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MID-WINTER FOOD USE AND BODY WEIGHTS OF MALLARDS AND WOOD DUCKS IN MISSISSIPPI

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Abstract: We obtained esophageal food samples from 311 mallards (*Anas platyrhynchos*) and 94 wood ducks (*Aix sponsa*) and body weights from 2,118 mallards and 315 wood ducks in western Mississippi during December and January 1979–83. On average, mallards ingested 3.0% animal food, principally aquatic invertebrates, and 97.0% plant food. Rice, soybeans, and seeds of "moist soil" plants provided 41.3, 41.6, and 10–11% of the total food intake. Wood ducks ingested nearly 100% plant food, of which 23.4% was soybeans and 74.3% was acorns from Nuttall (*Quercus nuttallii*), water (*Q. nigra*), and willow oaks (*Q. phellos*). Mallard food use varied with water conditions; the use of rice decreased and soybeans increased during 1980–81 when cumulative November–January precipitation was <50% of normal. Wood duck food use varied with habitat; the diet included more acorns at sites having larger acreages of intact bottomland hardwood forest. Mallard and wood duck body weights varied within and among winters. Mallard weights decreased by about 2% from December to January each year. We considered this a regulated loss, whereas we attributed increases and decreases of 4–5% in average weights during wet and dry winters to changes in feeding opportunities associated with winter precipitation. Wood duck weights followed similar trends. We concluded that continued drainage in the Mississippi Delta will adversely affect waterfowl foraging opportunities, and that research on winter feeding ecology will progress more rapidly if we develop an understanding of the foraging efficiencies associated with alternate food resources.

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Seasonally flooded bottomland hardwoods provide habitat for a substantial portion of the waterfowl wintering in the Mississippi Flyway. Bellrose (1976) reported that nearly 1.5 million mallards winter in the Mississippi Alluvial Valley (MAV) or Delta and that this area also provides important wintering and nesting habitat for wood ducks. Bottomland hardwood wetlands have been drastically reduced by drainage for flood control and clearing for agricultural development. The cumulative effect of these actions has reduced the original 10.1 million ha of bottomland hardwoods to about 2.1 million ha (Forsythe and Gard 1980), a loss of nearly 80%. Thus, the remaining wetlands have become increasingly important to the perpetuation of this habitat type and its waterfowl resources.

Compared with our knowledge of breeding biology, the ecological requirements of post-breeding waterfowl are understood poorly (Fredrickson and Drobney 1979). For example, Reinecke (1981) reviewed the titles of >2,500 waterfowl publications and found that only 211 (8%) pertained to winter, 14 (0.5%) concerned the MAV, and still fewer dealt with feeding ecology in the MAV.

Although data are available concerning the foods of waterfowl wintering in the Lower Mississippi Valley, most pertain to coastal marshes (Davis et al. 1961, Junca et al. 1962, Glasgow and Bardwell 1965) or encompass broad geographical areas (McAtee 1918, Martin and Uhler 1939). Wright (1961) and Forsyth (1965) have provided the principal esophageal food habits data for mallards wintering in the MAV.

Because mallards forage in agricultural areas more readily than wood ducks, these 2 species can provide valuable comparative data on feeding ecology in bottomland habitats. Accordingly, our study was designed to measure the relative contribution of natural and agricultural foods to the mid-winter diet of mallards and wood ducks and to relate food use to habitat conditions and bird weights.

We are grateful to the waterfowl hunters of Mississippi, particularly D. Barrett, P. M. Barrett, Jr., B. J. Cross, and J. C. Griffin, for allowing us to dissect their ducks. F. J. Horne, R. E. Kirk, and G. Simard assisted with fieldwork. H. B. Bell and G. L. Chandler, former managers, and the staff at Hillside Natl. Wildl. Refuge provided use of refuge facilities. C. R. Bingham, A. H. Clarke, L. G. Sanders, and F. M. Uhler aided in taxonomic identifications, and B. K. Williams and E. D. Heinlein supervised the statistical analyses.

STUDY AREA

The MAV is a relatively flat expanse of land lying in the Mississippi Embayment, a northward extension of the Gulf Coastal Plain. Elevations increase gradually from sea level in southern Louisiana to 100 m in southeastern Missouri. An average accumulation of 43 m of alluvial deposits lies beneath the present land surface (Saucier 1974). Land use is predominantly agricultural; cotton, rice, and soybeans are the major crops. Farmers in the MAV till a higher proportion of wet soils than in any comparable agricultural region of the United States (Dideriksen et al. 1979). MAV soils are exclusively sands, silts, and clays, and soil texture and organic content are related to past and present hydrologic processes (Bedinger 1981). Our study was conducted at Panther Swamp and Hillside refuges, Delta National Forest, and several hunting clubs in Holmes, Humphreys, Sharkey, and Yazoo counties in westcentral Mississippi. Elevations there vary from 26 to 33 m, and the topography is relatively flat except for natural and man-made levees associated with the Yazoo River and its principal tributaries. The climate is temperate with hot, humid summers and wet, mild winters; mean temperatures at Yazoo City during December and January are 8.8 and 7.8 C, respectively.

