Activity Patterns of Dabbling Ducks Wintering in Coastal South Carolina

Brian T. Gray,[1] *Delta Waterfowl and Wetlands Research Station, Atlantic Flyway Substation, Star Route 1, Box 226, Georgetown, SC 29440; and Department of Wildlife and Fisheries, Mississippi State University, Box 9690, Mississippi State, MS 39762*

David H. Gordon,[2] *Delta Waterfowl and Wetlands Research Station, Atlantic Flyway Substation, Star Route 1, Box 226, Georgetown, SC 29440; and Department of Wildlife and Fisheries, Mississippi State University, Box 9690, Mississippi State, MS 39762*

Richard M. Kaminski, *Department of Wildlife and Fisheries, Mississippi State University, Box 9690, Mississippi State, MS 39762*

Abstract: Nearctic dabbling ducks (Anatini) use varied wintering habitats. Spatial and structural variability among these may translate into differing capabilities of habitats to meet behavioral and physiological requirements of ducks. Our study was conducted on the Santee River Delta (SRD) in South Carolina, an important wintering area for dabbling ducks in the Atlantic Flyway. Our objectives were to determine (1) activities of dabbling ducks wintering on the SRD, (2) if different habitats within managed wetlands had differing functional values (intra-and interspecific), based on dabbling duck behavioral usage, and (3) if there were intraspecific differences in activity patterns between those observed in this study and those reported for other continental wintering locations. We quantified activities of northern pintail (*Anas acuta*), American green-winged teal (*A. crecca carolinensis*), American wigeon (*A. americana*), gadwall (*A. strepera*), northern shoveler, (*A. clypeata*), mallard (*A. platyrhynchos*), and blue-winged teal (*A. discors*) by sex and habitat type. Frequency of activities differed ($P < 0.001$) between male and female pintail, green-winged teal, shoveler, and mallard in some habitats, but did not differ ($0.06 < P < 0.90$) between male and female wigeon, gadwall, and blue-winged teal in any habitats. Although activity patterns were similar among certain species, the frequency of occurrence of activities generally differed ($P < 0.05$) among habitats within species and among species within habitats. Frequency of occurrence of feeding, resting, and swimming differed ($P < 0.05$) most among species, whereas comfort, alert, and

[1] Present address: Institute For Wetland and Waterfowl Research, Stonewall P.O. Box 1160, Oak Hammock Marsh, MB, Canada R0C 2Z0

[2] Present address: U.S. Fish and Wildlife Service, 7030 Bears Bluff Road, Wadmalaw Island, SC 29487.

courtship activities differed least. Pintail, mallard, gadwall, blue-winged teal, and green-winged teal spent substantially more diurnal time feeding in the SRD than in any other wintering area previously studied. We hypothesize that greater feeding frequency in the SRD may be explained by ambient temperatures below lower critical temperatures and by reliance on natural foods with lower metabolizable energy than agricultural seeds. We recommend against the introduction of agricultural foods to the SRD as a management option; rather, we believe that current management practices in the SRD will continue to provide important habitat for a wintering dabbling ducks and other wildlife.

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Migration and wintering periods are important phases of waterfowl life cycles that influence birds' survival and/or reproduction (Heitmeyer and Fredrickson 1981, Krapu 1981, Hepp et al. 1986, Kaminski and Gluesing 1987). Nearctic dabbling ducks (Anatini) use varied wintering habitats. For example, the same species may be found wintering in tropical regions with mild climates (Baldassarre et al. 1989, Thompson and Baldassarre 1991), temperate regions with wet (Gordon et al. 1989, Chabreck et al. 1989, Reinecke et al. 1989) or dry (Anderson and Ohmart 1988, Heitmeyer et al. 1989) climates, and temperate harsh climates (Ball et al. 1989, Jorde et al. 1984, Ringleman et al. 1989). Indeed environmental characteristics of habitats vary, differing in climate, physiognomy, floristic composition, hydrology, predator communities, and food resources. Therefore, variability among habitats may translate into differing capabilities of habitats to meet fundamental requirements of wintering dabbling ducks.

Theoretically, as individuals occupy given habitats during winter, they should invoke strategies to allocate activities in time and space to meet immediate and subsequent life-cycle requirements. Previous studies have shown that intraspecific activities vary geographically, suggesting this variability is at least partially due to regional environmental differences (Paulus 1988, Thompson and Baldassarre 1991). Additionally, intraspecific activity patterns may vary among habitats within geographic regions (e.g., Paulus 1984, Rave and Baldassarre 1989).

Understanding the role of behavior in habitat use and selection is fundamental to formulating effective management to sustain populations (Verner 1975). By quantifying behavior within habitat types, functional roles of habitats can be discerned. An improved understanding of functional significance of habitats used by dabbling ducks during winter should allow managers to enhance these areas for wintering ducks and other avifauna (Gray et al. 1987).

South Carolina is an important wintering area for waterfowl of the Atlantic Flyway, particularly dabbling ducks (*Anas* spp.) (Gordon et al. 1987, 1989). Based on U.S. Fish and Wildlife Service Midwinter Waterfowl Survey data (1970–1986), South Carolina harbored 25% of all dabbling ducks present in the entire Atlantic Flyway, including 54% of the American green-winged teal, 50% of the northern shoveler, 35% of the mallard, 32% of the northern pintail, 32% of the American wigeon, and 31% of the gadwall (Gordon et al. 1987). Furthermore, managed wetlands in coastal South Carolina are important to all these species (Prevost 1987, Strange 1987).

Our study was undertaken to determine: (1) activities of dabbling ducks wintering in coastal South Carolina, (2) if habitats within managed brackish wetlands had differing functional values (intra- and interspecific) for dabbling ducks, and (3) if there were intraspecific differences in activity patterns between those observed in this study and those reported for other wintering locations.

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Methods

Study Area

Our study was conducted during the 1985–86, 1986–87, 1987–88 winters on the Santee River Delta (SRD) (32°–34° N), east of U.S. Highway 17 approximately 24 km south of Georgetown, South Carolina (Gordon et al. 1989). The SRD encompases 19,503 ha, including 8,031 ha of managed brackish wetland impoundments, 1,605 ha of tidal freshwater marsh, 2,641 ha of brackish marsh, and 7,226 ha of salt marsh (Tiner 1977). Nearly all impoundments east of Highway 17 are brackish impoundments and are located within the brackish and salt marsh zones of the Delta. Generally, extreme tidal amplitude (1.2 m/day [Natl. Ocean. and Atmos. Admin. 1992]) prevents growth of preferred waterfowl food plants outside managed wetland impoundments (Strange 1987). Tidal brackish marsh is dominated by giant cordgrass (*Spartina cynosuroides*), smooth cordgrass (*S. alterniflora*), and black needlerush (*Juncus roemerianus*), and the tidal salt marsh is dominated by smooth cordgrass, marsh-hay cordgrass (*S. patens*), and salt grass (*Distichlis spicata*). Therefore, due to limited food availability for dabbling ducks, extreme tidal amplitudes, and human disturbances, unmanaged marsh in the SRD receives little wintering use by *Anas* spp. (Gordon et al. 1987, 1989).

