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SPRING FEEDING ECOLOGY OF CINNAMON TEAL IN ARIZONA

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ABSTRACT.—I examined feeding behavior and diet of Cinnamon Teal (*Anas cyanoptera*) breeding on high-elevation (>1950 m) wetlands in northern Arizona to determine the dietary strategies this species uses to meet energy and nutrient demands from spring arrival through laying. Females spent more diurnal time feeding ($P < 0.001$) and contained more total food and a greater proportion (dry mass basis) of animal food ($P < 0.10$) than their mates. Invertebrate proportion of female diets varied ($P = 0.029$) among three reproductive categories (64–76%) and among three locations (64–85%), whereas male diets did not ($P = 0.179$). Aquatic dipterans and gastropods comprised 36% and 15% of female diets and 32% and 8% of male diets, respectively. Dietary strategies of Cinnamon Teal nesting on high-elevation wetlands in Arizona are similar to those of other *Anas* species breeding on prairie habitats. *Received 28 March 1994, accepted 2 Oct. 1994.*

Dabbling ducks (genus *Anas*) produce large clutches of eggs that have a high energy density and are large relative to female mass (King 1973). Females of most species rely to some extent on endogenous reserves acquired before or after arrival on breeding areas for the lipid component of clutch formation but use exogenous food sources to meet egg protein requirements (Alisauskas and Ankney 1992). To meet protein demands, females shift from a plant-dominated nonbreeding diet and forage intensively on protein-rich aquatic invertebrates prior to and during egg-laying (Krapu and Reinecke 1992, but see Wishart 1983). These data on dabbling duck feeding ecology are based primarily on studies conducted in the prairie pothole region, however, and may not reflect dietary patterns of populations or species breeding in other wetland landscapes (Krapu and Reinecke 1992).

The North American breeding range of the Cinnamon Teal (*A. cyanoptera*) is centered in the arid Great Basin and surrounding intermountain areas; a few pairs nest in the prairie pothole region (Bellrose 1980). In Arizona, Cinnamon Teal breed primarily on wetlands above 1950 m elevation, near the southern rim of the Colorado Plateau (Brown 1985). Early food habits studies indicated that breeding Cinnamon Teal rely primarily on plant foods (Mabbot 1920, Munro 1939, Martin et al. 1951, Spencer 1953), but these results are biased toward hard foods because contents of the gizzard, rather than the esophagus and proventriculus, were examined (Swanson and Bartonek 1970). I examined the diet and feeding behavior of Cinnamon Teal on high-elevation wetlands in Ari-

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zona. Based on studies of prairie-nesting *Anas* species, I predicted that paired females would spend more time feeding and feed to a greater extent on invertebrate foods than their mates and that diets of laying females would contain proportionately more animal foods than diets of pre-laying females. I also examined whether Cinnamon Teal diets differed among three sites differing in elevation and wetland habitat characteristics.

STUDY AREA AND METHODS

I studied Cinnamon Teal feeding ecology during March–June in 1992 and 1993 at three locations on the Colorado Plateau in northern Arizona: the Anderson Mesa, the White Mountains, and wastewater effluent wetlands located northwest of the White Mountains (see Brown 1985 and Piest and Sowls 1985 for detailed descriptions). On the Anderson Mesa (2100–2200 m elevation), Cinnamon Teal were most common on seasonal and semipermanent wetlands dominated by spikerushes (*Eleocharis* spp.), hardstem bulrush (*Scirpus acutus*), and smartweeds (*Polygonum* spp.). In the White Mountains (2500–2900 m elevation), Cinnamon Teal occurred primarily on large, semipermanent wetlands supporting water sedge (*Carex aquatilis*), manna grass (*Glyceria borealis*), and some bulrush and smartweeds. On two effluent marshes (1937 and 2048 m elevation), Cinnamon Teal fed in seasonally flooded habitats characterized by cattails (*Typha* spp.), bulrushes, spikerushes and a variety of annual seed-producing plants.

