FOODS OF MIGRATING COOTS (*FULICA AMERICANA*) AND SYMPATRIC DUCKS DURING FALL AND SPRING IN NORTHEASTERN OKLAHOMA

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PREFACE

The objective of this study was to determine and compare food habits of American coots and common sympatric ducks migrating through northeastern Oklahoma during fall and spring.

Funds for the study were provided by the Accelerated Research Program for Webless Migratory Shore and Upland Game Birds USFWS, Oklahoma Department of Wildlife Conservation, Oklahoma Cooperative Wildlife Research Unit, and Oklahoma State University.

Sincere appreciation is extended to my major advisor, John A. Bissonette, for the freedom, suggestions, and patience throughout the study. The assistance in project design and statistical analyses provided by W. D. Warde is greatly appreciated. I thank Larry G. Talent and Jerry L. Wilhm for serving as members of my graduate committee.

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I thank Dr. Paul A. Vohs Jr. for his help in obtaining funds. I am grateful to Dr. Fritz L. Knopf for his part in obtaining funds, his advice, and interest throughout the project. Special thanks are extended to William R. Eddleman for comments and suggestions and for his assistance with the field work. Don Martin was invaluable in collecting field data and work in the lab. I thank the undergraduate volunteers

who aided with the field work.

Finally, I thank the "gang" out at the farm for their constant reassurement and moral support throughout the study. The patience, encouragement, and understanding shown by my parents is sincerely appreciated.

TABLE OF CONTENTS

LIST OF TABLES

Table Page

LIST OF FIGURES

CHAPTER I

INTRODUCTION

The manuscript "Foods of American coots (Fulica americana) and sympatric ducks during fall and spring in northeastern Oklahoma" (Chapter II) was written in the JOURNAL OF WILDLIFE MANAGEMENT format and is complete without additional data.

Written approval for submitting the thesis in scientific journal format was received from the Dean of the Graduate College on July 8, 1981.

CHAPTER II

FOODS OF MIGRATING AMERICAN COOTS (*Fulica americana*) AND SYMPATRIC DUCKS DURING FALL AND SPRING IN NORTHEASTERN OKLAHOMA

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Abstract: Food habits of American coots were studied during fall 1979 and 1980 and during spring 1980 and 1981. Major foods of coots during spring consisted of algae (*Cladophora* sp.), grasses (Poaceae), and adult insects while foods during fall consisted of submergent vascular aquatic plants, algae, sedges (*Cyperus* spp.), and smartweed (*Polygonum* spp.) seeds. Female coots ate more (P=0.001) invertebrates than males (28% vs 12% dry wt, respectively) during spring while males ate more algae (54% dry wt) than females (38%, P=0.036). Diets of male and female coots were similar during fall. Adults consumed more grass (38% dry wt) than immatures (6% dry wt, P=0.004) and immatures did not eat aphids (Aphididae) during spring; however, differences were attributed to a differential migration between adults and immatures. Diets between adults and immatures were similar during fall.

Food habits of gadwall (*Anas strepera*), wigeon (*A. americana*),

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mallard (A. platyrhynchos), and redhead (Aythya americana) were studied during fall 1980 and compared with diets of coot. These sympatric birds generally ate similar vegetative foods. However, mallards ate more animal foods than coots in stands of flooded smartweed, and redheads ate sago pondweed (Potamogeton pectinatus) while sympatric coots, gadwall, wigeon, and mallards ate naiad (Najas guadalupensis). Food habits of coots, gadwall, wigeon, mallards, redheads, and blue-winged teal (Anas discors) were also described during spring 1980 and and 1981. Gadwall, wigeon, and redheads ate vegetation, while mallards and blue-winged teal ate mostly animal foods.

American coots have responded well to habitat management practices for waterfowl (Fredrickson et al. 1977). Public and private programs to preserve wetlands for waterfowl have benefited coots because waterfowl areas provide habitat for nesting, staging, and resting during migration and for wintering. However, reliable food habit information on sympatric areas is lacking (Fredrickson et al. 1977). Food habit studies on coots have not differentiated food preferences by sex and age classes (Jones 1940, Eley and Harris 1975, Fitzner et al. 1980). Most studies neglected biases associated with gizzard analyses from birds taken during fall migration (Swanson and Bartonek 1970) and information on food habits during spring migration are scant.

The objective of this study was to describe and compare food habits of coots and sympatric ducks during spring and fall migration. Coots, gadwall, wigeons, mallards, and redheads were studied during spring and fall. Blue-winged teal were present and examined only during spring. Northern Oklahoma is an ideal area to study feeding

ecology of coots and ducks during migration because few of these birds winter (except mallards) or nest in the area (Sutton 1967).

We are grateful to D. Martin for field and laboratory assistance; E. Waugh, J. Savage, and J. Akin for allowing us access to the study areas and to collect birds; and to student volunteers aiding in collecting the field data. F. L. Knopf, L. G. Talent, W. R. Eddleman, and J. L. Wilhm reviewed the manuscript. This project was funded by the U. S. Fish and Wildlife Service, Accelerated Research Program, through a contract to F. L. Knopf, with supplemental funding provided by the Oklahoma Division of Wildlife through P. A. Vohs of the Oklahoma Cooperative Wildlife Research Unit.