Wetland management in the SRD encourages growth of certain naturally occurring plant communities to provide high quality waterfowl foraging habitat (Gordon et al. 1989). Target species in managed brackish impoundments include saltmarsh bulrush (*Scirpus robustus*), sprangletop (*Leptochloa* sp.), dwarf spikerush (*Eleocharis parvula*), and widgeon grass (*Ruppia maritima*). Managed impoundments in the salt marsh zone have plant communities dominated by widgeon grass, muskgrass (*Chara* sp.), and sea purslane (*Sesuvium* sp.). Our study focused on managed brackish wetlands, because our concurrent investigation of dabbling duck habitat associations indicated that virtually all dabbling ducks within the SRD restricted their activities to these wetlands (Gordon et al. 1987, Gordon et al. unpubl. data). These managed wetlands are shallow (average depth 22 cm), generally hard-bottomed, and seldom ice-covered.

Winters along the South Carolina coast are relatively mild due to the southerly latitude, low elevation, and influence of the Atlantic Ocean and northward-flowing Gulf Stream (Purvis 1987). Average temperatures (min.-max.) for December through February range from 2.6–15.9 C. Mean annual precipitation ranges between 114–139 cm, with an average monthly precipitation of 9 cm for December through February.

Waterfowl hunting occurred throughout the SRD during December and January on public and private lands. Waterfowl hunts on most managed wetlands in coastal South Carolina are limited to ≤2 times per week (mornings only), and the density of hunters on any given property is low. Most managers and landowners minimize hunting disturbance to allow waterfowl maximum opportunity to use managed habitats.

The dabbling duck guild in the SRD is composed primarily of mallard, northern pintail, American green-winged teal, American wigeon, gadwall, blue-winged teal, and northern shoveler. Dominant habitats in the managed brackish wetlands included open water areas dominated by widgeon grass and dwarf spikerush (hereafter referred to as open water), saltmarsh bulrush, smooth cordgrass, black needlerush, sprangletop, and salt grass (Gordon et al. 1987). These 7 duck species and 6 habitat types were selected for study.

Behavioral Observations

Four-sided plywood observation blinds, mounted atop 6-m platforms, were erected in managed brackish wetlands to overlook as many different habitat types as possible. When possible, blinds were placed on interior dikes so ducks could be observed 360° around the blind. Four and 6–7 blinds were used during winters 1985–86 and 1986–88, respectively.

One or 2 observers recorded diurnal (sunrise to sunset) duck activities 5–6 days per week from mid-December through mid-March each winter. Diurnal periods were divided into 3 equal time blocks, and the blocks into 3 1-hour observation periods. On each sampling day, observation period (first, middle, or last hour) and site were randomly selected for each time block. This protocol assured that observations were equally distributed across diurnal periods and habitats.

Due to number of duck species observed, habitats investigated, and labor constraints, we used a modified scan-sampling approach (Altman 1974) to quantify dabbling duck behavior (Gray et al. 1987). Activity data were recorded using a cassette tape recorder and a 15-60x spotting scope. Observations were initiated 15 minutes after an observer entered a blind to allow birds to settle. During this interval, observers recorded date, time, and weather conditions, and randomly selected a side (i.e., front, rear, left, or right) of the blind to begin observations. When observation commenced, a clockwise scan of habitats within approximately 500 m of the blind was initiated, with the observer recording species, sex, activity, and habitat for each individual duck observed. The procedure continued until a 360° scan around the tower was completed or 1 hour elapsed, whichever event occurred first. We categorized activities as feeding, resting, swimming, comfort movements, alert, courtship, agonistic, or flying. The habitat type assigned to each observed duck was defined as the most prevalent habitat type within a 3 m radius of the bird.

Analyses

Dabbler activity budgets were estimated by calculating percentage of time spent in activities relative to classification criteria. Because our primary objective was to discern activity patterns of dabbling ducks within each of the major habitat types within the managed wetlands of the SRD, we pooled data across years to maximize sample sizes. Activity budgets were first calculated for males and females separately within habitats. Next, sexes were pooled for assessment of intra- and interspecific activity patterns among and within habitats, respectively. Percentages were calculated using all behavior data combined, rather than using individual scans as replicates. Therefore, all statistical analyses were based on tests of frequency data. Chi-square tests of independence (Daniel 1990:181–187, Systat 1990) were used to test the null hypotheses that frequencies of each species' activities (first criterion of classification) were similar between sexes (second criterion of classification) within habitats. Additionally, a simultaneous G test (Sokal and Rohlf 1981:728–747) was performed to test if frequencies of each activity (first criterion of classification) differed among duck species within habitats or among habitats within duck species (second criteria of classification). We decided *a priori* to conduct analyses only when second criteria of classification column totals were ≥100. Additionally, due to the range of sample sizes (i.e., $231 \leq N \leq 66{,}566$) in the various contingency tables, we decided *a priori* to deem activities not significantly different when $P \geq 0.05$, or not substantively different when there was ≤3% difference in activities between/among the second criteria of classification (Turnbull and Baldassarre 1987).

Results

We conducted approximately 500 hours of observations during the three winters. Insufficient numbers of observations were obtained from the black needlerush habitat; therefore, this habitat was eliminated from further analyses. Total observations of 66,566 northern pintail, 31,364 American green-winged teal, 14,945 American wigeon, 10,273 northern shoveler, 7,966 gadwall, 3,324 mallard, and 3,490 blue-winged teal were obtained from the other 5 habitats (Table 1).

Table 1. Percent occurrence of diurnal activities by dabbling ducks in managed brackish habitats, coastal South Carolina, December–March 1985–86–1987–88