The two effluent wetlands and randomly selected wetlands on the Anderson Mesa (N = 40) and the White Mountains (N = 45) were censused weekly throughout the study period. Wetlands occupied by Cinnamon Teal were visited at least three times each week, and pairs on each wetland were randomly selected for 15-min focal time-activity sessions during early morning (one-half h before sunrise until 2 h after sunrise), mid-day (2 h after sunrise until 2 h before sunset), or late afternoon (2 h before sunset until 0.5 h after sunset) time periods. Each day, focal sessions were not conducted on the same pair more than once during any time period. Pair-bonds were identified before focal sessions, and verified during focal sessions, by the behavior of pair members toward each other and conspecifics. Behaviors (feeding or non-feeding) of both pair members were recorded at 10-sec intervals during each session.

I shot both members of 34 pairs (pair members were feeding <1 m from each other), and females from 18 additional pairs of Cinnamon Teal. All birds were observed feeding for >10 min before collection and contained >0.001 g (dry mass) of food. I removed the esophagus and proventriculus from each bird and stored them with their contents in 80% ethanol immediately after collection. I assigned females to the following reproductive categories: arrival/migrant—no developing ovarian follicles; RFG—≥ 1 follicle ≥ 6.0 mm and accumulating yolk, and no ruptured follicles; or laying—ruptured and developing follicles present. Males were assigned the reproductive status of their mate.

Food items from each bird were identified using standard references (Martin and Barkley 1961, Pennak 1978, Merritt and Cummins 1984), sorted, and dried (65°C) to constant mass. I calculated the aggregate percent dry mass (Swanson et al. 1974b) and frequency of occurrence of each food item for each sex, location, and reproductive status.

I used Wilcoxon signed-ranks tests (Daniel 1978) to make paired comparisons between sexes of (1) the percent time spent feeding by pairs during focal observations and (2) the proportion of animal foods in the diet and total dry mass of food contents in the 34 pairs of Cinnamon Teal I collected. For each sex (N = 54 females, 34 males), I used two-way ANOVA to test the effects of the independent variables reproductive category and location on the dependent variable animal proportion of the diet (dry mass) and Tukey's studentized range test to compare means among groups (PROC GLM; SAS Institute Inc. 1987). Because small sample sizes increased the likelihood of type II errors, I used an alpha level of 0.10 for all comparisons.

RESULTS

Paired female Cinnamon Teal spent a greater ($P < 0.001$) percentage of diurnal time feeding than did their mates in 1992 (65% versus 52%, N = 259 focal sessions) and 1993 (56% versus 48%, N = 323). Females in all reproductive categories contained more ($P < 0.01$) food (plant and animal) than did their mates (Table 1). Arrival/migrant and laying female diets contained a greater proportion of invertebrates ($P < 0.01$) than did their mates; RFG female diets also contained higher proportions of animal food than did their mates, but this difference was not significant ($P = 0.14$) (Table 1).

The animal proportion of female diets differed among reproductive categories and locations (Table 1). Invertebrate proportion of laying female diets was greater than in RFG female diets ($P < 0.10$), but neither of these groups differed ($P > 0.10$) from the invertebrate content of arrival/migrant female diets. Diets of females collected on effluent marshes contained more ($P < 0.05$) animal matter than diets of females collected on White Mountain wetlands, whereas the invertebrate proportion of female diets on Anderson Mesa wetlands was similar to other locations ($P > 0.10$). Male diets did not differ among reproductive categories or collection locations (Table 1).

Aquatic dipterans (primarily Chironomidae larvae) and snails (Gastropoda) were the most important animal foods in the diet for each sex, reproductive category, and location, together comprising 51% and 41% of the diet of females and males, respectively (Table 2). Chironomids comprised 42% (females) and 46% (males) of the diet of Cinnamon Teal collected on effluent marshes but <14% of the diet of birds collected at other locations. Aquatic coleopterans and hemipterans together comprised 24% of the diet of laying females but <6% of arrival/migrant and RFG female diets.

Seeds were the most common plant foods consumed (Table 2), and taxa varied among collection locations in accordance with the dominant seed-producing plants in wetlands used by Cinnamon Teal. In the White Mountains, *Carex* seeds accounted for 44% and 63% of plant foods in the diet of females and males, respectively, whereas *Eleocharis* (57% and 30%) and *Scirpus* (23% and 45%) dominated the plant diet of Cinnamon Teal on the Anderson Mesa. On effluent marshes, *Eleocharis* (33%) and *Polygonum* (39%) seeds comprised the majority of plant foods in the diet