STUDY AREAS

This study was conducted at Sequoyah National Wildlife Refuge in eastern Oklahoma and on Lake Carl Blackwell and Sooner Reservoir in north central Oklahoma. Eastern Oklahoma, in the Arkansas Valley Region (Baily 1976), is characterized by Pennsylvanian sandstone and shales with well developed oak (Quercus spp.)-hickory (Carya spp.) woodlands or savannah type vegetation (Bruner 1931). North-central Oklahoma has gently rolling plains with red Permian clays and shales (Bruner 1931). Cultivation of wheat and soy beans is the most common land-use at Sequoyah NWR, while cattle grazing is the primary land-use of the areas surrounding Lake Carl Blackwell and Sooner Lake. Soil, geology, hydrology, climate, and flora have been described previously (Gray and Galloway 1959, Oklahoma Water Resources Board 1972a,b).

Predominant vegetation on Sequoyah NWR included water primrose (Jussiaea repens), Eurasion watermilfoil (Myriophyllum spicatum),

algae, and cattail (Typha latifolia). Milfoil was less common during spring than fall on Sequoyah NWR. Vegetation on ponds near Sooner Lake (Sooner Ponds) was mainly aquatic and consisted of naiad, pondweeds (Potamogeton spp.), muskgrass (Chara vulgaris), and algae. Vegetation on Sooner Lake differed between spring and fall. During spring, aquatic vegetation was comprised of algae with stands of Johnson grass (Sorghum halapense), dock (Rumex crispus), sunflowers (Helianthus sp.), and grasses (Poaceae) occurring frequently near shorelines. Low water levels during fall of 1980 created shorelines of mud flats on Sooner Lake and vegetation consisted of sparse beds of naiad. The predominant vegetation on Lake Carl Blackwell during spring was algae. However, during fall, vegetation in collection sites on Lake Carl Blackwell consisted of naiad, muskgrass, algae, buttonbush (Cephalanthus occidentalis), and stands of flooded smartweed (Polygonum spp.).

METHODS

Coots were collected from all study sites from 15 September to 15 December and from 1 March to 8 May each year from 1979-1980. Ducks were collected from Sequoyah NWR, Sooner Ponds, and Lake Carl Blackwell during fall and from Sequoyah NWR, Sooner Ponds, and Sooner Lake during spring. Ducks were not observed feeding and hence were not collected from Lake Carl Blackwell during spring and on Sooner Lake during fall.

Vegetation was identified at collection sites. Density within a 1 m radius of where each bird was collected was scaled as sparse, moderate, or high. Feeding behavior was categorized as picking, tipping-up, dabbling, diving, or grazing and was recorded prior to collection. Birds were observed feeding for at least 10 minutes prior

to collection and esophageal contents were removed and immediately preserved in 80% ethanol to prevent post-mortem digestion (Swanson and Bartonek 1970). Esophageal contents were later sorted and oven dried for 10-12 hr at 100°C and weighed to the nearest mg on a Mettler analytical balance.

Plant seeds were identified following Martin and Barkley (1961) and by use of a reference collection; Fasset (1957) and Steyermark (1963) were used as authorities for identifying vegetation. Invertebrates were identified using Pennak (1953) and Borror et al. (1976).

Foods found in esophagi are presented as aggregate percent dry weight and percent occurrence (Martin et al. 1946). The aggregate percent method was chosen because it greatly reduces the importance of foods infrequently consumed in large quantities (Swanson et al. 1974b). Dry weights rather than volumetric measurement were used to avoid errors due to variable water content (Reinicke and Owen 1980). Esophageal contents weighing less than 0.001 g dry weight were excluded from this analyses and food comprising $<$ 1% of the aggregate percent dry weight were regarded as trace amounts.

Since foods of ducks and coots differed among areas, diets of birds were compared only when collected from the same reservoir. From Morisita (1959), the degree of overlap in the diet (C_o) was computed as follows:

$$C_o = \frac{2 \sum_{i}^{t} X_i Y_i}{X_i^2 + Y_i^2},$$

where t is the total number of food species and X_i and Y_i are the proportions of the total diet comprised of food species i for 2 bird

species. Values vary from 0 when the samples are completely distinct to 1 when they are identical.

Data were analyzed using the Statistical Analysis System (Barr et al. 1979). Dietary differences between ages and sexes were tested using a Student's t-test.

RESULTS

Food Habits of Coots

Esophageal contents from 98 male and 107 female (147 adult:58 immature) coots were used to describe food habits during spring. Algae and grasses (Poaceae, wheat) predominated in the diet of coots (Table 1). Other vegetative foods were important and consisted of muskgrass (Chara vulgaris), narrow-leafed pondweed (Potamogeton foliosus), cattail, and naiad. Detritus was common, but consumed in low amounts. Of the 16 taxa of animal foods found in coot esophagi, adult midges (Chironomidae) and aphids were in greatest abundance. Larval midges were important by occurrence, but were probably ingested incidentally with aquatic vegetation.