Habitat/	Northern pintail			Green-winged teal			Northern shoveler			Mallard			American wigeon			Gadwall			Blue-winged teal		
Activity	Male	Female	Both	Male	Female	Both	Male	Female	Both	Male	Female	Both	Male	Female	Both	Male	Female	Both	Male	Female	Both
Open water																					
Feed	71.0	76.5*[a]	72.6	60.1*	54.7	58.4	43.0	48.4	44.8	44.8	49.8	46.8	67.2	69.4	68.0	68.1	70.9	69.3	40.1	40.8	40.4
Rest	3.1	3.7	3.3	3.8	5.1	4.2	3.2	2.8	3.1	7.6	5.5	6.8	2.7	3.2	2.9	2.1	1.6	1.9	3.2	4.0	3.5
Swim	15.5	13.2	14.8	25.6	31.0*	27.3	39.7	38.2	39.2	30.0	32.8	31.1	21.5	20.1	21.0	18.4	17.6	18.1	43.7	43.6	43.7
Comfort	3.5	2.6	3.2	3.1	3.8	3.3	6.5	4.7	5.9	7.8	4.6	6.5	4.3	3.7	4.1	5.0	4.7	4.9	5.2	3.6	4.5
Alert	3.5	2.1	3.1	2.7	2.6	2.7	2.7	2.1	2.5	7.0	3.8	5.7	3.3	2.8	3.1	5.2	4.7	5.0	4.6	4.5	4.6
Courtship	2.6	1.3	2.2	3.7	2.1	3.2	1.2	1.1	1.2	0.9	1.6	1.2	0.1	0.2	0.1	0.7	0.2	0.5	0.8	1.0	0.9
Agonistic	0.3	0.2	0.3	0.6	0.2	0.5	0.8	0.4	0.7	0.5	0.5	0.5	0.6	0.3	0.5	0.3	0.2	0.3	0.6	0.5	0.6
Fly	0.5	0.4	0.5	0.4	0.5	0.4	2.9	2.3	2.7	1.4	1.4	1.4	0.3	0.3	0.3	0.2	0.1	0.2	1.8	2.0	1.9
N	24,365	10,176	34,541	9,025	4,075	13,100	1,624	809	2,433	554	366	920	6,458	3,757	10,215	2,176	1,615	3,791	871	606	1,477
Saltmarsh bulrush																					
Feed	46.7	52.0*	48.3	62.3	67.8*	64.6	54.9	61.9*	57.2	54.4	60.5*	57.1	61.1	66.0	63.1	76.0	77.9	76.8	62.2	67.0	64.4
Rest	20.3	24.2*	21.4	21.6*	18.6	20.4	20.2	17.9	19.5	11.0	10.4	10.7	13.1	11.3	12.4	4.2	4.8	4.5	11.1	10.5	10.8
Swim	16.0	13.1	15.2	10.0	7.8	9.1	13.9*	10.5	12.8	17.2	18.2	17.6	16.2	14.5	15.5	11.1	10.3	10.7	16.6	14.4	15.6
Comfort	7.3	5.4	6.7	3.9	4.2	4.0	6.3	5.9	6.2	6.3	4.0	5.3	5.7	5.0	5.4	3.3	2.9	3.1	5.8	4.7	5.3
Alert	6.4*	3.3	5.5	1.2	1.2	1.2	1.4	1.0	1.3	9.0*	4.8	7.1	2.7	1.9	2.4	3.7	3.4	3.6	3.0	1.8	2.5
Courtship	2.3	1.3	2.0	0.6	0.2	0.4	0.6	0.4	0.5	0.5	0.4	0.5	0.1	0.1	0.1	0.8	0.2	0.5	0.3	0.4	0.3
Agonistic	0.2	0.1	0.2	0.2	0.1	0.2	0.3	0.2	0.3	0.2		0.1	0.1	0.4	0.2	0.3	0.1	0.2	0.2	0.4	0.3
Fly	0.8	0.6	0.7	0.2	0.1	0.2	2.4	2.2	2.3	1.4	1.7	1.5	1.0	0.8	0.9	0.6	0.4	0.5	0.8	0.8	0.8
N	19,353	8,013	27,366	5,121	3,610	8,731	3,832	1,823	5,655	1,179	947	2,126	1,542	1,059	2,601	2,065	1,635	3,701	604	493	1,097
Salt grass																					
Feed	19.2	23.7*	20.7	31.7	41.9*	36.2	23.2	25.4	24.0	25.2	22.8	24.1	56.6	62.7	59.2	64.0	65.1	64.5			
Rest	57.7	60.9	58.7	56.9*	49.8	53.8	65.7	66.6	66.0	48.3	51.2	49.6	32.2	30.8	31.6	11.2	16.0	13.4			
Swim	4.1	3.0	3.7	1.0	1.0	1.0	2.9	1.8	2.5	8.6	7.1	7.9	4.1	1.5	3.0	7.2	7.6	7.4			
Comfort	12.0	9.3	11.1	8.1	6.3	7.3	6.7	5.1	6.1	11.9	13.4	12.6	3.7	1.5	2.8	5.6	4.7	5.2			
Alert	6.2	2.9	5.1	1.7	0.7	1.3	0.6	0.5	0.6	6.0	5.5	5.8	3.0	2.5	2.8	4.0	1.9	3.0			
Courtship	0.4	0.1	0.3	0.1		0.1	0.3	0.3	0.3					0.5	0.2	8.0	3.8	6.1			
Agonistic	0.1		0.1	0.3	0.1	0.2	0.3		0.2				0.4	0.5	0.4		0.9	0.4			
Fly	0.3	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.3												
N	1,602	765	2,367	1,169	926	2,095	1,417	768	2,185	151	127	278	270	204	474	125	106	231			

Continued

Table 1. (Continued)

Habitat/ Activity	Northern pintail			Green-winged teal			Northern shoveler			Mallard			American wigeon			Gadwall			Blue-winged teal		
	Male	Female	Both	Male	Female	Both	Male	Female	Both	Male	Female	Both	Male	Female	Both	Male	Female	Both	Male	Female	Both
Smooth cordgrass																					
Feed	36.7	43.8	38.5	[b]												80.4	79.9	80.2			
Rest	33.7	32.3	33.3													2.4	4.3	3.3			
Swim	13.0	10.3	12.3													5.5	4.4	5.0			
Comfort	7.3	4.1	6.5													4.7	4.4	4.6			
Alert	7.3	7.4	7.3													6.2	5.2	5.7			
Courtship	1.0		0.7																		
Agonistic		0.4	0.1														0.9	0.4			
Fly	1.0	1.7	1.2													0.8	0.9	0.8			
N	690	242	932													128	115	243			
Sprangletop																					
Feed	63.4	67.4	64.9	59.6	57.6	58.9							72.3	74.3	73.1				63.3	71.2	66.5
Rest	19.3	16.8	18.4	19.2	22.3*	20.3							6.4	5.8	6.2				7.5	7.2	7.4
Swim	4.8	7.2	5.7	8.9	8.1	8.6							10.1	8.3	9.4				13.4	10.8	12.3
Comfort	7.5	6.0	7.0	9.1	9.2	9.1							8.2	7.7	8.0				9.0	7.0	8.2
Alert	3.5	2.0	3.0	2.0	1.5	1.8							1.9	2.3	2.1				3.1	3.0	3.1
Courtship	1.2	0.4	0.9	0.5	0.2	0.4							0.1	0.4	0.2				0.4		0.2
Agonistic	0.2		0.1	0.5	0.8	0.6							1.0	1.0	1.0				2.4	0.3	1.5
Fly	0.1	0.2	0.1	0.2	0.3	0.2								0.2	0.1				0.9	0.5	0.7
N	862	498	1,360	4,809	2,629	7,438							968	687	1,655				545	371	916
All																					
Feed	58.5	63.8*	60.1	58.7	58.4	58.6	45.6	50.2*	47.1	49.2	54.5*	51.5	66.2	69.1	67.3	71.6	74.1	72.7	53.0	57.3	54.8
Rest	12.9	15.0	13.5	15.3	17.3	16.0	25.8	25.5	25.7	13.0	12.7	12.9	5.8	6.0	5.9	3.6	3.9	3.7	6.7	7.0	6.8
Swim	15.1	12.6	14.4	16.2	15.7	16.0	17.5	15.1	16.7	20.2	20.9	20.5	19.0	17.0	18.2	14.2	13.3	13.8	27.5	25.6	26.7
Comfort	5.5	4.1	5.1	5.1	5.4	5.2	6.5	5.4	6.1	7.2	5.0	6.2	4.9	4.3	4.7	4.5	3.9	4.2	6.4	4.8	5.7
Alert	4.9	2.7	4.2	2.1	1.7	2.0	1.5	1.2	1.4	8.2*	4.6	6.6	3.0	2.6	2.8	4.5	4.0	4.3	3.7	3.2	3.5
Courtship	2.3	1.2	2.0	1.9	0.9	1.5	0.6	0.5	0.6	0.6	0.7	0.6	0.1	0.2	0.1	0.9	0.3	0.6	0.5	0.5	0.5
Agonistic	0.2	0.1	0.2	0.4	0.3	0.4	0.4	0.2	0.3	0.3	0.1	0.2	0.6	0.4	0.5	0.3	0.2	0.3	0.9	0.4	0.7
Fly	0.6	0.5	0.6	0.3	0.3	0.3	2.1	1.9	2.0	1.3	1.5	1.4	0.4	0.4	0.4	0.4	0.3	0.4	1.3	1.2	1.3
N	46,872	19,694	66,566	20,124	11,240	31,364	6,873	3,400	10,273	1,884	1,440	3,324	9,238	5,707	14,945	4,495	3,471	7,966	2,020	1,470	3,490

