired from anthropogenic habitats. Also, anthropogenic food items are thought to digest quickly (Ottoni et al. 2009); consequently, Sacred Ibises that appeared to consume only natural food, and were categorized as having consumed a natural diet, may have also consumed anthropogenic food.

We detected a greater biomass of food in the anthropogenic diets relative to the natural diets. Although we do not know if this indicates a higher-quality diet, it does suggest that Sacred Ibises commonly ingest novel food items, which could lead to the discovery, by the birds, of new food sources. Such a trait would be advantageous for a species introduced or expanding its range into new habitats.

The notion that some species of birds can adapt to newly available anthropogenic resources has wide support. Landfills in particular have long been known to be a resource opportunity available to avian populations (Burger and Gochfeld 1983, Belant et al. 1993, Bertellotti et al. 2001, Baxter and Allan 2006, Kruszyk and Ciach 2010). Smaller refuse opportunities in human areas, such as development and household trash containers, are able to support large populations of birds, such as corvids (Kristan et al. 2004). Even smaller sources of anthropogenic supplements, such as those provided by bird feeders, have been shown to affect nest initiation and clutch size as well as the length of the nesting period, and have been successfully exploited by North American passerine populations (Robb et al. 2008). The "free ecological niche", as Luniak (2004) describes human-manipulated environments, is an underutilized resource available to those species, native or non-native, that are capable of learning how to exploit this opportunity.

Studies, such as this one, have provided evidence of differential use of anthropogenic and natural food in individuals and populations of birds. A study of foraging Bald Eagles (*Haliaeetus leucocephalus*) in Alaska, for example, revealed that there may be refuse specialists within populations, and these resources may be used differentially between species (Elliot et al. 2006). Some populations that do exploit anthropogenic resources do so seasonally. Black Kites (*Milvus migrans*) in Spain have shown higher consumption of anthropogenic food (refuse) during the non-breeding season while shifting toward a more natural diet when breeding (Blanco 1997). Exactly how differences of nutrition between anthropogenic and natural food may affect avian demographics, and even physiology or morphology, will require additional research (Tortosa et al. 2002, Campbell et al. 2003, Auman 2008, Kruszyk and Ciach 2010).

There are conflicting reports on the effects of anthropogenic food on the nesting success of breeding birds. A study of White Stork (*Ciconia ciconia*) populations in Spain showed that birds using anthropogenic resources during the breeding season had higher nesting success than did those birds at control sites (Tortosa et al. 2002). In contrast, a mixed colony of wading birds, observed foraging at a landfill in Palm Beach County, Florida, had reproductive rates similar to those of other colonies in the region (Rumbold et al. 2009). Thus, the question remains about the degree of integration of anthropogenic food into the diets of free-ranging birds, but evidence that it is occurring is mounting.

This study suggests that human food resources, and the habitats that contain them, may have the ability to support the establishment of the Sacred Ibis in South Florida. It has been shown that anthropogenic pressure has modified natural processes in many parts of the globe (Vitousek et al. 1997a, Vitousek et al. 1997b, Masero 2003, Ludynia et al. 2005, Ellis and Ramankutty 2008), so if restoration of impacted natural areas, like the Everglades, is to be successful, urban habitats and their resources should be considered for their potential influence on natural ecosystem dynamics. Further investigation, of ecologically similar species, may elucidate linkages between food resources in urbanized areas and impacts in nearby natural habitats.

ACKNOWLEDGMENTS

This work was supported by the National Science Foundation Undergraduate Research & Mentoring program and the Avian Ecology Laboratory at Florida Atlantic University. We are indebted to Toby Harrison, Michael Avery, and the staff at the United States Department of Agriculture, Wildlife Services. We are especially grateful for actions taken by Skip Snow at Everglades National Park and the ECISMA team to avert the development of another threat to a greatly stressed ecosystem and areas beyond it. Michelle Petersen provided edits and conversation contributing to this manuscript. Much appreciation is given to Evelyn Frazier, Rod Murphey, and Laura Macesic for their mentoring. We thank the members of the FAU Avian Ecology Laboratory for their insight.

LITERATURE CITED

AGORAMOORTHY, G., AND M. HSU. 2007. Ritual releasing of wild animals threatens island ecology. Human Ecology 35:251-254.

AUMAN, H. 2008. The Effects of Anthropogenic Food on the Body Condition, Biochemistry, Stable Isotopes and Egg Quality of Silver Gulls in Tasmania. Doctoral Thesis, School of Zoology, University of Tasmania.

BANCROFT, G. T., A. M. STONG, R. J. SAWICKI, W. HOFFMAN, AND S. D. JEWELL .1994. Relationships Among Wading Bird Foraging Patterns, Colony Locations, and Hydrology in the Everglades. Pages 615-657 *in* Everglades. The Ecosystem and Its Restoration (S. M. Davis and J. C. Ogden, Eds.). St. Lucy Press, Boca Raton, Florida.