Fall food habits were based on esophageal contents from 61 male and 57 female (39 adult:79 immature) coots. Vegetation comprised most of the diet and consisted mainly of naiad, algae, milfoil, and sedges (Cyperus sp.). Seeds of pale smartweed (Polygonum lapathifolium) and pinkweed (P. pensylvanicum) were important to 12 coots feeding in stands of flooded smartweed.

Dietary Differences Between Spring and Fall

Diets of coots differed considerably between spring and fall. Consumption of algae and animal foods by coots decreased ($P < 0.008$)

Table 1. Aggregate percent dry weight (% Dry) and frequency of occurrence (% Freq) of esophageal contents from adult and immature coots collected during spring 1980 and 1981 and during fall 1979 and 1980.

Food Item	MARCH-MAY				MARCH				APRIL-MAY				SEPTEMBER-DECEMBER							
	Male n = 98		Female n = 107		Adult n = 79		Immature n = 10		Adult n = 68		Immature n = 48		Male n = 61		Female n = 57		Adult n = 39		Immature n = 79	
	% Dry	% Freq	% Dry	% Freq	% Dry	% Freq	% Dry	% Freq	% Dry	% Freq	% Dry	% Freq	% Dry	% Freq	% Dry	% Freq	% Dry	% Freq	% Dry	% Freq
Vegetation	88	89	72	77	79	85	98	100	84	88	68	75	94	100	93	98	97	100	91	99
Algae	54	58	38	46	55	63	39	40	33	38	43	56	21	25	20	23	21	26	21	23
Poaceae	16	20	11	22	10	14	27	30	23	24	4	8			tr	2	tr	2		
Wheat	2	2	8	8					15	15	2	2								
Najas guadalupensis	2	2	tr	1	4	5			2	2			46	49	34	37	56	59	33	35
Myriophyllum spicatum	1	2	3	2					2	2	6	10	16	16	23	26	14	15	20	24
Chara vulgaris	5	5			5	5	20	20					2	2	3	4	2	2	3	3
Potamogeton foliosus	2	2	3	3					3	3	4	8								
Typha latifolia	1	2	3	7					4	4	4	8	1	5	2	4	1	3	2	5
Eleocharis spp.	2	2			1	1					4	4	1	3	1	4	2	5	1	4
Cyperus sp.													4	5	4	7			7	9
Juncus sp.															2	2			1	1
Plant roots			2	1			10	10	1	1			2	2	3	4			2	4
Detritus	2	22	2	9	5	33	2	30	1	1	1	21	1	3	1	7	1	1	1	1
Invertebrate	12	39	28	53	19	50	tr	20	17	40	31	63	1	8	1	12	tr	15	3	16
Chironomidae (adult)	7	12	15	19	tr	1			16	21	26	35								
Aphididae	4	4	9	9	18	20														
Chironomidae (larvae)	tr[b]	16	1	16	tr	20	tr	20	tr	12	2	19	tr	4	tr	2	tr	8	tr	5
Scarabaeidae	tr	1	1	2	1	3					2	2					tr	1		
Carabidae											tr	2	tr	2					1	4
Corixidae															1	2			1	3
Gastropoda													1	2	tr	9	tr	3	1	6
Miscellaneous[a]	1	13	2	6	tr	3			1	4	1	19								
															6	18	3	16	7	19
Seeds	tr	8	tr	3	1	7	2	10	tr	4	1	6	5	19						
Polygonum spp.			tr	1	tr	3					tr	2			4	9	1	10	5	9
P. lapathafolium					tr	1			tr	1			3	10	1	5	1	3	2	10
P. pennsylvanicum	tr	5							tr	3			2	10	1	2	1	3		
Potamogeton pectinatus																				
Poaceae	tr	3	tr	2	1	3					1	2								
Scirpus sp.							2	10			tr	2								

[a] Miscellaneous categories include coleoptera, cicadellidae, Lygaeidae, Termitidae, Fish eggs, Nancoridae, Dipter, Coenigrionidae

[b] Less than 1% of dry weight

from spring to fall while consumption of vascular aquatic plants and seeds increased (P=0.001) from spring to fall.

Dietary Differences Between Male and Female Coots

During spring, female coots consumed more invertebrates (28% dry wt) than males (12% dry wt, P=0.001) (Table 1). Males ate a larger proportion of algae (54% dry wt) than females (38% dry wt, P=0.036) during spring. No differences ($P < 0.327$) in diets between male and female coots existed during fall (Table 1).

Dietary Differences Between Adults and Immatures

Diets of immature and adult coots were not similar during spring (Table 1). Adults consumed more grass (38% dry wt) than immatures (6% dry wt, P=0.004) and esophagi from immature coots did not contain aphids. Immature coots consumed more invertebrates (30% dry wt) than adults (17% dry wt) but the difference was not significant (P=0.186). Immature coots migrated later than adults (Oklahoma Cooperative Wildlife Research Unit, unpublished data) explaining in part dietary differences between adult and immatures since foods differed between March and April-May (Table 1). When 10 immatures were collected during March, for example, aphids were not abundant. A larger proportion of immatures comprised the sample during April-May but the proportion within particular areas fluctuated greatly. Only 1 immature among 11 coots was collected while grazing on wheat at Sequoyah NWR and only 4 among 25 coots were collected while grazing on grasses at Sooner Lake.