[a]When the null hypothesis that activities were similar between sexes was rejected ($P < 0.05$) for a habitat × species combination, the * indicates a significantly ($P < 0.05$) greater occurrence of the activity for the indicated sex. However, when < 3% difference existed between sexes, we decided *a priori* to deem them not substantively different, regardless of statistical results.

[b]Blanks within partially completed columns denote that no observations were acquired; blank columns denote that <100 observations were made for males and/or females.

Male vs. Female Activities

Male-female activity patterns emerged enabling us to group species to facilitate presentation of results. We grouped pintail and green-winged teal, shoveler and mallard, and wigeon, gadwall, and blue-winged teal.

Northern Pintail and American Green-winged Teal. With the exception of green-winged teal observations in the smooth cordgrass habitat, adequate numbers of observations were recorded in all habitats for pintail and green-winged teal to proceed with analyses (Table 1). Frequency of activities differed ($P < 0.001$) between male and female pintail and green-winged teal in open water, saltmarsh bulrush, and salt grass habitats. Additionally, frequency of activities differed ($P < 0.01$) between male and female green-winged teal in sprangletop habitat, but did not differ between male and female pintail in sprangletop ($P = 0.106$) or smooth cordgrass ($P = 0.094$) habitats (Table 1).

Female pintail and green-winged teal fed more ($P < 0.025$) often than males of both species in saltmarsh bulrush and salt grass habitats. Female pintail also fed more ($P < 0.001$) than males in the open water habitat, whereas female green-winged teal fed less ($P < 0.001$) than males in this habitat. Female pintail rested more ($P < 0.001$) than males in saltmarsh bulrush, whereas female green-winged teal rested less ($P < 0.001$) than males in this habitat. Additionally, female green-winged teal rested more ($P < 0.001$) than males in sprangletop habitat and less ($P < 0.001$) than males in salt grass habitats. Finally, male pintail were alert more ($P < 0.001$) than females in saltmarsh bulrush and salt grass habitats, and female green-winged teal swam more ($P < 0.05$) than males in open water habitat.

When observations for all habitat types were combined for pintail, time spent in activities were significantly different ($P < 0.001$) (Table 1), with females feeding significantly more ($P < 0.001$) often than males. This result was not surprising inasmuch as 97% of all pintail observations were in open water, saltmarsh bulrush, and salt grass habitats; females fed more than males in all these habitats. When all observations for green-winged teal were combined across habitats, frequency of activities was not substantively different between sexes.

Northern Shoveler and Mallard. Sufficient numbers of observations were recorded for shoveler and mallard in open water, saltmarsh bulrush, and salt grass habitats (Table 1). Time spent in activities differed ($P < 0.001$) between males and females of both species in saltmarsh bulrush habitat, but did not differ in open water ($P \geq 0.121$) or salt grass ($P \geq 0.354$) habitats. In saltmarsh bulrush habitat, females of both species fed more ($P < 0.001$) than males; whereas, female shovelers swam less ($P < 0.001$) than males, and female mallards were alert less ($P < 0.001$) than males.

When all observations were combined across habitats, time spent in activities were significantly different ($P < 0.001$) between males and females of both species (Table 1), with females feeding more ($P < 0.001$) often than males. Additionally, female mallards were alert less ($P < 0.001$) than males. These results were not surprising inasmuch as 55% and 64% of the shoveler and mallard observations, respectively, were recorded in the saltmarsh bulrush habitat, which had similar patterns.

American Wigeon, Gadwall, and Blue-winged Teal. Time spent in activities did not differ ($0.061 \leq P \leq 0.909$) between male and female wigeon, gadwall, and blue-winged teal in any habitats (Table 1). Moreover, when all observations were combined, time spent in activities were either not statistically ($P > 0.10$) or substantively different between males and females of these species.

Activity Patterns among Habitats

Male and female data were pooled to assess intra- and interspecific activity patterns among and within habitats, respectively. Agonistic activities and flying were least frequently observed, seldom exceeding 1% occurrence of all activities. Moreover, neither activity ever exceeded 3% occurrence in any species by habitat combination (Table 1). Therefore, these activities were omitted from analyses. As with the analyses of male-female activities, we grouped species with similar activity patterns to facilitate presentation of results. Specifically, we grouped pintail, green-winged teal, shoveler, and mallard.

Northern Pintail, American Green-winged Teal, Northern Shoveler, and Mallard. Feeding was the most frequently observed activity by pintail, green-winged teal, shoveler, and mallard in all habitats, except salt grass (Table 1). The proportion of individuals feeding was greatest ($P < 0.05$) in open water (pintail) and saltmarsh bulrush habitats (green-winged teal, shoveler, and mallard), and least ($P < 0.05$) in salt grass habitat (Table 2). Resting and swimming were the next most frequently observed activities. Proportions of individuals resting were greatest ($P < 0.05$) in salt grass habitat, and least ($P < 0.05$) in open water habitat for these species. Conversely, proportions of individuals swimming were greatest ($P < 0.05$) in open water habitat, and least ($P < 0.05$) in salt grass habitat for all species except pintail. Comfort, alert, and courtship activities were observed less frequently than feeding, resting, and swimming activities (Table 1). The proportion of individuals in comfort activities differed ($P < 0.05$) among habitats for pintail, green-winged teal, and mallard (Table 2). The proportion of individuals in alert activities differed ($P < 0.05$) among habitats for pintail, and the proportion of individuals in courtship activities differed ($P < 0.05$) among habitats for green-winged teal (Table 2).