The distribution of natural vegetation in the MAV is determined by the interaction of hydrologic and edaphic conditions (Larson et al. 1981). A typical transect from open water to upland may include common baldcypress (*Taxodium distichum*), water tupelo (*Nyssa aquatica*), and common buttonbush (*Cephalanthus occidentalis*) in the area of relatively permanent inundation; water hickory (*Carya aquatica*), waterelm (*Planera aquatica*), and overcup oak (*Quercus lyrata*) in the zone of inundation or saturation that persists >25% of the growing season; Nuttall oak, willow oak, and American sweetgum (*Liquidambar styraciflua*) in the zone that is flooded or saturated regularly during the dormant season but <25% of the growing season; and cherrybark oak (*Q. falcata* var. *pagodaefolia*), water oak, and American hornbeam (*Carpinus caroliniana*) in the zone that is flooded only temporarily during the dormant season. Greentree reservoirs and ponds constructed for the commercial production of channel catfish (*Ictalurus punctatus*) supplement the winter habitat provided by wetlands with natural hydrologic regimes.

METHODS

Mallard and wood duck body weights and food samples were obtained during December 1979–81 and January 1980–82 from hunters and by collecting. Only mallard body weights were recorded during December 1982 and January 1983. We weighed each duck to the nearest 10 g on a spring scale, determined age from wing plumage (Krapu et al. 1979), and measured flattened wing length to the nearest millimeter as an index of structural size (Owen and Cook 1977). If food was present, the esophagus was severed at the pharynx and proventriculus and frozen. Later, food samples were separated, identified, dried for 48 hours at 50–55 C, and weighed. Samples containing <0.01 g (dry wt) of food were deleted from the analysis, and among the usable samples, foods contributing <0.01 g were recorded as trace. Plant foods were identified with texts by Martin and Barkley (1961) and Godfrey and Wooten (1979, 1981) and invertebrates with Pennak (1978). Most foods were identified to genus and some to species.

Table 1. Body weights, wing lengths, and condition of mallards in Mississippi during mid-winter, 1979–80 through 1982–83.

Sex	Age[a]	Year	Month	N	Body wt (g) $\bar{x}$	Body wt (g) SE	Wing length (mm) $\bar{x}$	Wing length (mm) SE	Condition index (g/mm) $\bar{x}$	Condition index (g/mm) SE
Male				1,477	1,239	3	292.0	0.2	4.24	0.01
	Im			169	1,181	8	286.4	0.6	4.12	0.03
	Ad			1,308	1,246	3	292.8	0.2	4.26	0.01
		1979–80		277	1,252	6	292.6	0.5	4.28	0.02
		1980–81		523	1,196	4	290.4	0.4	4.12	0.01
		1981–82		408	1,235	5	294.2	0.3	4.20	0.02
		1982–83		269	1,314	6	291.3	0.5	4.51	0.02
			Dec	429	1,257	5	292.6	0.4	4.29	0.02
			Jan	1,048	1,231	3	291.8	0.3	4.22	0.01
Female				641	1,079	4	273.9	0.3	3.94	0.01
	Im			188	1,040	8	270.1	0.5	3.85	0.03
	Ad			453	1,095	5	275.5	0.4	3.97	0.02
		1979–80		116	1,099	9	274.2	0.7	4.01	0.03
		1980–81		264	1,036	6	273.1	0.5	3.79	0.02
		1981–82		148	1,093	9	275.5	0.6	3.97	0.03
		1982–83		113	1,139	9	273.5	0.7	4.16	0.03
			Dec	192	1,095	8	274.6	0.6	3.99	0.03
			Jan	449	1,072	5	273.6	0.4	3.91	0.02

[a] Im = immature, Ad = adult.

We measured food use as dry weight and expressed food importance as percent occurrence, aggregate dry weight, and aggregate percentage (Swanson et al. 1974). Differences between sexes and among years in the frequency of occurrence and percentage of animal food in the diet of mallards were tested with G-statistics and a 2-way analysis of variance (ANOVA) on percentage data following angular transformation (Sokal and Rohlf 1981). Differences in body weight, wing length, and condition index were tested among years and between ages, sexes, and months with a 4-way ANOVA using the general linear model procedure from the Statistical Analysis System (Helwig and Council 1979).

To illustrate the role of seed size in food choice, we estimated the dry weights of 17 potential winter foods of mallards by analyzing the numerical counts and dry weights from individual food samples. Finally, the percentage of bottomland hardwood forest within a 3-km radius of 3 wood duck collection sites was estimated with a dot grid overlay and National Wetland Inventory maps at a scale of 1:62,500.