BAXTER, A., AND J. ALLAN. 2006. Use of raptors to reduce scavenging bird numbers at landfill sites. Wildlife Society Bulletin 34:1162-1168.

BELANT, J., T. SEAMANS, S. GABREY, AND S. ICKES. 1993. Importance of landfills to nesting Herring Gulls. Condor 95:817-830.

BERTELLOTTI, M., P. YORIO, G. BLANCO, AND M. GIACCARDI. 2001. Use of tips by nesting Kelp Gulls at a growing colony in Patagonia. Journal of Field Ornithology 72:338-348.

BLANCO, G. 1997. Role of refuse as food for migrant, floater and breeding Black Kites (*Milvus migrans*). Journal of Raptor Research 31:71-76.

BURGER, J., AND M. GOCHFELD. 1983. Behavior of nine avian species at a Florida garbage dump. Colonial Waterbirds 6:54-63.

CAMPBELL, P., A. HONTELA, J. RASMUSSEN, A. GIGUÈRE, A. GRAVEL, L. KRAEMER, J. KOVESCES, A. LACROIX, H. LEVESQUE, AND G. SHERWOOD. 2003. Differentiating between direct (physiological) and food-chain mediated (bioenergetic) effects on fish in metal-impacted lakes. Human and Ecological Risk Assessment 9:847-866.

CLARKE, K. R. 1993. Non-parametric multivariate analyses of changes in community structure. Australian Journal of Ecology 18:117-143.

CLARKE, K. R., AND R. N. GORLEY. 2006. PRIMER v6: User Manual/Tutorial. PRIMER-E, Plymouth.

CLARK, R. 1979. The food of the Sacred Ibis at Pretoria, Transvaal. Ostrich 50:104-111.

CLARK, R. A. AND A. CLARK. 1979. Daily and seasonal movements of the Sacred Ibis at Pretoria, Transvaal. Ostrich 50:94-103.

CLERGEAU, P., AND P. YESOU. 2006. Behavioural flexibility and numerous potential sources of introduction for the sacred ibis: causes of concern in western Europe. Biological Invasions 8:1381-1388.

CONSTANTIN, B. 2008. Invasive Species—Sacred Ibis Removal. Final Report of the Everglades Cooperative Invasive Species Management Area to the Everglades Foundation. Everglades Foundation, Palmetto Bay, Florida.

ELLIOT, K., J. DUFFE, S. LEE, P. MINEAU, AND J. ELLIOT. 2006. Foraging ecology of Bald Eagles at an urban landfill. The Wilson Journal of Ornithology 118:380-390.

Ellis, E., and N. Ramankutty. 2008. Putting people in the map: anthropogenic biomes of the world. Frontiers in Ecology and the Environment 6:439-447.

del Hoyo, J., A. Elliott, and J. Sargatal, Eds. 1992. Handbook of the Birds of the World Vol. 1. Lynx Edicions, Barcelona.

Gawlik, D. E. 2002. The effects of prey availability on the numerical response of wading birds. Ecological Monographs 72:329-346.

Herring, G., E. Call, and M. Johnston. 2006. A non-indigenous wading bird breeding in the Florida Everglades: the Sacred Ibis. Florida Field Naturalist 34:4-8.

Herring, G., and D. E. Gawlik. 2008. Potential for successful population establishment of the nonindigenous sacred ibis in the Florida Everglades. Biological Invasions 10:969-976.

Kahl, M. P., Jr. 1964. Food ecology of the Wood Stork (*Mycteria americana*) in Florida. Ecological Monographs 34:97-117.

Kopij, G., O. Kok, and Z. Roos. 1996. Food of Sacred Ibis *Threskiornis aethiopicus* nestlings in the Free State province, South Africa. Ostrich 67:138-143.

Kristan, W. III, W. Boarman, and J. Crayon. 2004. Diet composition of common ravens across the urban-wildland interface of the West Mojave Desert. Wildlife Society Bulletin 32:244-253.

Kruszyk, R., and M. Ciach. 2010. White Storks, *Ciconia ciconia*, forage on rubbish dumps in Poland—a novel behaviour in population. European Journal of Wildlife Research 56:83-87.

Lowe, K. W., and G. C. Richards. 1991. Morphological variation in the Sacred Ibis *Threskiornis aethiopicus* superspecies complex. Emu 91:41-45.

Luniak, M. 2004. Synurbization–adaptation of animal wildlife to urban development. Pages 50-55 *in* Proceedings of the 4th International Symposium on Urban Wildlife Conservation (W. W. Shaw, L. K. Harris, and L. VanDruff, Eds.). University of Arizona, Tucson.