Diets of immature and adult coots were similar during fall except at Sequoyah NWR where immatures consumed more sedges, rushes (Juncaceae), and milfoil than adult coots ($P < 0.05$). More immatures than adults

fed at Sequoyah NWR during fall 1980 ($\underline{X}^2$=50.86, P < 0.005). Ninety-two percent (n=23) of the coots collected at Sequoyah NWR while feeding were immatures, while coots collected loafing were mostly adults (62% adult vs 38% immature) (Oklahoma Cooperative Wildlife Research Unit, unpublished data).

Comparisons of Food Habits of Coots and Sympatric Ducks During Spring

Diets of coots and ducks and the species collected differed among reservoirs. Therefore, food habits of coots and ducks are presented for each reservoir.

Sequoyah NWR.--Plant foods of 58 coots consisted mostly of algae, milfoil, wheat, and cattail (Table 2). Adult midges (Chironomidae) were the main animal food of coots although 1 bird ate only ground beetles (Carabidae). By occurrence, larval midges were also important but made up only a small percentage of the dry weight. Seeds were unimportant in the diet except for 2 coots that ate seeds of bulrush (Scirpus sp.). Algae was the only food found in 11 of the 12 gadwall collected. The remaining gadwall ate algae and milfoil. Wigeons were not observed feeding on wetlands during spring, but frequently fed in wheat and soy bean fields. The esophagus of one wigeon collected in a wheat field contained only wheat. Gastropods, crayfish (Procambarus sp.), adult midges, and mosquito fish (Gambusia affinis) were the major animal foods consumed by 4 mallards. Seeds of dock (Rumex crispus) were found in 2 mallards and 1 male contained only algae. Blue-winged teal ate gastropods, larval and adult midges, and damselfly (Coenagriadidae) nymphs. Seeds of dock and Johnson grass (Sorghum halapense) were also important foods for blue-winged teal.

Table 2. Percent dry weight (% Dry) and frequency of occurrence (% Freq) of esophageal contents from coots and ducks collected on Sequoyah NWR during spring, 1980 and 1981.

Food Item	Coots n = 58		Gadwall n = 12		Wigeon n = 1		Mallards n = 4		Blue-winged teal n = 14	
	% Dry	% Freq	% Dry	% Freq	% Dry	% Freq	% Dry	% Freq	% Dry	% Freq
Vegetation	58	66	99	100	100	100			2	21
Algae	21	29	91	100			25	75	1	14
Myriophyllum spicatum	7	14	8	17						
Wheat	19	19			100	100				
Typha latifolia	8	16	tr[a]	25						
Detritus	1	7	1	25					1	7
Poeceae	2	3								
Sibara virginica	tr	2								
Animal	41	53	tr	8			67	100	83	86
Chironomidae (larvae)	1	9	tr	8			tr	25	9	21
Chironomidae (adults)	39	48					17	25	9	21
Gastropoda							21	25	58	79
Coenagrionidae							1	25	6	14
Libellulidae									tr	14
Pelycopoda									1	7
Procambarus							14	25		
Gambusia affinis							13	50		
Corixidae							1	50		
Carabidae	1	2								
Miscellaneous									tr	21

Table 2. Continued.

Food Item	Coots n = 58		Gadwall n = 12		Wigeon n = 1		Mallards n = 4		Blue-winged teal n = 14	
	% Dry	% Freq	% Dry	% Freq	% Dry	% Freq	% Dry	% Freq	% Dry	% Freq
Seeds	1	3	1	8			8	50	15	21
Rumex crispus							8	50	7	14
Sorghum halapense									7	14
Helianthus sp.									tr	7
Poaceae									tr	7
Polygonum pennsylvanicum									1	14
Typha latifolia			1	8						
Scirpus sp.	1	3								

[a]Less than 1% of aggregate percent dry weight

Sooner Ponds.--Foods of 16 coots, 2 gadwall, 3 wigeons, and 11 redheads consisted entirely of aquatic vegetation (Table 3). The most important plant foods of coots in order of importance were algae, muskgrass (Chara vulgaris), naiad, and narrow-leafed pondweed. One wigeon consumed muskgrass, while 2 wigeon and 11 redheads ate naiad. Two mallards tracts contained only animal foods, mainly bullfrog (Rana catesbiana) tadpoles, but dragonfly (Libellulidae) nymphs and larval midges were found also.

Sooner Lake.--Algae was the most important food of 51 coots, 8 gadwall, 2 wigeon, and 1 redhead (Table 4). Based on occurrence, larval midges and fish eggs were important to coots but were consumed incidentally to algae. Larval midges, fish eggs, gastropods, and damselfly nymphs were important animal foods of 8 mallards, while seeds of Johnson grass, dock, pigweed (Amaranthus sp.), and sunflower were the most important seeds consumed. Animal foods of 15 blue-winged teal in order of important were gastropods, larval midges, fish eggs, predacious diving beetles (Dytiscidae), and mosquito fish. Of 12 taxa of seeds found in blue-winged teal, Johnson grass, panic grass, crab grass (Digitaria sp.), and euphorbs (Euphorbia sp.) were most important. Pigweed seeds were important by occurrence but the percent dry weight was low.