RESULTS

Body Weights

Mallards.—Mid-winter body weights of 1,477 male and 641 female mallards averaged 1,239 and 1,079 g (Table 1). Results of a 4-way ANOVA indicated that sex, age, month, and year each accounted for a significant part of the variation in body weights. Males were heavier than females ($P < 0.001$); adults weighed more than immatures ($P < 0.001$); both sexes were heavier in December than in January ($P < 0.001$); and body weights varied among years ($P < 0.001$), with low weights in 1980–81, comparable weights in 1979–80 and 1981–82, and high weights in 1982–83 ($P < 0.05$, Duncan's test). The general linear model used for the ANOVA accounted for 44% of the variation in mallard body weights. Body weight variation was associated with changes in winter precipitation. Cumulative rainfall at Yazoo City during November, December, and January of 1979–80 and 1981–82 was about average but was only 50% of the 30-year mean in 1980–81 and more than twice the mean in 1982–83 (Table 2, Natl. Oceanic and Atmos. Adm. 1979–83).

Variation of the condition index was similar to body weight; sex ($P < 0.001$), age ($P < 0.001$),

Table 2. Winter rainfall at Yazoo City, Mississippi (Natl. Oceanic and Atmos. Adm. 1979–83).

Month	Normal	Year 1979–80	1980–81	1981–82	1982–83
Nov	4.29	5.57	3.35	2.24	8.60
Dec	5.41	4.87	1.38	3.66	17.34
Jan	4.83	5.96	2.30	8.53	6.36
Total	14.53	16.40	7.03	14.43	32.30

Table 3. Body weights, wing lengths, and condition of wood ducks in Mississippi during mid-winter, 1979–80 through 1981–82.

Sex	Age[a]	Year	Month	N	Body wt (g) $\bar{x}$	Body wt (g) SE	Wing length (mm) $\bar{x}$	Wing length (mm) SE	Condition index (g/mm) $\bar{x}$	Condition index (g/mm) SE
Male				199	686	4	229.8	0.5	2.98	0.02
	Im			49	662	9	225.0	1.0	2.94	0.04
	Ad			150	694	5	231.4	0.5	3.00	0.02
		1979–80		55	703	8	230.4	1.0	3.05	0.03
		1980–81		59	673	7	227.2	1.0	2.96	0.03
		1981–82		85	685	7	231.3	0.6	2.96	0.03
			Dec	83	689	6	229.8	0.7	3.00	0.02
			Jan	116	684	6	229.9	0.7	2.98	0.02
Female				116	640	5	223.4	0.6	2.86	0.02
	Im			40	627	8	221.1	0.9	2.83	0.03
	Ad			76	647	6	224.5	0.8	2.88	0.02
		1979–80		28	645	10	222.3	1.2	2.90	0.04
		1980–81		41	639	7	221.7	0.9	2.88	0.03
		1981–82		47	637	8	225.4	1.0	2.83	0.03
			Dec	42	644	8	223.5	1.1	2.88	0.03
			Jan	74	637	6	223.3	0.7	2.85	0.02

[a] Im = immature, Ad = adult.

month ($P < 0.001$), and year ($P < 0.001$) all affected condition. The index was different each year ($P < 0.05$, Duncan's test) and followed the same pattern as cumulative rainfall. Mean lengths of testes from drake mallards were 13.7, 14.0, and 14.5 mm during early (10–20 Dec), mid- (1–10 Jan), and late (20–30 Jan) winter, and the largest ovarian follicles in females averaged 2.0, 2.1, and 3.2 mm during the same intervals.

Wood Ducks.—Mid-winter body weights of 199 male and 116 female wood ducks were 686 and 640 g (Table 3). Variation of body weight was similar to mallards, but sample sizes were smaller and differences less distinct. Males outweighed females ($P < 0.001$) and adults were heavier than immatures ($P < 0.001$); weights also were lower in January and during 1980–81, but the differences were not significant ($P > 0.1$). The model accounted for only 25%

Table 4. Important foods of mallards in Mississippi during mid-winter, 1979–80 through 1981–82.