American Wigeon. Feeding was the most frequently observed activity of wigeon in all habitats (Table 1). The proportion of individuals feeding was greatest ($P < 0.05$) in sprangletop habitat and least ($P < 0.05$) in saltmarsh bulrush and salt grass habitats, which had similar ($P > 0.30$) occurrences of feeding (Table 2). Wigeon exhibited intermediate levels of feeding in open water habitat (Table 2). Resting and swimming were next most frequently observed. The proportion of individuals resting was greatest in salt grass habitat and least in open water habitat, with significant ($P < 0.05$) differences in resting among all habitats. Conversely, the proportion of individuals swimming was greatest in open water habitat and least in salt grass habitat, with significant ($P < 0.05$) differences in swimming among all habitats. Comfort, alert, and courtship activities were observed less frequently than feeding, resting, and swimming (Table 1). Comfort activities were less ($P < 0.05$) frequent in open water and

Table 2. Intra-specific patterns of percent time spent in diurnal activities within habitats in the Santee River Delta, South Carolina, 1985-86–1987-88. Only activities with differences among habitats are presented; different letters within rows indicate statistical significance ($P < 0.05$[a]).

Species/Activity	Open water	Saltmarsh bulrush	Salt grass	Smooth cordgrass	Sprangletop
Northern pintail					
Feed	72.6E	48.3C	20.7A	38.5B	64.9D
Rest	3.3A	21.4B	58.7D	33.3C	18.4B
Swim	14.8B	15.2B	3.7A	12.3B	5.7A
Comfort	3.2A	6.7B	11.1C	6.5B	7.0B
Alert	3.1A	5.5AB	5.1AB	7.3B	3.0A
Green-winged teal					
Feed	58.4B	64.6C	36.2A	[b]	58.9B
Rest	4.2A	20.4B	53.8C		20.3B
Swim	27.3C	9.1B	1.0A		8.6B
Comfort	3.3A	4.0A	7.3B		9.1B
Courtship	3.2B	0.4AB	0.1A		0.4AB
American wigeon					
Feed	68.0B	63.1A	59.2A		73.1C
Rest	2.9A	12.4C	31.6D		6.2B
Swim	21.0D	15.5C	3.0A		9.4B
Comfort	4.1A	5.4AB	2.8A		8.0B
Northern shoveler					
Feed	44.8B	57.2C	24.0A		
Rest	3.1A	19.5B	66.0C		
Swim	39.2C	12.8B	2.5A		
Gadwall					
Feed	69.3A	76.8B	64.5A	80.2B	
Rest	1.9A	4.5A	13.4B	3.3A	
Swim	18.1C	10.7B	7.4AB	5.0A	
Courtship	0.5A	0.5A	6.1B	0.0A	
Mallard					
Feed	46.8B	57.1C	24.1A		
Rest	6.8A	10.7B	49.6C		
Swim	31.1C	17.6B	7.9A		
Comfort	6.5A	5.3A	12.6B		
Blue-winged teal					
Feed	40.4A	64.4B			66.5B
Rest	3.5A	10.8C			7.4B
Swim	43.7B	15.6A			12.3A
Comfort	4.5A	5.3AB			8.2B

[a]Based on a simultaneous G test (Sokal and Rohlf 1981:728–730). However, when <3% difference existed between/among habitats, we decided *a priori* to deem them not substantively different, regardless of statistical results.

[b]Blank columns denote that $N < 100$ observations were made for males and/or females for the species by habitat combination.

salt grass habitats than in sprangletop habitat (Table 2). Alert activities did not differ substantively and courtship did not differ ($P > 0.70$) among habitats.

Gadwall. Feeding was the most frequently observed activity of gadwall in all habitats (Table 1). The proportion of individuals feeding was greatest ($P < 0.05$) in the saltmarsh bulrush and smooth cordgrass habitats (Table 2). Feeding occurred least

($P < 0.05$) in salt grass and open water habitats (Table 2). Swimming and resting were the next most frequently observed activities. The proportion of individuals swimming was greatest ($P < 0.05$) in open water habitat and least ($P < 0.05$) in smooth cordgrass habitat. The proportion of individuals resting did not differ substantively among open water, saltmarsh bulrush, and smooth cordgrass habitats, all of which had proportionately fewer ($P < 0.05$) individuals resting than did the salt grass habitat. Comfort, alert, and courtship activities were observed less frequently than feeding, resting, and swimming activities (Table 1). The proportion of individuals in comfort and alert activities did not differ substantively among habitats. The proportion of individuals performing courtship activities did not differ ($P > 0.30$) among open water, saltmarsh bulrush, and smooth cordgrass habitats, all of which had proportionately fewer ($P < 0.05$) individuals courting than in salt grass habitat (Table 2).

Blue-winged Teal. Feeding was the most frequently observed activity of blue-winged teal in all habitats except open water (Table 1). The proportion of individuals feeding did not differ ($P > 0.30$) between saltmarsh bulrush and sprangletop habitats, which had more ($P < 0.05$) individuals feeding than in open water habitat (Table 2). Swimming and resting were next most frequent activities. The proportion of individuals swimming did not differ ($P > 0.10$) between saltmarsh bulrush and sprangletop habitats, which had lower ($P < 0.05$) proportions of individuals swimming than did open water habitat. The proportion of individuals resting was greatest in saltmarsh bulrush habitat and least in open water habitat, with significant ($P < 0.05$) differences among all habitats. Comfort, alert, and courtship activities were observed less frequently than feeding, resting, and swimming activities (Table 1). Alert activities did not differ substantively, and courtship activities did not differ ($P > 0.05$) among habitats. The proportion of individuals performing comfort activities was greatest ($P < 0.05$) in the sprangletop habitat and least ($P < 0.05$) in the open water habitat (Table 2).

Interspecific Comparisons Within Habitats

Although activity patterns were similar among certain duck species, frequency of occurrence of activities generally differed ($P < 0.05$) among species within habitats (Table 3). Frequency of occurrence of feeding, resting, and swimming differed most frequently among species, whereas comfort, alert, and courtship activities differed least frequently.

Within open water habitat, shoveler, mallard, and blue-winged teal spent similar ($P > 0.05$) amounts of time feeding and had the lowest ($P < 0.05$) feeding rates of the 7 species. Pintail spent the most ($P < 0.05$) time feeding in this habitat, and gadwall, wigeon, and green-winged teal feeding rates were intermediate (Table 3). Conversely, pintail spent the least ($P < 0.05$) time swimming, while shoveler and blue-winged teal spent the greatest ($P < 0.05$) time swimming. With exception of mallards, resting, comfort, and alert activities did not substantively differ among species; and with exception of green-winged teal, courtship activities did not substantively differ among species.

Within saltmarsh bulrush habitat, pintail spent the least ($P < 0.05$) and gadwall

Table 3. Inter-specific patterns of percent time spent in diurnal activities within habitats in the Santee River Delta, South Carolina, 1985–86—1987–88. Only activities with inter-specific differences are presented; different letters within rows indicate statistical significance ($P < 0.05$[a]).