TABLE 1

DIET CHARACTERISTICS OF CINNAMON TEAL IN NORTHERN ARIZONA, 1992–1993

Location	Reproductive category				Statistical analyses[a]			
	Arrival/migrant	RFG	Laying	Combined	Source	*F*	df	*P*
			Females					
Anderson Mesa	75.7[b] (8)[c]	41.2 (6)	71.0 (6)	64.1 (20)	Model[d]	2.96	8	0.03
White Mountains	36.4 (4)	54.3 (6)	68.1 (4)	52.2 (14)	Rep. status	2.37	2	0.10
Effluent wetlands	73.6 (9)	96.8 (6)	95.3 (3)	85.0 (18)	Location	4.50	2	0.02
Combined	67.3 (21)	64.4 (18)	75.7 (13)	68.3 (52)				
			Males					
Anderson Mesa	48.0 (5)	25.5 (5)	27.2 (3)	32.1 (13)	Model	1.69	8	0.18
White Mountains	39.7 (2)	80.0 (5)	50.5 (2)	47.3 (9)				
Effluent wetlands	87.4 (4)	59.6 (6)	25.0 (2)	60.8 (12)				
Combined	60.7 (11)	55.3 (16)	33.2 (7)	52.5 (34)				
	0.031[e]	0.563	0.029					
Mates combined[f]	63.1 (11)	66.4 (16)	71.7 (7)					
	0.162	0.897	0.044					

[a] Based on ANOVA with type III sums of squares.
[b] Mean percent (dry weight) animal foods in diet.
[c] Sample size.
[d] A nonsignificant ($P > 0.1$) interaction term (reproductive category × location) was not included in this model.
[e] Mean dry mass (g) of all esophageal food contents (plant and animal).
[f] Mean percent animal foods and dry mass of total food contents for females paired to males in each reproductive category.

TABLE 2

AGGREGATE PERCENT DRY MASS AND PERCENT FREQUENCY OF OCCURRENCE OF FOOD ITEMS CONSUMED BY CINNAMON TEAL IN NORTHERN ARIZONA, 1992–1993

	Females (N = 52)		Males (N = 34)	
Food item	Dry mass	Occurrence	Dry mass	Occurrence
Diptera[a]	35.8	85	32.6	71
(Chironomidae)	(21.1)	(60)	(20.8)	(50)
Gastropoda[b]	15.5	33	8.4	24
Hemiptera[c]	5.5	29	3.0	15
Coleoptera[d]	4.0	19	3.5	9
Ephemeroptera	1.7	4	0.6	6
Amphipoda	1.6	4	0	0
Cladocera	1.1	12	2.0	12
Ostracoda	0.9	15	0.3	9
Oligochaeata	0.8	2	0	0
Arachnida	0.5	10	0	0
Odonata	0.5	8	2.1	12
Trichoptera	0.4	2	0	0
Copepoda	tr[e]	2	0	0
Total animal	68.3	98	52.5	79
Seeds[f]	31.7	65	43.6	76
Plant material	0	0	3.9	12
Total plant	31.7	65	47.5	79

[a] Includes (in addition to Chironomidae) Ceratopogonidae, Chaoboridae, Culicidae, and unidentified adults and larvae.
[b] Includes Lymnaeidae, Physidae, and Planorbidae.
[c] Includes Corixidae and Notonectidae.
[d] Includes Curculionidae, Dytiscidae, Haliplidae, and unidentified.
[e] Trace ($<0.5\%$ aggregate percent dry mass).
[f] Includes *Carex, Echinochloa, Eleocharis, Glyceria, Polygonum, Potamogeton, Scirpus,* and unidentified.

of females, and *Polygonum* (44%) and *Scirpus* (36%) seeds were the primary plant foods consumed by males.

DISCUSSION

Diet comparisons with prairie-nesting species.—Cinnamon Teal are similar to other dabbling ducks in that the female diet contains a greater proportion of invertebrates during breeding than during the nonbreeding period (Krapu and Reinecke 1992). Plant foods comprised 63–91% of the diet during fall migration in the Rio Grande Valley (Thorn and Zwank 1993) and 67% of the diet on Mexican wintering areas (Migoya and Baldassarre 1993). In contrast, animal foods comprised 68% of the diet of females in this study and 30–74% of the diet of spring migrant females in the Rio Grande Valley (Thorn and Zwank 1993). Cinnamon Teal are also similar to several other dabbling ducks in that invertebrate consumption by breeding females was highest during laying (Krapu and Reinecke 1992).