Food[a]	Males (N = 219) % occurrence	Males Aggregate Dry wt	Males Aggregate %	Females (N = 92) % occurrence	Females Aggregate Dry wt	Females Aggregate %	Both sexes (N = 311) % occurrence	Both sexes Aggregate Dry wt	Both sexes Aggregate %
Plant	99.5	99.2	97.3	98.9	98.3	96.5	99.4	98.9	97.0
Agricultural	55.7	83.0	48.2	51.0	82.8	49.3	54.3	82.9	48.6
Soybeans	34.2	45.1	29.0	29.3	34.8	28.3	32.8	41.6	28.8
Rice	21.9	37.9	19.2	22.8	48.0	21.0	22.2	41.3	19.8
Nonagricultural	63.9	16.2	49.1	70.7	15.5	47.2	65.9	16.0	48.4
Junglerice barnyardgrass	23.7	6.2	4.5	27.2	3.6	3.7	24.8	5.3	4.3
Broadleaf signalgrass	11.9	3.1	2.3	14.1	0.2	0.6	12.5	2.1	1.8
Fall panicum	13.2	1.2	0.7	6.5	tr[b]	tr	11.3	0.8	0.5
Rice cutgrass	30.6	0.7	26.6	34.8	4.2	27.1	31.8	1.9	26.7
Flatsedge	10.9	1.5	1.2	9.5	4.2	1.2	10.6	2.4	1.2
Dotted smartweed	9.6	0.7	3.3	9.8	2.7	5.0	9.6	1.4	3.8
Animal	24.6	0.8	2.7	27.2	1.7	3.5	25.4	1.1	3.0
Snails	14.2	0.5	1.7	18.5	1.0	0.8	15.4	0.6	1.5

[a] Thirty-nine plant and 42 animal taxa that contributed <0.5% aggregate dry wt were excluded from the table.
[b] tr = <0.5%.

of the variation in wood duck body weights. Condition indices of males exceeded females ($P < 0.01$) and adults were greater than immatures ($P < 0.01$); condition was lower in January, but the difference was not significant ($P > 0.1$). Mean lengths of testes from drake wood ducks were 9.5, 9.5, and 11.5 mm during early, mid-, and late winter, and the largest ovarian follicles in females averaged 3.1, 2.9, and 3.3 mm, respectively.

Food Use

Mallards.—We analyzed 311 mallard food samples containing nearly 2 kg (dry wt) of plant and 20 g of animal foods. The aggregate (total) dry weight ingested by mallards included 1.1% animal food, principally aquatic invertebrates, and 98.9% plant food, of which 82.9% was agricultural grains (Table 4). The aggregate (average) percentage included 3.0% animal and 97.0% plant foods.

Although animal food was present in 79 (25.4%) of the birds, 17 contained only trace amounts. One pair of mallards, collected from a dead-timber swamp, contained 32.9% of the animal foods eaten by all birds. Snails (*Physa* spp.) represented 58.7% of the animal food; the remainder included 40 taxa of invertebrates and 2 species of fish, black crappie (*Pomoxis nigromaculatus*) and mosquitofish (*Gambusia affinis*). Neither the frequency of occurrence nor the aggregate (average) percentage of invertebrates in the diet varied between sexes or among years ($P > 0.1$). However, invertebrates occurred more frequently in the diet of mallards that fed on rice than on other foods ($P < 0.005$, G-statistic).

Rice and soybeans contributed almost equally to the total food intake of mallards (Table 4), but year-to-year variation was observed. The aggregate dry weight of rice was 44.6% during 1979–80, 8.3% in 1980–81, and 63.4% in 1981–82; the use of soybeans varied inversely. Both the frequency of occurrence ($P < 0.005$, G-statistics) and aggregate (average) percentage ($P < 0.01$, t-tests) of rice in the diet were greater during 1979–80 and 1981–82 when water conditions were more favorable.

Natural plant foods provided about 16% of the aggregate dry weight (Table 4). Annual plant species associated with moist soil or marginal agricultural sites, including junglerice barnyardgrass (*Echinochloa colonum*), broadleaf signalgrass (*Brachiaria platyphylla*), fall panicum (*Panicum dichotomiflorum*), and flatsedge (*Cyperus* spp.) contributed 10–11%, and the perennials rice cutgrass (*Leersia oryzoides*), dotted smartweed (*Polygonum punctatum*), and other flatsedges provided 5–6%. Rice cutgrass had a high frequency of occurrence and aggregate percentage but contributed only 1.9% of the total dry weight.

Table 5. The relative size of potential foods of mallards wintering in the Mississippi Alluvial Valley.

Food	Dry wt (mg/seed)	Seeds/g dry wt
Nuttall oak	2,580.00	0.39
Water oak	684.00	1.46
Willow oak	619.00	1.62
Soybeans	120.00	8.36
Rice	15.80	63.50
Broadleaf signalgrass	2.92	342.00
Prickly sida (*Sida spinosa*)	2.31	432.00
Dotted smartweed	1.86	538.00
Rice cutgrass	1.44	696.00
Junglerice barnyardgrass	1.06	943.00
Curltop ladysthumb (*Polygonum lapathifolium*)	0.99	1,010.00
Swamp smartweed (*P. hydropiperoides*)	0.69	1,450.00
Hairy crabgrass (*Digitaria sanguinalis*)	0.55	1,810.00
Devils beggarticks (*Bidens frondosa*)	0.40	2,500.00
Fall panicum	0.38	2,630.00
Flatsedge	0.14	7,320.00
Mud plaintain	0.05	18,500.00

Among the potential foods of mallards wintering in the MAV, Nuttall oak acorns are the largest, and weigh nearly 50,000 times more than seeds of mud plantain (*Heteranthera limosa*), which are the smallest (Table 5). However, the difference in nutrient content (per gram) is less because of the low food value of acorn shells. Nevertheless, the relative weight of potential mallard foods varies over 4 orders of magnitude. If acorns and agricultural grains are excluded, the seed weights for a group of 10 plant foods, primarily grasses and smartweeds, vary only 1 order of magnitude, from 0.38 to 2.92 mg/seed (Table 5).