Comparisons of Food Habits of Coots and Sympatric Ducks During Fall

Sequoyah NWR.--Vegetation predominated in the diets of 21 coots during fall (Table 5). Aquatic vegetation included milfoil and algae, but coots also grazed on sedges. Gastropods comprised most of the food from 1 coot. Larval midges, damselfly nymphs, and water boatmen were

Table 3. Percent dry weight (% Dry) and frequency of occurrence (% Freq) of esophageal contents from coots and ducks collected on Sooner Ponds during spring, 1980 and 1981.

Food Item	Coots n = 16		Gadwall n = 2		Wigeons n = 3		Redheads n = 11		Mallards n = 2	
	% Dry	% Freq	% Dry	% Freq	% Dry	% Freq	% Dry	% Freq	% Dry	% Freq
Vegetation	100	100	100	100	100	100	100	100		
Chara vulgaris	50	31			33	33				
Najas guadalupensis	34	25			67	67	100	100		
Potamogeton foliosus	10	6	100	100						
Detritus	6	13								
Animal									100	100
Rana catesbiana (tadpoles)									93	100
Chironomidae (larvae)									2	50
Libellulidae									5	100
Coenagrionidae									tr[a]	50
Corixidae									tr	50

[a]Less than 1% of aggregate percent dry weight

Table 4. Percent dry weight (% Dry) and frequency of occurrence (% Freq) of esophageal contents from coots and ducks collected on Sooner Lake during Spring, 1980 and 1981.

Food Item	Coots n = 51		Gadwall n = 8		Wigeon n = 2		Redheads n = 1		Mallards n = 8		Blue-winged teal n = 15	
	% Dry	% Freq	% Dry	% Freq	% Dry	% Freq	% Dry	% Freq	% Dry	% Freq	% Dry	% Freq
Vegetation	79	91	93	100	100	100	100	100	6	25	6	13
Algae	47	52	91	100	100	100	100	100				
Poaceae	29	22									1	7
Detritus	3	33	2	44					6	25	5	7
Animal	20	42	tr	22					41	67	45	87
Aphididae	16	17										
Chironomidae (larvae)	1	15	tr	22					23	25	9	20
Chironomidae (adult)	1	2										
Scarabaeidae	1	3										
Cornagrionidae	tr[a]	1							1	25		
Libellulidae											1	13
Corixidae											1	27
Dytiscidae											5	7
Gammaridae									tr	25		
Gambuzia affinis											2	13
Fish eggs	1	9							11	25	7	7
Gastropoda									6	25	20	40
Seeds	tr	4	7	11					52	56	50	67
Sorghum halapense									31	50	21	31
Panicum sp.			7	11							12	33
Amaranthus sp.									6	13	1	33
Rumex crispus									2	13	tr	13
Euphorbia sp.											4	13
Digitaria sp.											6	7
Desmanthus sp.											1	7
Polygonum spp.	tr	1									2	13
Solanum sp.											1	7
Anemone sp.									3	13		
Miscellaneous	tr	3							tr	13	tr	27

[a]Less than 1% of aggregate percent dry weight

Table 5. Percent dry weight (% Dry) and frequency of occurrence (% Freq) of esophageal contents from coots and ducks collected on Sequoyah National Wildlife Refuge during fall 1980.

Food Item	Coots n = 21		Gadwall n = 4		Wigeons n = 7	
	% Dry	% Freq	% Dry	% Freq	% Dry	% Freq
Vegetation	94	100	100	100	100	100
Myriophyllum spicatum	45	52	56	75	83	86
Algae	16	19	44	50	3	14
Cyperus sp.	25	33				
Juncus sp.	4	5				
Typha latifolia	4	5				
Potamogeton nodosus					14	14
Animal	7	33				
Gastropoda	4	10				
Chironomidae (larvae)	1	14				
Coenigrionidae	1	5				
Corixidae	1	5				

frequently consumed but made up a small percentage of foods eaten. Milfoil and algae were the only foods found in 4 gadwall. Five wigeons ate mostly milfoil, 1 wigeon ate a small portion of algae, and 1 other wigeon contained only leaves of floating-leafed pondweed (Potamogeton nodosus).

Sooner Ponds.--Naiad was the main food of 14 coots, 15 gadwall, 13 wigeon, and 3 mallards (Table 6), while sago pondweed (Potamogeton pectinatus) was the main food of redheads. One coot and 1 gadwall ate muskgrass. Coots, redheads, and mallards contained seeds of pondweed although the amount consumed was low.

Lake Carl Blackwell.--Vegetation was the main food of 36 coots. Foods consumed consisted of naiad, algae, spike rush (Eleocharis sp.), muskgrass, and plant roots (Table 7). Seeds of pale smartweed (Polygonum lapathifolium) and pinkweed (P. pensylvanicum) were also important. Naiad was the only food found in 2 gadwall and 3 redheads. Five wigeons ate naiad also while 1 wigeon consumed muskgrass. Seeds of pale smartweed, pinkweed, and vegetative parts of naiad comprised the bulk of food eaten by 6 mallards. Animal foods comprised 17% of mallards diet and consisted of blue gills (Lepomis macrochirus), dragonfly nymphs, gastropods, and water striders (Gerridae).

