Winter Time-Activity Budgets of Diving Ducks on Eastern Texas Reservoirs

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Abstract.—Wintering diving duck (*Aythya spp.*) time-activity budgets have been developed for many species in different regions. As such, direct comparisons can be made among studies where substantial deviations in "normal" activity budgets can provide insight as to how location, food resources, habitat, weather and human disturbance may differentially influence behavior(s) during winter. To examine how diving ducks use large reservoirs in eastern Texas, 1,275 individual time-activity budgets were quantified for Canvasback (*Aythya valisineria*), Lesser Scaup (*A. affinis*) and Ring-necked Duck (*A. collaris*) wintering on B.A. Steinhagen, Sam Rayburn and Toledo Bend Reservoirs during winter 2003/2004 and 2004/2005. Behaviors varied among species ($P < 0.001$), where food acquisition, locomotion and resting-related behaviors dominated time-activity budgets. All three species spent similar time feeding compared to other studies in the southeastern United States, but spent substantially more time locomoting than previously reported. Human disturbances from boat traffic were associated with time spent locomoting, but no species dramatically increased time feeding to compensate for increased time locomoting. Wintering diving duck activity budgets on these large eastern Texas reservoirs were generally similar to previous studies in the southeast. However, the (in)direct impacts of boat disturbances warrants closer investigation, specifically related to wintering waterfowl responses and the potential utility or value of voluntary avoidance areas during winter. *Received 21 November 2008, accepted 19 March 2009.*

Key words.—*Aythya*, Canvasback, east Texas, Lesser Scaup, Ring-necked Duck, time-activity budgets, reservoirs, waterfowl behavior, wintering waterfowl.

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Several diving duck species have experienced long-term population declines throughout North America, resulting in reduced or altered bag limits, and shortened seasons (Austin *et al.* 2000; Afton and Anderson 2001). Loss, degradation and alteration of breeding, migrating and wintering habitats are thought to have contributed to these long-term declines (Baldassarre and Bolen 1994). Consequently, research has been performed on diving ducks during summer (Doty *et al.* 1984; Barzen and Serie 1990), migration (Serie and Sharp 1989; Hine *et al.* 1996; Knapton *et al.* 2000) and winter (Hohman 1984; Bergan *et al.* 1989; Hohman and Rave 1990; Day *et al.* 1993). Although reproductive success is thought to limit waterfowl populations, waterfowl are also affected by habitat and environmental changes (Hohman and Rave 1990) and human disturbances during other seasons (Havera *et al.* 1992; Korschgen and Dahlgren 1992; Knapton *et al.* 2000). For example, how waterfowl respond to variable conditions during winter may affect immediate survival, pair bond formation, migration timing and success, and eventually reproductive success (Haramis *et al.* 1986; Kaminski and Gluesing 1987).

Time-activity budget studies of wintering waterfowl provide insight into seasonal habitat use (Poulton *et al.* 2002; Michot *et al.* 2006), and the influence of hunting pressure, habitat changes, environmental variability and other disturbances on behavior (Hohman and Rave 1990; Michot *et al.* 1994; Knapton *et al.* 2000; Woodin and Michot 2006). Wintering waterfowl spend most of their time feeding and loafing (Paulus 1988; Bergan *et al.* 1989; Michot *et al.* 1994; Woodin and Michot 2006), but deviations from "normal" activity budgets may affect energy budgets, reduce survival and impair reproductive productivity and success in subsequent breeding seasons (Haramis *et al.* 1986; Paulus 1988). Therefore, wintering waterfowl time-activity budgets can be used to evaluate relative habitat/food quality and quantity, hypothesize about energy demands and/or ability to meet those demands, compare activity patterns within and among species in different geographic regions and project perceived responses to proposed management or conservation activities (Hohman 1984; Paulus 1988; Woodin and Michot 2006).