Increased consumption of invertebrate foods by female Cinnamon Teal was probably related to protein demands associated with molt (Heitmeyer 1988) and with clutch production (Alisauskas and Ankney 1992). Females in all reproductive categories were engaged in prebasic molt (Gammonley, unpubl.; see also Thorn and Zwank 1993), and laying females also rely primarily upon exogenous sources to meet the large protein demands of clutch production (Gammonley, unpubl. data). The protein content of invertebrates is typically much higher than in most plant foods consumed by dabbling ducks (Krapu 1979). Thus, when invertebrate foods are readily available, molting and breeding female Cinnamon Teal likely meet their nutrient requirements more efficiently with an invertebrate-dominated diet.

Like many prairie-nesting *Anas* species, laying Cinnamon Teal use stored lipid reserves during clutch production (Gammonley, unpubl., Alisauskas and Ankney 1992). In contrast to large-bodied species such as the Mallard (*A. platyrhynchos*; Krapu 1981) that can acquire lipid reserves before arrival on breeding areas, female Cinnamon Teal obtain reserves after arrival in Arizona, prior to and during RFG (Gammonley, unpubl. data). By feeding >50% of diurnal hours, female Cinnamon Teal apparently obtain sufficient lipids to acquire reserves from a diet of invertebrates and seeds, despite the relatively low lipid content of these foods (Krapu 1979).

Although important invertebrate taxa (dipterans and gastropods) were similar, the invertebrate proportion of the diet of laying female Cinnamon Teal on high-elevation wetlands in Arizona was less than for prairie-nesting Blue-winged Teal (*A. discors*). Invertebrates comprised 99% (volume) and 90–94% (dry mass) of laying female Blue-winged Teal diets in North Dakota (Swanson et al. 1974a, Swanson and Meyer 1977) and Saskatchewan (Young 1991), respectively. These species are morphologically similar, and Blue-winged Teal also depend on exogenous food sources to meet protein requirements of egg formation (Young 1991). Few Blue-winged Teal breed in Arizona (Brown 1985), so direct comparisons of diets of these species on the study area were not possible. I did not measure invertebrate abundance quantitatively, but higher invertebrate availability on prairie wetlands compared to high-elevation wetlands in Arizona may contribute to diet differences between Cinnamon and Blue-winged teal (see below).

Sex-related differences in feeding ecology.—Comparisons of the feeding ecology of breeding Cinnamon Teal pairs support the hypotheses that pre-breeding and breeding females select animal foods and require more food and feeding time than males. Differences between females and males in invertebrate proportion of the diet, mass of food contents, and time spent feeding can be attributed primarily to sex-related differences in nutritional requirements, because by comparing pair members collected while feeding together, I controlled any influences of time of day, season, weather, wetland habitat, and food item availability on selection of food resources (Krapu and Reinecke 1992). Laying female Gadwalls (*A. strepera*) also ate more invertebrates than did their mates (Serie and Swanson 1976) on prairie wetlands. Males do not molt before or during nesting (Gammonley, unpubl. data), and have a much lower energetic commitment to clutch formation than females (Alisauskas and Ankney 1992). Males do not use nutrient reserves from arrival through laying (Gammonley, unpubl. data) and apparently meet the energetic costs of vigilance and mate defense by feeding approximately 50% of diurnal hours.

Diet differences related to location.—Invertebrate foods, and particularly chironomids, comprised a higher proportion of foods consumed by female Cinnamon Teal on effluent marshes than on White Mountain wetlands. Chironomids dominated the invertebrate community at effluent marshes (Piest and Sowls 1985), whereas few chironomids were detected in a study of invertebrate communities on White Mountain wetlands (Buege 1993). My qualitative observations suggest that overall invertebrate abundance on Anderson Mesa wetlands is intermediate between effluent marshes and White Mountain wetlands. Differences in water quality (Stull and Kessler 1978, Piest and Sowls 1985), elevation and dominant vegetation among these three locations may influence invertebrate community characteristics (Reid 1985). Cinnamon Teal apparently forage on chironomids when they are available and abundant, as do many prairie-nesting ducks (Swanson and Meyer 1977, Woodin and Swanson 1989). On high-elevation natural wetlands in Arizona, Cinnamon Teal apparently meet the nutrient and energy requirements of breeding from a diet comprised of various invertebrate and seed taxa.

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