A Measure of Food Overlap: Morisita's Index

Coots and ducks were found to exploit many of the same food resources. Algae, submergent vascular aquatic plants, invertebrates, and seeds were common to the diets of coots and most of the ducks. Measures of diet overlap (Morisita 1959) were used to determine the

Table 6. Percent dry weight (% Dry) and frequency of occurrence (% Freq) of esophageal contents from coots and ducks collected on Lake Carl Blackwell during Fall 1980.

Food Item	Coots n = 36		Gadwall n = 2		Wigeon n = 6		Redheads n = 3		Mallards n = 6	
	% Dry	% Freq	% Dry	% Freq	% Dry	% Freq	% Dry	% Freq	% Dry	% Freq
Vegetation	82	94	100	100	100	100	100	100	22	33
Najas guadalupensis	60	67	100	100	83	83	100	100	22	33
Algae	9	14								
Eleocharis	5	17								
Chara vulgaris	2	3			17	17				
Poaceae	tr[a]	3								
Plant roots	6	6								
Detritus	tr	3								
Animal									17	67
Lepomis macrochirus									12	17
Libellulidae									3	17
Gastropoda									2	67
Gerridae									tr	17
Seeds	18								62	100
Polygonum lapathifolium	12	25							13	83
pennsylvanicum	6	31							49	100

[a]Less than 1% of aggregate percent dry weight

Table 7. Percent dry weight (% Dry) and frequency of occurrence (% Freq) of esophageal contents from coots and ducks collected on Sooner Ponds during Fall 1980.

Food Item	Coots n = 14		Gadwall n = 15		Wigeons n = 13		Redheads n = 11		Mallards n = 3	
	% Dry	% Freq	% Dry	% Freq	% Dry	% Freq	% Dry	% Freq	% Dry	% Freq
Vegetation	100	100	100	100			97	100	100	100
Najas guadalupensis	89	93	83	87	100	100	19	27	100	100
Potamogeton pectinatus							78	82		
Chara vulgaris	7	7	13	13						
Algae			4	13						
Seeds	4	9					3	45	tr	67
Potamogeton pectinatus	4	7					2	45	tr	67
nodosus							1	9		

similarity in diets among coots and ducks that fed in the same reservoir.

Values of Morisita's Index among coots and ducks during spring on Sequoyah NWR ranged between C_o = 0.02 and C_o = 0.64 (Table 8). Although mallards had high overlap values with coots and gadwall (C_o = 0.58 and C_o = 0.46, respectively), only 1 mallard of 4 collected ate algae accounting for most of the overlap with coots and gadwall. Diets of mallards were probably more similar to blue-winged teal (C_o = 0.64). Coots consumed foods similar to wigeon and gadwall within particular areas; however, values of diet overlap with gadwall and wigeon were low (C_o = 0.31 and C_o = 0.36, respectively). There was no overlap between the diets of wigeon and other species of ducks on Sequoyah NWR.

On Sooner Ponds during spring, wigeons and redheads had the highest value of overlap with coots (C_o = 0.76 and C_o = 0.43, respectively, Table 8). Measures of overlap for coots and gadwall was low, however, sample sizes of gadwall were small (n=2). Wigeons and redheads ate mostly naiad and had high (C_o = 0.86) overlap values. Mallards had no foods in common with other sympatric ducks or coots on Sooner Ponds.

Coots, gadwall, wigeon and redheads ate mostly algae on Sooner Lake during spring and Morisita's index approached 1.0 among species (Table 8). Values of overlap indicated that diets of mallards and blue-winged teal were nearly identical (C_o = 0.98). Mallards and blue-winged teal had almost no foods in common with other sympatric species.

During fall, the main food item consumed by coots, gadwall, and wigeon on Sequoyah NWR was Eurasion milfoil. Morisita's index

Table 8. Diet overlap among coots and ducks during spring on Sequoyah NWR, Sooner Ponds, and Sooner Lake as measured by Morisita's (1959) Index.

		Coots	Gadwalls	Wigeon	Redheads	Mallards	Blue-winged Teal
Sequoyah NWR	Coots	1.00					
	Gadwall	0.36	1.00				
	Wigeon	0.31	0	1.00			
	Mallards	0.58	0.46	0	-	1.00	
	Blue-winged teal	0.13	0.02	0	-	0.64	1.00
Sooner Ponds	Coots	1.00					
	Gadwall	0.15	1.00				
	Wigeon	0.76	0	1.00			
	Redheads	0.43	0	0.86	1.00		
	Mallards	0	0	0	0	1.00	
Sooner Lake	Coots	1.00					
	Gadwall	0.99	1.00				
	Wigeon	0.98	0.99	1.00			
	Redhead	0.98	0.99	1.00	1.00		
	Mallards	0.02	0	0	0	1.00	
	Blue-winged teal	0.01	0.02	0	0	0.98	1.00

reflected this and were high among all 3 species (Table 9).

