Food Habits of Three Bird Species on Phosphate-mine Settling Ponds and Natural Wetlands[1]

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Abstract: Common moorhens (*Gallinula chloropus*), double-crested cormorants (*Phalacrocorax auritus*), and mottled ducks (*Anas fulvigula*) were collected from phosphate-mine settling ponds and natural wetlands in north and central Florida between June and October 1981. Contents of esophagi, proventriculi, and stomachs were removed from 185 birds, identified, and measured by volumetric displacement. Aggregate percentages of food items in diets were compared between settling ponds and natural wetlands. Rank order of items in moorhen diets differed among the 2 habitats. Plant foods comprised at least 80% of moorhen diets on both habitats. Cormorants primarily consumed the same species of fish on settling ponds and natural areas. However, high numbers of mosquito fish (*Gambusia affinis*) and small invertebrates were consumed on the settling ponds but not on the natural wetlands. Mottled duck diets from settling ponds and natural wetlands in central Florida were not positively correlated based on rankings of food items. A diversity of both plant and animal species were consumed by these ducks. Mottled duck diets included 27% animal matter on settling ponds and 50% animal matter on natural wetlands.

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Wildlife habitats in Florida include nearly 17 million acres of wetlands and water bodies (Chamberlain 1960). These wetlands have suffered losses

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and degradation as a result of drainage to accommodate human population growth, agriculture, industrial development, and mining. Recent regulations of the Florida Department of Natural Resources (Chapter 16C-16 Mine Reclamation) offer opportunities to partially offset the trend of wetland loss by requiring that wetlands providing wildlife habitat values be created in phosphate-mine reclamation.

Information concerning ecological requirements of wetland wildlife is important for designing functional wetlands with positive habitat values. This paper concerns the food habits of 3 species of wetland birds resident on phosphate-mined lands including common moorhens, double-crested cormorants, and mottled ducks.

With the exception of a paper by Simpson (1939), quantitative analyses of common moorhen food habits in the United States are lacking. Food habits of double-crested cormorants in freshwater habitats apparently have not been described in the southeastern United States. McLeod and Bondar (1953) and Roney (1979) described cormorant diets on freshwater lakes in Manitoba and Saskatchewan, respectively. Lewis (1929), Behle (1958), and Mitchell (1977) reported food habits of adults or young on freshwater lakes in Utah.

Diets of mottled ducks have been more adequately described. Martin et al. (1951) listed important plant and animal foods of the species. Food habits of mottled ducks in Florida have been reported by McAtee (1918), Beckwith and Hosford (1955, 1957), Stieglitz (1972), Montalbano et al. (1978), and Montalbano (1980).

In this paper we provide food-habits data from 185 birds collected on phosphate-mined and natural wetlands in north and central Florida. This information should provide a useful comparison for evaluating ecological relationships of the 3 species studied and for planning reclamation goals for phosphate-mined lands. Establishment of wetland plant and animal species important as food items for wildlife should enhance wildlife habitat in phosphate mine reclamation.

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Methods

Phosphate-mine settling ponds are diked impoundments used for storing and dewatering waste clays. Phosphatic clays are separated from the phosphate ore during the beneficiation process. These clays are pumped into settling ponds as a clay/water slurry. The clays are consolidated through subsequent settling and decanting of supernatant water. The process of introducing clays and subsequent dewatering may continue for the 15 to 20 year life of the settling pond.

Vegetative characteristics depend on the age and management history of settling ponds. Vegetation on younger ponds is typically dominated by cattails (*Typha* sp.) with emergents such as bulrush (*Scirpus* sp.), rushes (*Juncus* sp.) and creeping marshpurslane (*Ludwigia repens*) also being present. Older ponds with more consolidated clays are characterized by dense stands of willow (*Salix* sp.), wax myrtle (*Myrica cerifera*), and saltbush (*Baccharis halimifolia*) (Cornwell and Atkins 1980, Gilbert et al. 1981).