While many studies have focused on diving duck behavior (Hohman 1984; Bergan *et al.* 1989; Hohman and Rave 1990), nutritional ecology (Hoppe *et al.* 1986; Hohman *et al.* 1990; Hohman 1993) and population biology during winter (Hohman *et al.* 1993; Herring and Collazo 2004), no studies have quantified time-activity budgets specifically for diving ducks wintering in inland reservoirs in Texas. An estimated 97%, 99% and 98% of the Central Flyway populations of Canvasback (*Aythya valisineria*), Lesser Scaup (*A. affinis*) and Ring-necked Duck (*A. collaris*) respectively, winter in Texas (U.S. Fish and Wildlife Service 2003), where manmade reservoirs in east Texas provide potentially important wintering diving duck habitat. As such, waterfowl time-activity budgets on such reservoirs will (1) provide new insight into how diving ducks allocate time, (2) allow for speculation about how these birds meet dietary/energy demands, and (3) provide new information to improve reservoir management strategies to benefit waterfowl. Therefore, the objective of this study was to quantify diurnal time-activity budgets of Canvasback, Lesser Scaup and Ring-necked Duck wintering on Toledo Bend, Sam Rayburn, and B.A. Steinhagen Reservoirs in east Texas.

METHODS

Study Area

The research was conducted on Toledo Bend, Sam Rayburn and B.A. Steinhagen Reservoirs in east Texas (Fig. 1). Toledo Bend Reservoir encompasses almost 75,000 ha extending into portions of Newton, Panola, Sabine and Shelby counties, Texas, and De Soto and Sabine parishes, Louisiana. Impounded in 1966, with a maximum depth of approximately 35 m, the reservoir is managed for water, hydroelectric generation and recreation. Sam Rayburn Reservoir encompasses >46,000 ha, extending into portions of Angelina, Jasper, Nacogdoches, Sabine and San Augustine counties, Texas. Impounded in 1965, with a maximum depth of approximately 30 m, the reservoir is managed for flood control, hydroelectric power and water for municipal, industrial, agricultural and recreational uses. B. A. Steinhagen Reservoir encompasses >6,800 ha; it extends into portions of Jasper and Tyler counties, Texas. Filled in 1951, with a maximum depth of nearly 11 m, the reservoir is managed for flood control, water and recreation.

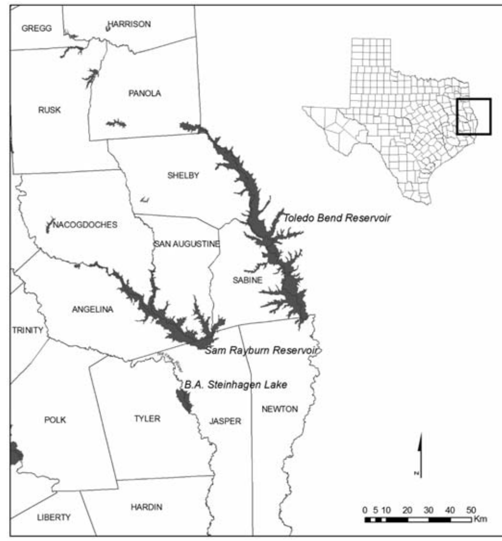

Figure 1. Location of Texas counties and Toledo Bend, Sam Rayburn and B. A. Steinhagen Reservoirs in eastern Texas for which Canvasback, Lesser Scaup and Ring-necked Duck behaviors were measured, November 2003-March 2004 and November 2004-February 2005.

Time-activity Budgets

We quantified time-activity budgets (*sensu* Bergan *et al.* 1989; Poulton *et al.* 2002) for Canvasback, Lesser Scaup and Ring-necked Duck from 19 November 2003 - 13 March 2004 (study year 1) and 8 November 2004 - 18 February 2005 (study year 2). We collected behavior data on each reservoir at least one day/week during each study year. Focal species were located (1) the evening prior to behavioral sampling, or (2) on an individual sampling day, where we located birds using binoculars and spotting scopes from a boat.