Wood Ducks.—We analyzed 94 wood duck food samples containing >1 kg of plant and 0.1 g of animal food. The aggregate dry weight was nearly 100% plant food including 74.3% acorns and 23.4% soybeans (Table 6). The frequency of occurrence of animal food in wood ducks (8 of 94) was too low for further analysis.

Table 6. Important foods of wood ducks in Mississippi during mid-winter, 1979–80 through 1981–82.

Food[a]	Males (N = 55)			Females (N = 39)			Both sexes (N = 94)		
	% occurrence	Aggregate		% occurrence	Aggregate		% occurrence	Aggregate	
		Dry wt	%		Dry wt	%		Dry wt	%
Nuttall oak	29.1	42.4	28.0	39.0	56.6	36.8	33.0	48.3	31.7
Water oak	21.8	17.4	16.0	17.9	20.4	13.0	20.2	18.7	14.7
Willow oak	7.3	5.2	2.6	7.7	7.4	5.7	7.4	6.1	3.9
Oak fragments	3.6	1.2	0.5	5.1	1.3	3.4	4.3	1.2	1.7
Devils beggarticks	9.1	2.3	5.5	5.1	0.1	2.5	7.4	1.4	4.3
Soybeans	40.0	31.0	39.6	25.6	12.8	23.1	34.0	23.4	32.8

[a] Twenty-one plant and 7 animal taxa that contributed <0.5% aggregate dry wt were excluded from the table.

Nuttall oak acorns were the principal food during the winters of 1979–80 and 1981–82; Nuttall and water oak acorns were equally important during 1980–81. Neither water nor willow oak acorns occurred in food samples during 1979–80. Production of acorns by Nuttall oaks was good during all years of the study, whereas water and willow oak acorn production was poor in 1979–80, fair to good in 1980–81, and fair in 1981–82 at Delta National Forest (T. Coppinger and J. Fort, pers. commun.).

Acorns and soybeans together provided 97.7% of the dry weight ingested (Table 6), but there was significant variation in the frequency of use of these foods among the 3 principal collection sites ($P < 0.005$, G-statistic). Soybeans dominated the diet of birds from hunting clubs (17 of 21), whereas acorns were eaten more frequently by birds obtained from the refuges (33 of 47 and 14 of 26). There was no difference in the use of soybeans or acorns between refuges ($P > 0.1$, G-statistic), but differences existed between each of the refuge sites and the hunting clubs ($P < 0.025$, G-statistics).

Examination of National Wetland Inventory maps indicated that 22, 48, and 43% of the habitat within a 3-km radius of the wood duck collection sites at the hunting clubs and 2 refuges were bottomland hardwoods. Thus, the acreage of seasonally flooded forest containing mast producing oaks was twice as large at the refuges.

Generally, hunting at private clubs and public management areas in Mississippi ends at noon; therefore, it is easier to obtain food samples from birds killed in the morning than evening. However, when we compared the frequency of occurrence of usable food samples in wood ducks killed by hunters during the morning with birds collected at dusk, we found that the frequency of food samples was much greater in the evening (46 of 70 vs. 48 of 245, $P < 0.005$, G-statistic).

DISCUSSION

Body Weights

Body weight variation was similar in both species and sexes. We included sex in the ANOVA model to test for interactions with age, month, and year. The analysis detected a sex × month interaction due to an increase in female weights between December 1979 and January 1980. However, we concluded that the sex-specific weight changes typical of breeding mallards (Krapu 1981) did not occur in mid-winter because the estimate of female body weight for December 1979 was based on our smallest sample ($N = 27$) and the other 7 comparisons between months indicated weight decreases.

At present the interpretation of weight differences associated with age and month is unclear. Juvenile mallards are generally lighter than adults in winter (Jorde 1981, this study), either because they are unable to attain adult weight or because they benefit in some way from being lighter. The decline in mallard weights during January is consistent with similar changes in wild (Owen and Cook 1977, Reinecke et al. 1982) and captive waterfowl (M. C. Perry, pers. commun.) and may be a regulated loss.

As our understanding of annual weight cycles increases (Ankney 1982), an important area for new research will be the study of year-to-year weight variation relative to habitat conditions. Fortunately, our study included winters as wet and dry as any in the 31-year period reviewed by Nichols et al. (1983:appendix 2). Disregarding age and month effects, male mallards weighed 1,235 and 1,252 g during 2 winters of average precipitation, and 1,196 and 1,314 g during respective dry and wet years. Female weights averaged 1,093 and 1,099 g in normal winters, and 1,036 and 1,139 g in dry and wet years, respectively. Greater body weights in wet years suggests that feeding opportunities in agricultural and natural areas improve when winter rainfall causes ponding of surface water and overbank flooding of streams and rivers.