Birds were collected from settling ponds with early- to mid-successional vegetative characteristics. North Florida study sites included 5 settling ponds on the Suwannee River Mine of Occidental Chemical Company (OXY), Hamilton County. In Polk County, Florida, 5 settling ponds on Agrico Mining Company's Fort Green and Payne Creek mines, and 4 settling ponds on International Minerals and Chemical Corporation's (IMC) Noralyn and Clear Springs mines were used.

Natural wetlands were selected for collection sites which were near phosphate mining regions of north and central Florida, yet were separated by sufficient distance to minimize inter-area movements of birds. Newnan's and Orange Lakes in Alachua County were sampled in north Florida. Lake Kissimmee, Osceola County, was selected as a natural wetland in central Florida.

Newnan's Lake had a surface area of 2,433 ha and a mean depth of 1.5 m (Shannon and Brezonik 1972). It was a cypress-fringed lake with scattered patches of cowlily (*Nuphar luteum*) and American lotus (*Nelumbo lutea*). The dominant submerged macrophyte was coontail (*Ceratophyllum demersum*).

Orange Lake had a mean depth of 2.9 m and a surface area of 4,921 ha. Percent cover of major aquatic vegetation in 1981 was 48.6% for cowlily, 28.2% for hydrilla (*Hydrilla verticillata*), and 0.4% for maidencane (*Panicum hemitomon*). Additional plant species included coontail, bladderwort (*Utricularia* sp.), and naiad (*Najas* sp.) (D. Colle, pers. commun.).

Lake Kissimmee included approximately 12,500 ha surrounded by maidencane marsh. Cowlily, American lotus, common pickerelweed (*Pontederia cordata*), and fragrant water lily (*Nymphaea odorata*) were common

emergents. Pondweed (*Potamogeton* sp.), American wild celery (*Vallisneria americana*) and a variety of other submerged plants were common.

Common moorhens, double-crested cormorants, and mottled ducks were collected from these lakes between June and October 1981 as part of a study to assess toxic and radioactive trace element levels in birds from phosphate-mine settling ponds and natural wetlands. A minimum of 15 birds of each species with food items in their digestive tracts were collected from settling ponds and natural wetlands in north and central Florida (Table 1). Mottled ducks are uncommon in north Florida and were only collected on central Florida study sites (Agrico, IMC, Lake Kissimmee).

Birds were collected using steel shot and were immediately frozen on dry ice. Upper gastrointestinal tracts were not injected with preservatives or removed in the field to avoid contamination of tissues needed for trace-element assays. Esophagi, proventriculi, and stomachs were subsequently removed in the laboratory. Contents of these organs were separated and identified as specifically as possible. Volumes of each taxa were measured by volumetric displacement; volumes <0.01 ml were recorded as "trace." Small volumes of food items in esophagi precluded segregating esophageal contents from gizzard contents as suggested by Swanson and Bartonek (1970).

Data from north and central Florida birds were pooled separately for settling ponds and natural wetlands to facilitate comparisons between these habitats. Percent frequency of occurrence, aggregate volume (percentage of total volume), and aggregate percentage (mean of volumetric percentages) were calculated for each food item for each bird species and habitat (Swanson et al. 1974). Birds with only trace amounts in their upper gastrointestinal tracts were excluded from aggregate volume and aggregate percentage estimates. Rank orders of aggregate percentages were compared between

Table 1. Numbers of 3 Bird Species Collected from Study Sites in North and Central Florida, June–October 1981

Collection Site	Species		
	Common Moorhen	Double-Crested Cormorant	Mottled Duck
Settling ponds			
OXY	20	18	
Agrico	12	10	16
IMC	10	8	4
Natural wetlands			
Orange Lake	19		
Newnan's Lake		16	
Lake Kissimmee	21	15	16
Total	82	67	36

habitats using Spearman's coefficient of rank correlation (Steel and Torrie 1960:409). Shannon-Weaver indices of diversity (Shannon and Weaver 1963) were calculated using aggregate percentages of identified food items occurring in greater than trace amounts for comparison between habitats.