A similar situation to Sequoyah NWR was evident on Sooner Ponds during fall except naiad was the main food for coots and dabbling ducks. Values of overlap indicate that diets of coots, gadwall, wigeon, and mallards were almost identical (Table 9). Redheads differed from coots and dabbling ducks by eating narrow-leafed pondweed and accounted for the low overlap values among redheads and other sympatric species.

The highest values of food overlap during fall on Lake Carl Blackwell were among coots, gadwalls, wigeons, and redheads (Table 11) which consumed mostly naiad. Diet overlap for mallards was highest with coots (C_o = 0.57) because both coots and mallards ate smartweed seeds and naiad.

Summary of Food Habits of Coots and Sympatric Ducks

Although food habits of coots and ducks differed among reservoirs during spring and fall, a summary of the data shows major differences and similarities among coots and duck diets (Figure 1). Diets of coots and ducks were more similar during fall than spring. The major food for all species during fall was submergent vascular aquatic vegetation. During spring, diets of coots, wigeons, and mallards consisted of several major food items while redheads and gadwall ate foods from only 2 food groups. Mallards and blue-winged teal ate similar foods during spring.

Table 9. Diet overlap among coots and ducks during fall on Sequoyah NWR, Sooner Ponds, and Lake Carl Blackwell as measured by Morisita's (1959) Index.

		Coots	Gadwall	Wigeon	Redheads	Mallards
Sequoyah NWR	Coots	1.00				
	Gadwall	0.80	1.00			
	Wigeon	0.75	0.79	1.00		
Sooner Ponds	Coots	1.00				
	Gadwall	0.99	1.00			
	Wigeon	0.99	0.97	1.00		
	Redheads	0.24	0.24	.23	1.00	
	Mallards	0.98	0.97	1.00	0.23	1.00
Lake Carl Blackwell	Coots	1.00				
	Gadwall	0.86	1.00			
	Wigeon	0.90	0.96	1.00		
	Redheads	0.86	1.00	0.96	1.00	
	Mallards	0.57	0.34	0.36	.34	1.00