The effect of water conditions on duck nesting habitat has been appreciated for some time (cf. Krapu et al. 1983), but similar research on the wintering grounds has just begun. Although the evidence for a relationship between winter rainfall and mallard body weights is circumstantial, it is supported by other recent research. For example, Nichols et al. (1983) showed that a greater proportion of mallards from prairie and parkland nesting areas wintered in the MAV during years of high rainfall. Presumably, increased body weights benefit survival and reproduction. Heitmeyer and Fredrickson (1981) demonstrated a correlation between winter precipitation in the MAV and the subsequent reproductive success of midcontinent mallards. Also, J. D. Nichols (pers. commun.) determined that annual survival rates of mallards associated with the MAV increased when winter water conditions were favorable. Thus, federal flood control activities and agricultural development, which decrease the occurrence and extent of shallow surface waters during winter, may affect the abundance, condition, survival, and productivity of mallards wintering in the MAV.

Food Use

Evidently acorns were previously the principal food of mallards wintering in the MAV (Rawls 1955, Wright 1961). However, we examined the digestive tracts of more than 1,700 mallards from Mississippi and found only 1 acorn. We know that willow oak and water oak acorns are acceptable to mallards (Wright 1961, Allen 1980), and that they were available in the study area, because they were important wood duck foods. In fact, acorns provided nearly 75% of the wood ducks' diet and increased in importance at sites with larger acreages of bottomland hardwoods. Data from our study and Drobney and Fredrickson (1979) indicate that both resident wood ducks and migrants wintering in the MAV continue to depend on natural foods from wooded wetlands.

Currently, the 3 most important categories of food for mallards in our study area are agricultural grain, seeds of moist soil plants, and invertebrates. Year-to-year variation in the use of rice and soybeans suggests that the importance of these foods is dependent on water conditions. Mallards evidently are unable to obtain rice unless they can filter it from shallow water. Thus, when drought restricts natural and agricultural feeding opportunities, the use of soybeans increases and body weights decrease. The importance of moist soil seeds in the mallards' diet indicates that techniques for the management of seasonally flooded impoundments (Fredrickson and Taylor 1982) offer an alternative means of producing food for wintering mallards. Moist soil management can be a cost effective method of providing habitat for a diversity of bird species while reducing soil erosion and maintaining water quality (Fredrickson and Taylor 1982).

Although recent studies have shown that wood ducks (Drobney and Fredrickson 1979) and many puddle ducks (Swanson et al. 1979) depend on invertebrates for successful reproduction, the importance of invertebrates during mid-winter may be different. Data from this and other studies indicate that the percentage of invertebrates in the diet is generally much lower during mid-winter. For example, <2% of the food in the esophagi of Northern pintails (*Anas acuta*) and teal (*A. crecca* and *A. discors*) collected in coastal Louisiana was invertebrates (Glasgow and Bardwell 1965). Invertebrates contributed <5% (dry wt) to the diet of gadwalls (*A. strepera*) feeding in marshes of various salinities along the Gulf coast (Paulus 1982). Also, in the long-term study recently summarized by Saunders and Saunders (1981:120–121), the esophagi of pintails collected from agricultural fields, saline bays, and 2 brackish lagoon systems in Mexico contained 4.2, 10, 5, and 10% (vol) invertebrates.

Our findings that invertebrates provide <5% (dry wt) of the diet during December and January are consistent with data for mallards from other habitats and locations. Outside the MAV, Dillon (1959), Allen (1980), and Jorde (1981) showed that mallards wintering in southern Louisiana, eastern Texas, and southcentral Nebraska ate <2% (vol), 2% (vol), and 5% (dry wt) invertebrates, respectively. Within the MAV, Wright (1961) and Forsyth (1965) reported that invertebrate use was ≤3%.

The winter foods of wood ducks are not as well known. Landers et al. (1977) examined 82 food samples collected in South Carolina from November through February and found from 1 to 7% (vol) invertebrates. For the northern MAV, Drobney and Fredrickson (1979) estimated that invertebrates provided 33 and 36% (wet wt, or about 10% as dry wt) of the diet of males and females during September and October. Our data indicated about 1% invertebrates (dry wt) in the diet during December and January.