Habitat/Activity	Northern pintail	Green-winged teal	American wigeon	Northern shoveler	Gadwall	Mallard	Blue-winged teal
Open water							
Feed	72.6D	58.4C	68.0B	44.8A	69.3B	46.8A	40.4A
Rest	3.3A	4.2AB	2.9A	3.1A	1.9A	6.8B	3.5AB
Swim	14.8A	27.3C	21.0B	39.2D	18.1B	31.1C	43.7D
Comfort	3.2A	3.3A	4.1AB	5.9AB	4.9AB	6.5B	4.5AB
Alert	3.1AB	2.7A	3.1AB	2.5A	5.0AB	5.7B	4.6AB
Courtship	2.2AB	3.2B	0.1A	1.2AB	0.5AB	1.2AB	0.9AB
Saltmarsh bulrush							
Feed	48.3A	64.6C	63.1C	57.2B	76.8D	57.1B	64.4C
Rest	21.4C	20.4C	12.4B	19.5C	4.5A	10.7B	10.8B
Swim	15.2CD	9.1A	15.5CD	12.8BC	10.7AB	17.6D	15.6CD
Comfort	6.7B	4.0AB	5.4AB	6.2B	3.1A	5.3AB	5.3AB
Alert	5.5BC	1.2A	2.4A	1.3A	3.6AB	7.1C	2.5A
Salt grass							
Feed	20.7A	36.2B	59.2C	24.0A	64.5C	24.1A	[b]
Rest	58.7D	53.8CD	31.6B	66.0E	13.4A	49.6C	
Swim	3.7A	1.0A	3.0A	2.5A	7.4B	7.9B	
Comfort	11.1C	7.3BC	2.8A	6.1AB	5.2AB	12.6C	
Alert	5.1B	1.3A	2.8AB	0.6A	3.0AB	5.8B	
Courtship	0.3A	0.1A	0.2A	0.3A	6.1B	0.0A	
Smooth cordgrass							
Feed	38.5A				80.2B		
Rest	33.3B				3.3A		
Swim	12.3B				5.0A		
Sprangletop							
Feed	64.9B	58.9A	73.1C				66.5B
Rest	18.4B	20.3B	6.2A				7.4A
Swim	5.7A	8.6AB	9.4BC				12.3C

[a]Based on a simultaneous *G* test (Sokal and Rohlf 1981:728–730). However, when <3% difference existed between/among species, we decided a priori to deem them not substantively different, regardless of statistical results.

[b]Blank columns denote that $N < 100$ observations were made for males and/or females for the species by habitat combination.

spent the greatest ($P < 0.05$) amounts of time feeding; whereas gadwall spent least ($P < 0.05$) time resting, and pintail, green-winged teal, and shoveler spent greatest ($P < 0.05$) time resting. Swimming differed ($P < 0.05$) among species, with green-winged teal spending least and mallard spending greatest amounts of time swimming. With exception of pintail and shoveler, comfort activities did not substantively differ among species, and with exception of pintail and mallard, alert activities did not substantively differ among species. Courtship activities did not differ substantively among species.

Within salt grass habitat, insufficient observations were obtained for analyses of blue-winged teal. Within this habitat, mallard, shoveler, and pintail spent least ($P < 0.05$) time feeding; wigeon and gadwall spent greatest ($P < 0.05$) time feeding. Resting differed among species, with shoveler spending greatest ($P < 0.05$) time and gadwall spending least ($P < 0.05$) time resting. With exception of mallard and gadwall, time swimming did not substantively differ among species. With exception of pintail and mallard, alert activities did not substantively differ among species. Courtship activities were similar ($P > 0.20$) among all species except gadwall, which spent the greatest ($P < 0.05$) time in courtship activities. Comfort activities differed ($P < 0.05$) among species; wigeon spent least and pintail and mallard spent greatest amounts of time in comfort activities.

Within smooth cordgrass habitat, sufficient observations were obtained only for pintail and gadwall. Pintail spent more ($P < 0.001$) time resting and swimming and less ($P < 0.001$) time feeding in this habitat than did gadwall. Comfort, alert, and courtship activities did not differ ($P > 0.05$) between these species.

Within sprangletop habitat, sufficient observations were obtained for pintail, green-winged teal, wigeon, and blue-winged teal. In this habitat, wigeon spent greatest ($P < 0.05$) and green-winged teal spent least ($P < 0.05$) time feeding. Conversely, pintail and green-winged teal spent greatest ($P < 0.05$) and wigeon and blue-winged teal spent least ($P < 0.05$) time resting. Pintail spent least ($P < 0.05$) and blue-winged teal spent greatest ($P < 0.05$) time swimming. Comfort, alert, and courtship activities did not substantively differ among species.

Discussion

Male vs. Female Activity Patterns

Following an extensive literature review, Paulus (1988) concluded that few sexual differences exist in time spent feeding by nonbreeding Anatinae; however, when differences did exist, females generally fed more than males. Subsequent investigations supported this pattern (e.g., Turnbull and Baldassarre 1987, Rave and Baldassarre 1989, Thompson and Baldassarre 1991). Moreover, our results support these observations in that activities of wigeon, gadwall, and blue-winged teal did not differ between sexes in any habitats; and when activities differed between sexes for pintail, green-winged teal, shoveler, and mallard (8 of 15 species-by-habitat combinations), females spent more time feeding than males in 7 of 8 occasions. Only male green-winged teal in open water habitats fed significantly more often than females.

When feeding rates of females are higher than males, it has been suggested that males may feed less because they spend more time courting and guarding their mates (Jorde 1981, Miller 1985). This phenomenon was true in our study; when male pintail, green-winged teal, shoveler, and mallard fed less than females, they spent more of the diurnal period in alert (0%–143%), courtship (25%–300%), and agonistic (50%–200%) behaviors than females.

Functional Values of Habitats

Open Water. Open water habitats, which are managed for widgeon grass and dwarf spikerush in the SRD, provided important feeding areas for all 7 dabbling duck species, with pintail spending a greater percentage of time feeding in this habitat than in any of the other habitats. Additionally, compared with other habitats, all 7 species of waterfowl generally spent least time in resting and comfort activities and greatest time swimming in open water habitat (possibly swimming between foraging areas). Therefore, it appears that this habitat serves primarily as feeding areas for dabbling ducks wintering in the SRD. Foliage and seeds of widgeon grass and foliage, seeds, and tubers of dwarf spikerush are important food items for pintail, wigeon, gadwall, and teal (Kerwin and Webb 1972, Landers et al. 1976, Prevost et al. 1978). Additionally, mallards and shovelers are known to consume these food items, but not to the extent of the other mentioned species (Gordon et al. 1989). Although published information on invertebrate consumption by dabbling ducks in the SRD is not available, we noted all species, especially shoveler, blue-winged teal, and green-winged teal, feeding on emerging insects (e.g., Chironomidae) and filter feeding at the surface in open water habitats throughout winter (B. T. Gray and D. H. Gordon pers. observ.).