Ludynia, K., S. Garthe, and G. Luna-Jorquera. 2005. Seasonal and regional variation in the diet of the Kelp Gull in northern Chile. Waterbirds 28:359-365.

Masero, J. 2003. Assessing alternative anthropogenic habitats for conserving waterbirds: Salinas as buffer areas against the impact of natural habitat loss for shorebirds. Biodiversity and Conservation 12:1157-1173.

Ottoni, I., F. De Oliveira, and R. Young. 2009. Estimating the diet of urban birds: The problems of anthropogenic food and food digestibility. Applied Animal Behaviour Science 117:42-46.

Pyle, P. 2008. Identification Guide to North American Birds. Part II: Anatidae to Alcidae. Slate Creek Press, Point Reyes Station, California.

Robb, G., R. Mcdonald, D. Chamberlain, and S. Bearhop. 2008. Food for thought: Supplementary feeding as a driver of ecological change in avian populations. Frontiers in Ecology and the Environment 6:476-484.

Rumbold D., M. Morrison, and M. Bruner. 2009. Assessing the ecological risk of a municipal solid waste landfill to surrounding wildlife: A case study in Florida. Environmental Bioindicators 4:246-279.

Shaw, P. 1999. Integrated management systems for Australian White Ibis *(Threskiornis molucca)* on the Gold Coast, Queensland, Australia. Bird Strike Committee Proceedings. 1999 Bird Strike Committee-USA/Canada, First Joint Annual Meeting. University of Nebraska, Lincoln.

Smith, J. P. 1995. Foraging flights and habitat use of nesting wading birds (Ciconiiformes) at Lake Okeechobee, Florida. Colonial Waterbirds 18:139-158.

Temby, I. 1999. Urban wildlife issues in Australia. Pages 26-34 *in* Proceedings of the 4th International Symposium on Urban Wildlife Conservation. (W. W. Shaw, L. K. Harris, and L. VanDruff, Eds.). University of Arizona, Tucson.

TORTOSA, F., J. CABALLERO, AND J. REYES-LÓPEZ. 2002. Effect of rubbish dumps on breeding success in the White Stork in southern Spain. Waterbirds 35:39-43.

VITOUSEK, P., C. D'ANTONIO, L. LOOPE, M. REJMANEK, AND R. WESTBROOKS. 1997a. Introduced species: a significant component of human-caused global change. New Zealand Journal of Ecology 21:1-16.

VITOUSEK, P., H. MOONEY, J. LUBCHENCO, AND J. MELILLO. 1997b. Human domination of Earth's ecosystems. Science 277:494.

WILLIAMS, A., AND V. WARD. 2006. Sacred Ibis and Gray Heron predation of Cape Cormorant eggs and chicks; and a review of ciconiiform birds as seabird predators. Waterbirds 29:321-327.

YESOU, P., AND P. CLERGEAU. 2005. Sacred Ibis: A new invasive species in Europe. Birding World 18:517-526.

Appendix A. Food item categories and descriptions.

Food Item category	Description
Arthropod	Coleoptera (beetle), Diplopoda (common millipede, *Narceus americanus*), Insect imago, Insect larvae, Malacostraca (crayfish)
Cheese[a]	White, identified by consistency, differing from vegetative matter
Fish	Subclass Osteichthye, identified by gills & vertebrae
Meat[a]	Shredded meat, bacon strips, hot dog, unknown origin meat
Mollusc	Entire shell, fragments
Paper pulp[a]	Printed paper pulp with organic matter
Pellet Meal[a]	Entire, circular, dissolved
Seed	*Zea mays* (yellow corn), unidentified seed, seed embryo, seed coat
Small Vertebrate	Bone, cartilage
Vegetable/Fruit	Carrot shavings, slices
Vegetative Matter	Grass, wood, filamentous algae, leafy matter, cellulose fibers

[a]Anthropogenic food item.

Appendix B. Summary body measurements for 13 adult Sacred Ibises. Body measurements were taken as described by Pyle (2008).

		Body mass (g)	Bill length to gape (mm)	Exposed culmen (mm)	Bill depth (mm)	Tarsus length (mm)	Wing chord (mm)	Tail length (mm)
Male	mean	1638	159.6	161.9	30.93	99.79	380.2	140.9
	range	1510-1810	144-175	149-175	27-32	95-104	374-390	132-148
	SD	94.1	9.9	8.6	0.7	3.2	9.6	5.6
	CV %	5.75	6.22	5.33	2.35	3.18	2.53	3.95
	n	8	8	8	8	8	8	8
Female	mean	1360	124.0	129.0	27.83	87.90	354.4	133.0
	range	1320-1420	100-135	105-139	27-30	82-94	339-361	123-139
	SD	42.4	17.8	17.5	2.2	7.3	13.3	6.8
	CV %	3.12	14.38	13.59	7.88	8.26	3.76	5.12
	n	5	5	5	5	5	5	5