Results and Discussion

Common moorhens from both habitats consumed more plant than animal matter (Table 2), however, diet composition differed and rankings of food items were not correlated ($r = 0.20$, $P = 0.15$) between habitats. Birds in both habitats consumed terrestrial, emergent, and submergent vegetation with 20 plant species identified in diets on settling ponds and 18 species in diets on natural areas. Only 8 of 30 plant species consumed were common to moorhen diets in both habitats. Bahia-grass (*Paspalum notatum*) and hydrilla, both introduced species, were the top food items on settling ponds and natural areas, respectively. Bahia-grass seeds were apparently obtained from the artificially planted settling pond embankments. Pooling of food items in esophagi and gizzards may have inflated the importance of hard food items, such as seeds, in these analyses (Swanson and Bartonek 1970).

Although moorhens consumed more animal taxa on settling ponds than on natural wetlands (16 versus 6), birds on natural wetlands consumed a greater proportion of animal matter in their diets. *Planorbella* (snails) was the second most abundant taxon consumed on natural wetlands. Diet diversity was greater on settling ponds than on natural wetlands as a result of both the consumption of a greater number of plant and animal taxa and a more even distribution of the diet among these taxa.

Ranks of food items consumed by cormorants were correlated between habitats ($r = 0.70$, $P = 0.003$). All fish consumed by cormorants on settling ponds also were consumed on the natural wetlands with the exceptions of mosquitofish (*Gambusia affinis*) and killifish (*Fundulus* sp.) (Table 3). Cormorants from settling ponds, however, consumed a greater diversity of food items and relied more heavily on smaller fishes and invertebrates. Mosquitofish, a small minnow, was the dominant food item on settling ponds. Several species of insects and other small invertebrates also were eaten on settling ponds but were absent from diets of birds on natural wetlands. The only invertebrate included in diets on natural wetlands was the crayfish (Decapoda). This appreciable utilization of invertebrates by cormorants on settling ponds has not, to our knowledge, previously been reported for cormorants in freshwater habitats.

Ranks of mottled duck food items were weakly but negatively correlated ($r = -0.34$, $P = 0.03$) between settling ponds and natural wetlands. Diets on both habitats included a diversity of plant and animal matter (Table 4).

Table 2. Food Habits of Common Moorhens on Study Areas in North and Central Florida, June–October, 1981

Food Item		Parts	Settling Ponds			Natural Wetlands		
Scientific Name	Common Name		% Occurrence $n = 42$	Aggregate Volume $n = 39$	Aggregate % $n = 39$	% Occurrence $n = 40$	Aggregate Volume $n = 40$	Aggregate % $n = 40$
Plants								
Paspalum notatum	Bahia-grass	S[a]	35.7	23.9	17.2	2.5	1.1	0.5
Oedogonium sp.	Green algae	V	14.3	7.4	10.7	2.5	1.1	1.5
Panicum sp.	Panic grass	S	11.9	6.3	7.3			
Utricularia vulgaris	Common bladderwort	V	14.3	12.9	7.1			
Lemna minor	Common duckweed	V	11.9	7.1	6.5			
Hydrilla verticillata	Hydrilla	V	7.1	6.2	5.3	52.5	48.6	43.1
Typha sp.	Cattail	S, V	7.1	4.5	4.5			
Scirpus sp.	Bulrush	S	7.1	2.7	2.7	7.5	0.3	1.3
Ludwigia repens	Creeping marshpurslane	V	2.4	0.7	2.6			
Sagittaria subulata	Dwarf arrowhead	V	2.4	0.9	2.6			
Nuphar luteum	Cowlily	S	4.8	0.6	1.8	2.5	T[b]	T
Vallisneria americana	American wild celery	S				15.0	17.8	10.9
Hydrochloa carolinensis	Common watergrass	V				12.5	5.0	7.7
Nymphaea odorata	Fragrant waterlily	S, V				17.5	2.8	4.9
Ceratophyllum demersum	Common hornwort	V				2.5	1.0	2.1