Once ducks were located, we collected behavior data while in the boat or from temporary blinds established on a nearby shoreline while maintaining a minimum observer-to-bird distance of 200 m. We used focal-individual sampling (Altmann 1974; Bergan *et al.* 1989; Poulton *et al.* 2002) to collect behavior data on randomly selected individuals within rafts by selecting the bird closest to the center of the field of view (Bergan *et al.* 1989; Poulton *et al.* 2002). We continuously recorded the following behaviors into a voice recorder for a maximum of 5 min. (DeLeon and Smith 1999; Poulton *et al.* 2002): (1) feeding/food acquisition (i.e. surface or subsurface feeding); (2) inter-dive loaf (i.e. loafing between dives); (3) locomotion (i.e. swimming or flying); (4) agonistic (i.e. bill threats, chasing and other aggressive behaviors); (5) loafing (i.e. stationary position with partially or fully retracted neck); (6) comfort movements (i.e. preening, stretching, bathing, etc.); (7) sleeping (i.e. bill tucked under wing); (8) courtship (i.e. pair bond displays, copulation and head-pumping); and (9) out-of-sight (i.e. bird lost from view while on water surface) (Hohman 1984; Bergan *et al.* 1989; Hohman and Rave 1990; Byrkjedal 1997). If an individual was lost from view for >10 s, or dove simultaneously with other individuals, we terminated that sample, randomly selected a new individual, and initiated a new focal sample. We terminated behavior sampling when (1) behaviors of each bird within small flocks (<20 birds) had been sampled, (2) birds moved too far to be observed, or (3) birds could no longer be observed due to darkness. All data were transcribed onto datasheets and entered into spreadsheets by a single observer (SLC). At the initiation of the study, a single observer collected behavior data (SLC); as new observers ($n = 6$) were added, they were trained to identify each behavior with the experienced observer (SLC) to standardize data collection among observers.

Data Analysis

We quantified time-activity budgets by calculating the proportion (%) of time spent in each behavior for each focal sample, which were our experimental units. We used a factorial multivariate analysis of variance (MANOVA) to examine differences in proportion of time spent in specific behaviors among species, between sexes, among reservoirs, between seasons (i.e. season 1, 1 November-10 January; season 2, 11 January-13 March), and between study years. We used a MANOVA because individual behaviors within a focal sample are not independent (Davis and Smith 1998). We did not transform percent data, as multivariate normality tests are lacking for greater than two dependent variables (Johnson and Wichern 1988: 146), normality does not affect the MANOVA test criterion (i.e. Wilks' lambda) (Olson 1976), and MANOVA is robust to heterogeneity in dispersion matrices (i.e. variance-covariance matrix) (Ito and Schull 1964; Ito 1969). If differences occurred ($P < 0.05$) in MANOVA, we used univariate analysis of variance (ANOVA). Least squares mean separation was used to examine differences ($P < 0.05$) occurring during ANOVAs (DeLeon and Smith 1999).

RESULTS

A total of 1,275 focal samples were collected for Canvasback (n = 663), Lesser Scaup ($n = 332$) and Ring-necked Duck ($n = 280$), from 106 h of focal observations. Behaviors varied among species (Wilks' λ = 0.95; 18, 2462 df; $P < 0.001$) (Table 1); where

Table 1. Means (%), Standard Errors (SE), and *F* and *P* values from univariate analysis of variance of wintering Canvasback, Lesser Scaup and Ring-necked Duck behaviors measured on Toledo Bend, Sam Rayburn and B. A. Steinhagen Reservoirs in eastern Texas (19 November 2003-13 March 2004, 8 November 2004-18 February 2005).