Variation in invertebrate use among studies can be attributed to habitat characteristics, methods of expressing results, and sampling errors. Although invertebrates provide a relatively small amount of food during mid-winter, we believe their occurrence in the diet is "intentional" for several reasons. First, the occurrence of invertebrates is consistent among studies. For example, the diets of male, female, adult, and juvenile mallards wintering in Nebraska included 3.0, 3.6, 2.7, and 4.6% (dry wt) invertebrates (Jorde 1981), and mallards in our study ate 1.4, 4.6, and 3.0% (dry wt) invertebrates during 1979–80, 1980–81, and 1981–82. Second, Sugden and Driver (1980) reported a higher percentage of invertebrates in the diet of field-feeding mallards than in birds that had not recently visited grain fields. Similarly, the frequency of occurrence of invertebrates, especially snails, in mallard esophagi during our study was greater in samples containing rice than other foods. For mallards investing the time and energy in a flight to a ricefield, inclusion of snails in the diet would be a poor food choice if rice were plentiful, because snails are high in ash content but low in energy. However, the choice is appropriate if snails are included for their nutrient value, because rice is a poor source of nitrogen and minerals (Natl. Res. Counc. 1977).

Finally, we suspect that there is significant temporal specialization of foraging for nutrients during winter. For example, wood ducks collected in the evening from refuges fed primarily on acorns and <1% invertebrates. However, acorns are very low in nitrogen (Short and Epps 1976) and are probably marginal as a source of maintenance protein requirements (K. J. Reinecke and R. E. Kirk, unpubl. data). Thus, wood ducks may obtain invertebrates in small numbers during the day and preferentially gather energy foods before returning to roosting sites at dusk.

LITERATURE CITED

ALLEN, C. E. 1980. Feeding habits of ducks in a green-tree reservoir in eastern Texas. J. Wildl. Manage. 44:232–236.

ANKNEY, C. D. 1982. Annual cycle of body weight in lesser snow geese. Wildl. Soc. Bull. 10:60–64.

BEDINGER, M. S. 1981. Hydrology of bottomland hardwood forests of the Mississippi embayment. Pages 161–176 *in* J. R. Clark and J. Benforado, eds. Wetlands of bottomland hardwood forests. Elsevier Sci. Publ. Co., New York, N.Y.

BELLROSE, F. C. 1976. Ducks, geese and swans of North America. Stackpole Books, Harrisburg, Pa. 543pp.

DAVIS, J. P., C. H. THOMAS, AND L. L. GLASGOW. 1961. Foods available to waterfowl in fallow ricefields of southwest Louisiana, 1960–1961. Proc. Annu. Conf. Southeast. Assoc. Game and Fish Comm. 15:60–66.

DIDERIKSEN, R. I., A. R. HIDLEBAUGH, AND K. O. SCHMUDE. 1979. Wet soils for crop production in the United States. Pages 632–641 *in* P. E. Greeson, J. R. Clark, and J. E. Clark, eds. Wetland functions and values: the state of our understanding. Am. Water Resour. Assoc., Minneapolis, Minn.

DILLON, O. W. 1959. Food habits of wild mallard ducks in three Louisiana parishes. Trans. North Am. Wildl. Conf. 24:374–382.

DROBNEY, R. D., AND L. H. FREDRICKSON. 1979. Food selection by wood ducks in relation to breeding status. J. Wildl. Manage. 43:109–120.

FORSYTH, B. 1965. December food habits of the mallard (*Anas platyrhynchos* Linn.) in the Grand Prairie of Arkansas. Proc. Arkansas Acad. Sci. 19:74–78.

FORSYTHE, S. W., AND S. W. GARD. 1980. Status of bottomland hardwoods along the lower Mississippi River. Trans. North Am. Wildl. and Nat. Resour. Conf. 45:333–340.

FREDRICKSON, L. H., AND R. D. DROBNEY. 1979. Habitat utilization by postbreeding waterfowl. Pages 119–131 *in* T. A. Bookhout, ed. Waterfowl and wetlands—an integrated review. North Cent. Sect. Wildl. Soc., Madison, Wis.

———, AND T. S. TAYLOR. 1982. Management of seasonally flooded impoundments for wildlife. U.S. Fish and Wildl. Serv. Resour. Publ. 148. 29pp.

GLASGOW, L. L., AND J. L. BARDWELL. 1965. Pintail and teal foods in south Louisiana. Proc. Annu. Conf. Southeast. Assoc. Game and Fish Comm. 16:175–184.

GODFREY, R. K., AND J. W. WOOTEN. 1979. Aquatic and wetland plants of southeastern United States: monocotyledons. Univ. Georgia Press, Athens. 712pp.

———, AND ———. 1981. Aquatic and wetland plants of southeastern United States: dicotyledons. Univ. Georgia Press, Athens. 933pp.

HEITMEYER, M. E., AND L. H. FREDRICKSON. 1981.

Do wetland conditions in the Mississippi Delta hardwoods influence mallard recruitment? Trans. North Am. Wildl. and Nat. Resour. Conf. 46: 44–57.

HELWIG, J. T., AND K. A. COUNCIL, editors. 1979. SAS user's guide. SAS Inst. Inc., Cary, N.C. 494pp.