	Other plant taxa[c]	52.4	1.1	2.4	35.0	4.4	3.1
	Unidentifiable plant material	26.2	7.4	17.3	25.0	4.3	4.9
	Total plant material		81.7	88.0		86.4	80.0
Animals							
Plumatella sp.	Bryozoids	9.5	11.9	5.7			
Chironomus sp.	Midge larvae	23.8	1.8	2.2	2.5	T	T
Coleoptera	Beetles	2.4	0.1	0.2	5.0	0.3	1.3
Planorbella sp.	Snails				65.0	13.7	16.3
	Other animal taxa[c]	33.3	3.8	2.7	20.0	0.7	1.8
	Unidentifiable insect material	28.6	0.5	1.3	12.5	0.4	0.9
	Total animal material		18.1	12.1		15.1	20.3
Diversity (H')/Evenness (J)				2.60/0.78			1.83/0.60

[a] S = seeds, V = stems and leaves.
[b] T = trace, <0.1%.
[c] Taxa with aggregate percentages ≤ 0.8%. A complete list is available from the authors.

Table 3. Food Habits of Double-Crested Cormorants on Study Areas in North and Central Florida, June–October 1981

Food Item		Settling Ponds			Natural Wetlands		
Scientific Name	Common Name	% Occurrence $n = 36$	Aggregate Volume $n = 36$	Aggregate % $n = 36$	% Occurrence $n = 31$	Aggregate Volume $n = 31$	Aggregate % $n = 31$
Gambusia affinis	Mosquitofish	36.1	14.6	27.6			
Dorosoma sp.	Shad	25.0	22.0	22.4	41.9	51.5	39.7
Ictalurus nebulosus	Brown bullhead	25.0	20.9	22.1	9.7	9.6	9.7
Lepomis sp.	Sunfish	11.1	22.1	8.4	12.9	21.5	12.9
Pomoxis nigromaculatus	Black crappie	11.1	8.6	5.4	6.5	2.4	5.4
Notemigonus crysoleucas	Golden shiner	2.8	2.3	2.8	3.2	13.0	3.2
Palaemonidae	Prawns	5.6	T[a]	1.5			
Aeschnidae	Darner nymphs	8.3	0.1	1.2			
Fundulus sp.	Killifish	2.8	1.7	1.0			
Planaria sp.	Flatworms	2.8	T	0.2			
Libellulidae	Dragonfly nymphs	2.8	0.1	0.1			
Chironomus sp.	Midge larvae	19.4	T	T			
Corixidae	Water boatmen	2.8	T	T			
Decapoda	Crayfish	2.8	T	T			
	Unidentifiable fish material	11.1	7.4	7.1	29.0	2.0	29.0
	Unidentifiable insect material	8.3	0.1	0.5			
Diversity (H')/Evenness (J)				1.73/0.72			1.24/0.77

[a] T = trace, <0.1%.

Table 4. Food Habits of Mottled Ducks on Study Areas in Central Florida, June–October, 1981

Food Item			Settling Ponds			Natural Wetlands		
Scientific Name	Common Name	Parts	% Occurrence $n = 20$	Aggregate Volume $n = 19$	Aggregate % $n = 19$	% Occurrence $n = 16$	Aggregate Volume $n = 16$	Aggregate % $n = 16$
Plant								
Polygonum sp.	Smartweed	S, V[a]	85.0	36.9	27.4	56.3	0.8	1.7
Myrica cerifera	Southern wax myrtle	S	35.0	1.5	11.0	81.3	2.6	6.8
Scirpus sp.	Bulrush	S	60.0	10.7	7.2	12.5	T[b]	T
Oedogonium sp.	Green algae	V	15.0	0.9	3.9			
Lemna sp.	Common duckweed	V	20.0	9.6	2.8			
Phytolaca americana	Common pokeberry	S	5.0	3.8	0.8			
Paspalum notatum	Bahia-grass	S	15.0	0.2	0.3			
Vallisneria americana	American wild celery	S				37.5	18.4	13.3
Nymphaea odorata	Fragrant water lily	S				18.8	12.5	6.2
Nuphar luteum	Cowlily	S, V				6.3	0.5	0.9
Gramineae	Grasses	V	5.0	0.9	2.3			
	Other plant taxa[c]		25.0	T	0.1	31.3	0.1	0.1
	Unidentifiable plant material		30.0	11.9	17.1	43.8	30.6	21.9
	Total plant material			76.4	72.9		65.5	50.9
Animal								
Hydrophilidae	Water scavenger beetle		25.0	2.6	11.8			