Saltmarsh Bulrush. Saltmarsh bulrush stands also provided important feeding areas for all 7 dabbling duck species in the SRD, with green-winged teal, shovelers, and mallards spending greater percentages of time feeding in this habitat than in any others. Saltmarsh bulrush seeds are important foods of mallards, teal, and pintails, and of less importance to wigeon, gadwall, and shovelers (Kerwin and Webb 1972, Landers et al. 1976, Prevost et al. 1978). We also noted all species, especially shoveler, blue-winged teal, and green-winged teal, feeding on emerging insects and filter feeding at the water surface in saltmarsh bulrush stands during winter. Therefore, it is possible that shovelers were primarily feeding on invertebrates in this habitat.

Sprangletop. Unlike saltmarsh bulrush, widgeon grass, and dwarf spikerush stands that can be managed effectively in the SRD, sprangletop stands usually occur sporadically in managed brackish marshes (Gordon et al. 1989). Nonetheless, sprangletop stands in the SRD provided important feeding areas for wigeon, pintail, green-winged teal, and blue-winged teal, with wigeon and blue-winged teal spending greater percentages of time feeding in this habitat than in any others. As with smooth cordgrass, sprangletop adds to the habitat diversity for aquatic invertebrates. Moreover, in other regions, it is known to harbor abundant invertebrate populations when flooded (R. M. Kaminski, unpubl. data).

Smooth Cordgrass. Smooth cordgrass, being a tall, robust emergent, provides good thermal cover for resting on windy days and pintail spent a relatively high percentage of time resting in this habitat. Smooth cordgrass is of no known food value for dabbling ducks, and its areal extent is often controlled through management in the SRD (Gordon et al. 1989); however, gadwall spent relatively more time feeding in this habitat than any other in the SRD. In managed impoundments, the plant typically occurs as small clumps well interspersed among small open water areas where widgeon grass and dwarf spikerush grow. Additionally, smooth cordgrass does add habitat diversity for aquatic invertebrates. Perhaps gadwall were feeding on widgeon grass, dwarf spikerush, and invertebrates in the smooth cordgrass habitat.

Salt Grass. As with smooth cordgrass, salt grass is believed to be of little nutritive value to dabbling ducks wintering in the SRD (Gordon et al. 1989). All species spent higher percentages of time resting and lower percentages of time in feeding and locomotion activities in this habitat compared with others. During winter in the SRD, salt grass typically occurs as a dense, flat vegetation mat at higher, infrequently flooded elevations within brackish marshes (Gordon et al. 1989). In contrast to other available habitats, only salt grass offers ducks sites where they can exit water to preen and rest, and also maintain vigilance for predators (D. H. Gordon and B. T. Gray, pers. observ.). Therefore, we conclude that salt grass habitats provided important resting areas for dabbling ducks in the SRD.

Comparisons with Dabbling Ducks in Other Regions

Paulus (1988:138) concluded that nonbreeding anatids average 20%–70% of their time feeding; 10%–50% resting; <20% in preening, alert, or locomotion activities; and <2% in social displays and agonistic activities. Overall, diurnal activities of pintail, green-winged teal, shoveler, and mallard were in these ranges in the SRD. However, wigeon, gadwall, and blue-winged teal rested <10% of the diurnal period, blue-winged teal spent >20% of the diurnal period swimming, and gadwall spent >70% of the diurnal period feeding. Below we compare individual species' activities with those reported for other regions.

Northern Pintail. Contrary to conclusions of Tamisier (1976), diurnal foraging was very important for pintail wintering in the SRD. Moreover, pintail spent more of the daytime feeding (60%) in the SRD than did conspecifics studied in Louisiana (5%–21% [Tamisier 1976, Rave and Cordes 1993]), California (21% [Miller 1985]), and Mexico (42%–48% [Thompson and Baldassarre 1991]). Pintail wintering in the SRD rely essentially on natural foods for their winter diet (Gordon et al. 1989) as do pintail wintering in Mexico (Thompson and Baldassarre 1991). Conversely, pintail studied in Louisiana and California forage heavily on rice, which provides relatively large quantities of foods with high metabolizable energy (Reinecke et al. 1989). It is generally accepted that waterfowl selecting foods of low water content and high energy value, such as agricultural grains, devote least amount of time to feeding (Baldassarre et al. 1983, Paulus 1988). Consequently, one would expect pintail to feed more often in the SRD than in agricultural areas, because the mass and energetic return of natural foods in the SRD are less than that of rice (Gordon et al. 1989). Additionally, lower daily temperatures, resulting in greater energy requirements for homeostasis, may have been a reason that pintail fed more in the SRD than in Mexico. For example, Thompson and Baldassarre (1991:938–939) estimated that pintail wintering in Yucatan, Mexico, experienced temperatures below the lower critical temperature (LCT) only 0–1% of the time; whereas, using Kendeigh et al.'s (1977:135) equation for estimating LCT, we estimated that pintail experienced temperatures below LCT >60% of the time while in the SRD. Other factors that may have contributed to different diurnal feeding rates include human and predator disturbance, diet composition, food availability, and nighttime activities.

Because pintail spent more time feeding in the SRD and Mexico than in other regions, it was not surprising that their other activities decreased accordingly. For example, swimming was reduced, but resting, comfort, and courtship activities were more prevalent in Louisiana (Tamisier 1976, Rave and Cordes 1993) and California (Miller 1985) than in Mexico (Thompson and Baldassarre 1991) and the SRD.

Green-winged Teal. Green-winged teal spent more of the daytime feeding (58%) in the SRD than did conspecifics in Louisiana (5%–33% [Tamisier 1976, Rave and Baldassarre 1989]) and Texas (<25% [Quinlan and Baldassarre 1984]). Green-winged teal in Louisiana and Texas relied heavily on rice and corn for food, respectively, which as discussed above, provide relatively large quantities of foods with high metabolizable energy compared with natural foods. Hence, again, one would expect green-winged teal to feed more in the SRD than in wintering areas with accessible agricultural seeds.

With respect to other activities, only resting differed substantively between SRD and other regions. Green-winged teal spent over twice as much time resting during the day in Texas (42%–67% [Quinlan and Baldassarre 1984]) and Louisiana (45% [Rave and Baldassarre 1989]) than in the SRD (16%). Reduced resting time in the SRD may be a consequence of greater time needed to acquire adequate food resources in the absence of agricultural fields.