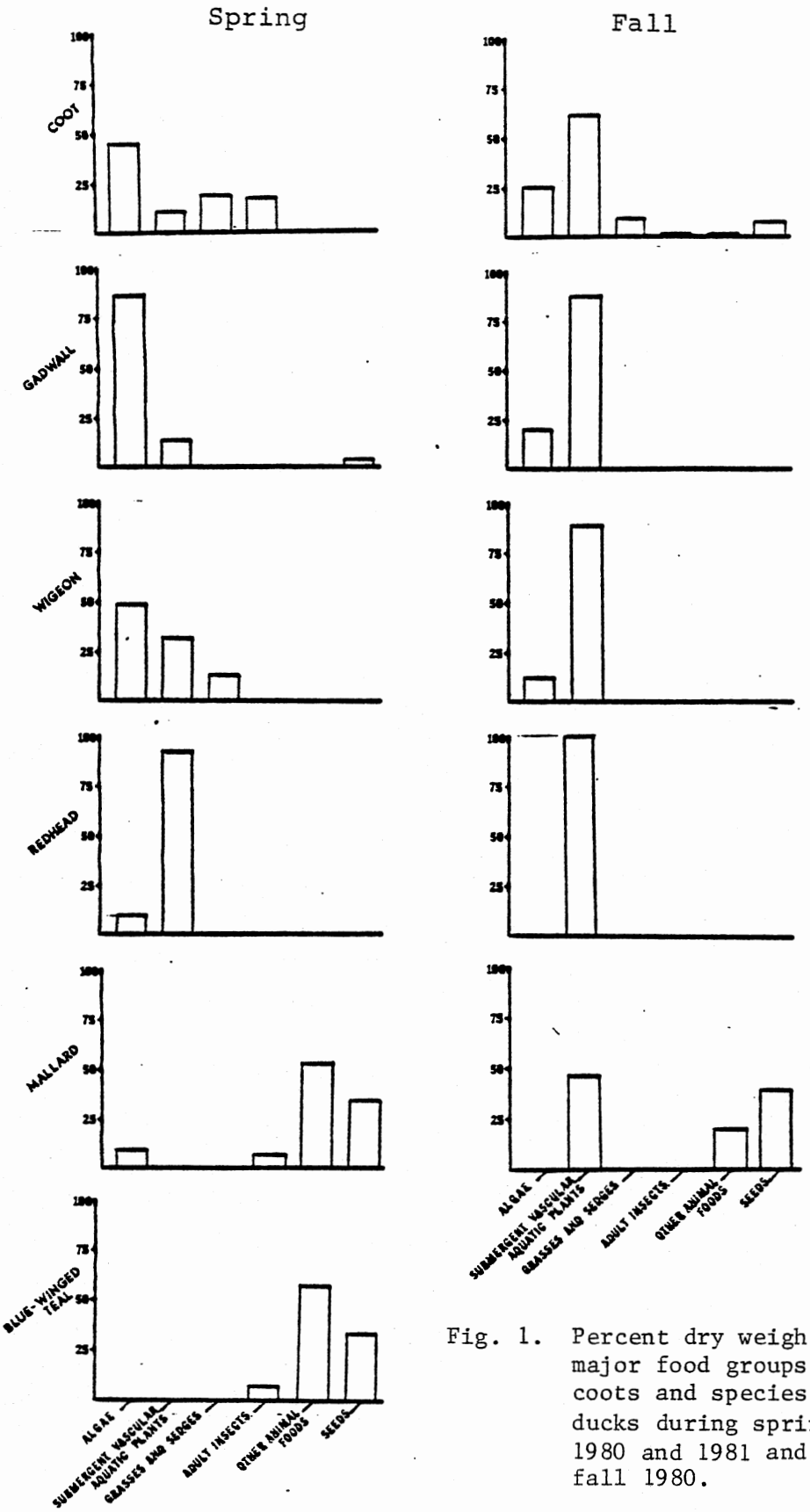

Fig. 1. Percent dry weight of major food groups of coots and species of ducks during spring 1980 and 1981 and fall 1980.

DISCUSSION

Spring Food Habits of Coots

Coots fed on a variety of foods in many habitats during spring. Algae was common during spring and was taken heavily. New-growth grasses were also important plant foods. Submergent vascular aquatic plants were uncommon during spring except on Sooner Ponds and hence were not consumed frequently.

By previous reports, animal foods were unimportant to coots except during summer (Jones 1940). However, insects were important components in diets of females during spring in the present study. Females may have eaten more insects than males in order to obtain high protein foods in preparation for breeding. Female dabbling ducks consumed animal foods during spring presumably to attain a physiological condition necessary for the egg laying period (Krapu 1974, Swanson et al. 1974a, Drobney and Fredrickson et al. 1978). The high incidence of animal food in female diets suggests that wetlands with high productivity (Heitmeyer 1980) may be important for adequate physiological development prior to the arrival on the breeding grounds. Arctic-nesting ducks and geese not in adequate physiological condition prior to the nesting period had either reduced clutch sizes or did not nest (Harvey 1971, Ankney and MacInnes 1978). Mallards attained body reserves used during the nesting period prior to their arrival on the breeding grounds (Krapu 1981). Wetlands used by coots during spring migration may be important to coots as areas to accumulate energy reserves used during the nesting period.

Fall Food Habits

Diets of coots during fall were similar to food habits reported by other researchers. Pondweeds, sedges, and algae were the predominate foods of coots during fall and winter from gizzard and gullet analyses (Jones 1940, Eley and Harris 1975, Fitzner et al. 1980). Although vegetation made up most of the foods from coots analyzed by Jones (1940), seeds were also important foods to certain coots. However, Jones (1940) did not indicate habitat types from which birds were collected. We found that seeds were important foods of coots feeding in stands of inundated smartweed. Coots fed on smartweed seeds by picking at the inflorescences.

During fall 1980, a significantly larger proportion of immatures than adults fed on Sequoyah NWR, perhaps in an attempt to accumulate fat reserves necessary for migration (Wypkema and Ankney 1979). Immatures need energy during summer for body growth and maintenance, while adults need energy for body maintenance and perhaps to return to a prebreeding weight. In adults, energy may accumulate as reserves, resulting in a better physiological condition during migration. Our results showed that immature gadwall had lower lipid levels than adult gadwall during fall migration in Oklahoma (Oklahoma Cooperative Wildlife Research Unit, unpublished data).

Comparison of Coots and Sympatric Ducks

Previous studies comparing diets of coots and ducks during fall indicated little overlap between dabbling ducks and coots (Munro 1939, Stollberg 1949). Coots ate the vegetative parts of plants, while dabbling ducks ate mainly seeds. Both coots and ducks ate aquatic

vegetation (i.e. Chara), but its abundance was great enough to preclude competition for food (Munro 1939). However, we note that these studies did not consider biases associated with gizzard content analyses (Swanson and Bartonek 1970).

We found that food overlap among coots, gadwall, wigeon, redheads, and mallards was high in certain feeding sites during fall, with overlap among coots, gadwall, and wigeon high in all feeding sites during fall. Redheads differed by eating large amounts of sago pondweed, while coots and dabbling ducks collected in the same area as redheads ate naiad.

Feeding behavior differed between redheads and other species collected. Coots and dabbling ducks fed by picking, while redheads fed by diving. This may partially explain the dietary differences since sago pondweed may have been more abundant at deeper water depths where redheads were feeding. Mallards differed from other ducks by consuming smartweed seeds and from coots and other ducks by eating animal foods during fall. However, most mallards used wetlands as loafing sites and fed in cultivated grain fields near the reservoirs.

Diet overlap among coots and ducks was less during spring than fall. Coots appeared to be food generalists during spring. Gadwall ate mostly algae during spring but had high diet overlap values with coots, wigeon, and redheads on Sooner Lake where algae was an important food. Only wigeons grazed on wheat on Sequoyah NWR. Diets of redheads were similar to those of coots, gadwall, and wigeons in particular feeding sites, however, redheads were present on the study area only during the first 3 weeks of March both years. Mallards and blue-winged teal were unique from other species by eating mostly aquatic animal

foods and seeds. Differences in diet between mallards and blue-winged teal were difficult to distinguish and larger sample sizes would be necessary to document differences.

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