Table 4. continued

Food Item			Settling Ponds			Natural Wetlands		
Scientific Name	Common Name	Parts	% Occurrence $n = 20$	Aggregate Volume $n = 19$	Aggregate % $n = 19$	% Occurrence $n = 16$	Aggregate Volume $n = 16$	Aggregate % $n = 16$
Libellulidae	Dragonfly nymphs		20.0	5.5	8.8			
Chironomus sp.	Midge larvae		15.0	11.7	4.5	6.3	0.5	1.2
Dytiscidae	Predaceous diving beetles		10.0	0.9	0.2	6.3	0.1	0.6
Physella sp.	Pouch snail		5.0	0.2	0.1	6.3	0.1	0.9
Planorbella sp.	Snails					81.3	20.4	27.8
Pomacea paludosa	Apple snails					12.5	5.7	9.3
Viviparus georgiana	Clams					31.3	2.7	4.4
Acrididae	Short-horned grasshoppers					12.5	4.2	3.4
Haliplidae	Crawling water beetles					6.3	0.1	1.1
Planaria sp.	Flatworms					12.5	0.4	0.4
Berosus sp.	Predaceous diving beetles					6.3	0.1	0.3
	Other animal taxa[c]		15.0	0.2	0.1	18.8	T	T
	Unidentifiable animal material		25.0	2.6	1.7	18.8	0.1	T
	Total animal material			23.7	27.2		34.4	49.5
Diversity (H')/Evenness (J)					2.00/0.74			2.04/0.72

[a] S = seeds, V = stems and leaves.
[b] T = trace, <0.1%.
[c] Taxa with aggregate percentages ≦ 0.1%. A complete list is available from the authors.

Ducks on settling ponds consumed 15 plant species and 11 animal taxa; ducks on natural wetlands consumed 11 plant species and 13 animal taxa. Only 6 of the plant species and 4 of the animal taxa consumed were common to the diets in the 2 habitats. Settling pond ducks consumed a greater percentage of plant material than ducks on the natural wetlands. Plant materials eaten on the natural area were primarily composed of seeds, whereas vegetative parts of green algae (*Oedogonium* sp.), duckweed (*Lemna* sp.), and grasses (Graminae) were important in mottled duck diets on settling ponds.

Our results, and those of other authors (McAtee 1918; Beckwith and Hosford 1955, 1957; Montalbano et al. 1978), show that mottled ducks are able to consume a diversity of plant and animal species and that diets differ on different areas. The high proportion of animal matter found in Florida duck diets is apparently due to the season in which birds were collected. Beckwith and Hosford (1955, 1957) found greater proportions of animal matter were eaten by Florida ducks during summer than winter months.

These food habits data must be interpreted with caution. Preponderance of a food item in a bird's diet on a man-made settling pond may represent either a preference for that item or the absence of preferred food items that are found on natural wetlands. For example, use of terrestrial bahia-grass by common moorhens on settling ponds may be in response to a deficiency of preferred aquatic plant species. Consumption of small vertebrates and invertebrates by cormorants may indicate a shortage of desirable size classes of fish in settling ponds. However, both moorhens and cormorants are abundant on settling ponds in north and central Florida (Maehr 1980, Gilbert et al. 1981), and mottled ducks are frequently observed using settling ponds in central Florida (Montalbano et al. 1978, Gilbert et al. 1981). These 3 bird species are apparently able to successfully adapt to differing availabilities of forage items. Creation of wetlands through phosphate-mine reclamation which produce a diversity of preferred food items will provide positive habitat values for these bird species.

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