American Wigeon. Overall, wigeon activities in the SRD were similar to those reported for conspecifics wintering in Alabama (Turnbull and Baldassarre 1987). However, Thompson and Baldassarre (1981), working in Mexico, reported lower percentages of time feeding (30%–49% in Mexico vs. 46%–74% in Alabama [Turnbull and Baldassarre 1987] and the SRD) and higher percentages of time swimming (30%–37% in Mexico vs. 11%–18% in Alabama [Turnbull and Baldassarre 1987] and the SRD). As with wigeon in the SRD, birds in Alabama and Mexico fed primarily on natural foods. Consequently, a plausible explanation for dissimilar feeding patterns between birds wintering in Mexico and the southern U.S. is climatic differences. Thompson and Baldassarre (1991:938–939) estimated that wigeon wintering in Yucatan, Mexico, experienced temperatures below LCT only 0–2% of the time, compared with 49%–99% of the time in Alabama. Furthermore, using Kendeigh et al.'s (1977:135) equation for LCT, we estimated that wigeon experienced temperatures below LCT > 60% of the time in the SRD. Therefore, greater energy requirements for homeostasis may be a reason that wigeon fed more in southern U.S. than in Mexico. Again, other factors, such as disturbance, diet, food availability, and nighttime activities, may be contributory.

Northern Shoveler. Overall, shoveler activities in the SRD were similar to those reported for conspecifics wintering in Mexico (Thompson and Baldassarre 1991). However, Christopher and Hill (1988), working on aquaculture ponds in Mississippi, reported higher percentages of time feeding (69% in Mississippi vs. 47% in the SRD) and lower percentages of time resting (11% in Mississippi vs. 26% in the SRD) and swimming (10% in Mississippi vs. 17% in the SRD). Factors that may have contributed to different diurnal feeding rates include temperature, disturbance, diet composition, food availability, and nighttime activities.

Gadwall. Paulus (1988), working in coastal Louisiana, reported relatively lower percentages of time feeding (64% in Louisiana vs. 73% in the SRD) and higher percentages of time resting (11% in Louisiana vs. 4% in the SRD) and alert (9% in Louisiana vs. 4% in the SRD). Because temperatures between the 2 regions are relatively similar and birds in both regions feed predominantly on natural foods, factors other than temperature, such as those mentioned earlier, may explain the different diurnal feeding rates.

Mallard. Mallards spent more of the daytime feeding (52%) in the SRD than did conspecifics studied in other wintering areas, such as Alabama (16%–36% [Turnbull and Baldassarre 1987]) and Nebraska (35% [Jorde et al. 1984]). However, mallards in Alabama and Nebraska relied heavily on cornfields, which as discussed above, provide relatively large quantities of foods with high metabolizable energy compared with natural foods. Therefore, it is not surprising that mallards fed more often in the SRD.

With respect to other activities, mallards spent less daytime resting (13%) and in comfort (6%), and more time swimming (20%) in the SRD than did conspecifics in Alabama (28%–49%, resting; 10%–17%, comfort; 13%–15%, swimming) and Nebraska (28%, resting; 18%, comfort; 13%, swimming). Reduced time available for resting and comfort activities and increased amount of time swimming in the SRD was likely a function of greater amount of time needed to acquire adequate food resources in the absence of agricultural habitats. Alert and agonistic activities were similar among the 3 regions (~5% and ≤1%, respectively), and mallards in Alabama devoted more time to courtship activities (2%–7%) than conspecifics in Nebraska and in the SRD, where they devoted <1% of their time to courtship.

Blue-winged Teal. Thompson and Baldassarre (1991), working in Mexico, reported relatively lower percentages of time feeding (38%–50% in Mexico vs. 55% in the SRD) and higher percentages of time resting (16%–25% in Mexico vs. 7% in the SRD). All other activities were similar. As with blue-winged teal in the SRD, birds in Mexico were reportedly feeding exclusively on natural foods. Consequently, a plausible explanation for dissimilar feeding patterns between birds wintering in Mexico and birds wintering in the SRD is climatic differences. Thompson and Baldassarre (1991:938–939) estimated that blue-winged teal wintering in Yucatan, Mexico, experienced temperatures below LCT only 0–4% of the time. Using Kendeigh et al.'s (1977:135) equation for estimating LCT, we estimated that blue-winged teal experienced temperatures below LCT > 80% of the time while in the SRD. Therefore, greater energy requirements for homeostasis could be the primary reason that blue-winged teal fed more often in SRD than in Mexico.

Management and Research Implications

Our results suggested that winter activity data gathered in 1 geographic area may not be applicable to birds in other areas. Therefore, as suggested by Rave and Baldassarre (1989), dabbling ducks seem to exhibit great flexibility in adjusting time budgets to regional habitat and/or climatic conditions. Consequently, determination of area-specific activity budgets of waterfowl seems necessary for proper management of local wintering populations.

Waterfowl management in the SRD is focused at providing a complex of wetland habitats that contain diversified diets of naturally occurring plant and invertebrate foods, which may in turn provide the needed balance of energy, protein, and minerals required by migrating and wintering waterfowl (Gordon et al. 1989). Our results showed that dabbling duck activities varied among habitats and among species within habitats in the SRD. Therefore, maintenance of a complex of managed wetlands seems warranted. However, further research is needed to discern (1) availability of invertebrate foods in these habitats during winter, (2) habitat-specific feeding ecologies of dabbling ducks, and (3) if and how ducks apportion time among available habitats. This research would help quantify importance of various invertebrate and plant foods in the diets of dabbling ducks and elucidate the best array of habitats to maximize food availability. Additionally, more information is needed about the type, distribution, and abundance of food as well as pursuit, handling, and feeding times of wintering dabbling ducks to explain observed geographic differences in dabbling duck foraging patterns.

Although we did not quantify activity budgets of dabblers at night, we obtained limited radio-telemetry information on mallard and pintail nocturnal activities (D. H. Gordon and B. T. Gray, unpubl. data), that suggested these species actively fed throughout night. Moreover, at dusk and throughout night, large flocks of mallard, pintail, teal, gadwall, and wigeon were observed moving among managed wetlands, presumably in feeding flights (D. H. Gordon and B. T. Gray, pers. observ.). Consequently, if these birds were disturbed during the day such that they could not forage as often as they do under current management practices, they might not be able to secure adequate resources to meet their overwintering or premigratory needs. By minimizing disturbance, managers allow waterfowl more opportunity to meet physiological and behavioral needs. Further research is needed to discern the impact of human disturbances on diurnal dabbling duck activities and thereby attempt to identify disturbance thresholds for dabbling ducks wintering in the SRD.

Managed wetlands in the SRD originated during the 18th-century rice industry and, outside the South Atlantic Coastal Zone, are globally unique (Gordon et al. 1989). In 1941, hydroelectric diversion of 80% of the freshwater flow from the Santee River to the Cooper River resulted in saltwater intrusion and conversion of the freshwater wetlands in the SRD to extensive brackish and saline emergent wetlands (Kjerve 1976). Consequently, soils and waters of most managed wetlands in the SRD have salt concentrations too high for the growth and propagation of most agricultural crops (Gordon et al. 1989). However, these managed wetlands produce a variety of naturally occurring plant and animal foods in a variety of habitats that benefit many taxonomic groups in addition to Anatini (Strange 1987, Epstein and Joyner 1988). Therefore, we and others (e.g., Strange 1987) do not believe agricultural crops should be introduced to the SRD as a management option. Instead, we believe that continued use of current habitat and disturbance management would continue to provide excellent habitat for dabbling ducks and other fish and wildlife species.

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