JORDE, D. G. 1981. Winter and spring staging ecology of mallards in south central Nebraska. M.S. Thesis, Univ. North Dakota, Grand Forks. 131pp.

JUNCA, H. A., E. A. EPPS, AND L. L. GLASGOW. 1962. A quantitative study of the nutrient content of food removed from the crops of wild mallards in Louisiana. Trans. North Am. Wildl. and Nat. Resour. Conf. 27:114–121.

KRAPU, G. L. 1981. The role of nutrient reserves in mallard reproduction. Auk 98:29–38.

———, D. H. JOHNSON, AND C. W. DANE. 1979. Age determination of mallards. J. Wildl. Manage. 43:384–393.

———, A. T. KLETT, AND D. G. JORDE. 1983. The effect of variable spring water conditions on mallard reproduction. Auk 100:689–698.

LANDERS, J. L., T. T. FENDLEY, AND A. S. JOHNSON. 1977. Feeding ecology of wood ducks in South Carolina. J. Wildl. Manage. 41:118–127.

LARSON, J. S., ET AL. 1981. Transition from wetlands to uplands in southeastern bottomland hardwood forests. Pages 225–273 *in* J. R. Clark and J. Benforado, eds. Wetlands of bottomland hardwood forests. Elsevier Sci. Publ. Co., New York, N.Y.

MARTIN, A. C., AND W. D. BARKLEY. 1961. Seed identification manual. Univ. California Press, Berkeley. 221pp.

———, AND F. M. UHLER. 1939. Food of game ducks in the United States and Canada. U.S. Dep. Agric. Tech. Bull. 634. 157pp.

MCATEE, W. L. 1918. Food habits of the mallard ducks of the United States. U.S. Dep. Agric. Bull. 720. 35pp.

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION. 1979–83. Climatological data: Mississippi, annual summaries. Natl. Climatic Cent., Asheville, N.C.

NATIONAL RESEARCH COUNCIL. 1977. Nutrient requirements of poultry. 7th ed. Natl. Acad. Sci., Washington, D.C. 62pp.

NICHOLS, J. D., K. J. REINECKE, AND J. E. HINES. 1983. Factors affecting the distribution of mallards wintering in the Mississippi Alluvial Valley. Auk 100:932–946.

OWEN, M., AND W. A. COOK. 1977. Variations in body weight, wing length and condition of mallard *Anas platyrhynchos platyrhynchos* and their relationship to environmental changes. J. Zool. (London) 183:377–395.

PAULUS, S. L. 1982. Feeding ecology of gadwalls in Louisiana in winter. J. Wildl. Manage. 46:71–79.

PENNAK, R. W. 1978. Freshwater invertebrates of the United States. 2nd ed. John Wiley and Sons, New York, N.Y. 803pp.

RAWLS, C. K. 1955. Reelfoot Lake waterfowl research. Tenn. Game and Fish Comm., Fed. Aid Fish and Wildl. Restor. Final Rep., Proj. W-22-R. 75pp.

REINECKE, K. J. 1981. Winter waterfowl research needs and efforts in the Mississippi Delta. Int. Waterfowl Symp. 4:231–236.

———, T. L. STONE, AND R. B. OWEN, JR. 1982. Seasonal carcass composition and energy balance of female black ducks in Maine. Condor 84:420–426.

SAUCIER, R. T. 1974. Quaternary geology of the Lower Mississippi Valley. Arkansas Archeol. Surv. Res. Ser. 6. 26pp.

SAUNDERS, G. B., AND D. C. SAUNDERS. 1981. Waterfowl and their wintering grounds in Mexico, 1937–1964. U.S. Fish and Wildl. Serv. Resour. Publ. 138. 151pp.

SHORT, H. L., AND E. A. EPPS. 1976. Nutrient quality and digestibility of seeds and fruits from southern forests. J. Wildl. Manage. 40:283–289.

SOKAL, R. R., AND F. J. ROHLF. 1981. Biometry. 2nd ed. W. H. Freeman and Co., San Francisco, Calif. 859pp.

SUGDEN, L. G., AND E. A. DRIVER. 1980. Natural foods of mallards in Saskatchewan parklands during late summer and fall. J. Wildl. Manage. 44:705–709.

SWANSON, G. A., G. L. KRAPU, J. C. BARTONEK, J. R. SERIE, AND D. H. JOHNSON. 1974. Advantages in mathematically weighting waterfowl food habits data. J. Wildl. Manage. 38:302–307.

———, ———, AND J. R. SERIE. 1979. Foods of laying female dabbling ducks on the breeding grounds. Pages 47–57 *in* T. A. Bookhout, ed. Waterfowl and wetlands—an integrated review. North Cent. Sect. Wildl. Soc., Madison, Wis. 148pp.

WRIGHT, T. W. 1961. Winter foods of mallards in Arkansas. Proc. Annu. Conf. Southeast. Assoc. Game and Fish Comm. 13:291–296.

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