Behavior	Canvasback ($n = 663$)		Lesser Scaup ($n = 313$)		Ring-necked Duck ($n = 271$)		F	P
	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE		
Feeding (%)	18B	0.9	27A	1.6	30A	1.6	7.06	<0.001
Locomotion (%)	40A	1.3	32B	1.8	24B	1.5	20.63	<0.001
Agonistic (%)	<1A	<0.1	<1A	<0.1	<1A	<0.1	2.09	0.124
Loafing (%)	14B	0.8	13B	1.1	16A	1.2	4.43	0.012
Comfort (%)	10A	0.8	9A	1.1	7A	0.9	1.57	0.209
Sleeping (%)	10A	1.1	9A	1.4	9A	1.4	0.77	0.464
Courtship (%)	<1A	0.1	0A	0.0	<1A	<0.1	0.14	0.872
Inter-dive loaf (%)	7B	0.5	10A	0.7	12A	0.8	7.33	<0.001
Alert (%)	<1A	0.3	<1A	0.2	<1A	0.4	1.14	0.320

Means followed by the same letter within the same row are not different ($P > 0.05$).

food acquisition, locomotion and resting-related behaviors dominated time-activity budgets (Table 1). Canvasback spent the most time locomoting and the least time in food acquisition behaviors, while Lesser Scaup and Ring-necked Duck spent similar time in food acquisition behaviors (Table 1). Although Ring-necked Duck spent more time loafing than Canvasback or Lesser Scaup, all three species spent similar amounts of time in resting-related behaviors (Table 1).

There was a species x season interaction (Wilks' $\lambda = 0.88$; 27, 3581 df; $P < 0.001$), where Canvasback and Ring-necked Duck increased time spent feeding between seasons, whereas time spent in feeding behaviors was consistent over time for Lesser Scaup (Table 2). Canvasback reduced loafing between seasons, while loafing behaviors were similar between seasons for Lesser Scaup and Ring-necked Duck (Table 2). There was also a species x reservoir interaction (Wilks' $\lambda = 0.93$; 36, 4596 df; $P < 0.001$), where Canvasback and Ring-necked Duck spent more time feeding on Toledo Bend than the other reservoirs, while Canvasback spent more time (>50%) locomoting on Sam Rayburn than Toledo Bend or B. A. Steinhagen (Table 3). Lesser Scaup spent more time locomoting on Sam Rayburn than Toledo Bend, while Ring-necked Duck time locomoting was similar between Toledo Bend and B. A. Steinhagen (Table 3). Although time loafing varied ($P < 0.05$) among species, time spent loafing was consistent among reservoirs within each species (Table 3).

DISCUSSION

Most studies attempt to associate different environmental or anthropogenic factors with activity budgets to address potential consequences of deviations from "normal" winter activity budgets (see Paulus 1988 for a review of early literature), as such deviations may have both ecological and conservation relevance. "Normal" winter activity budgets for Canvasback, Lesser Scaup and Ring-necked Duck are dominated by food acquisition, locomotion and resting behaviors (see Table 4). How each allocates time to different behaviors varies among studies, but all three species in this study concurred with published ranges for food acquisition and resting behaviors (Table 4). For example, we estimated Canvasback spent 25% of their time in food acquisition behaviors (i.e. feeding and inter-dive loaf); this is within the 13-33% reported in other studies (Table 4). Lesser Scaup spent slightly more than a third of their time feeding in this study, similar to Scaup in Mississippi (35%) and South Carolina (31%), but more than in California (24%) (Table 4). Finally, Ring-necked Duck spent nearly 40% of their time feeding, similar to findings in South Carolina (44%), Mississippi (36%) and central Florida (35%) (Table 4). Canvasback spent less time resting (≈25%) and more time locomoting (37-53%) than other studies (30-42% resting and 19-29% locomoting) although Lesser Scaup spent similar time resting (≈22% as compared to 10-28%), but like Canvasback, Lesser Scaup tended to locomote more in this study (32%) than other studies (12-31%; Table 4). Finally, Ring-necked Duck rested about 25% of their time, similar to other studies (20-34%), but spent more time locomoting (≈25%) than in other studies (16-18%; Table 4).

Although time spent in feeding activities can be misrepresented for diving ducks, depending upon sampling technique used (i.e. instantaneous, scan or focal individual sampling), our data are within reported ranges (Table 4). Beyond specific sampling techniques (Hepworth and Hamilton 2001), some studies use permanent blinds to record behavior data (Alexander 1980; Hohman 1984; Hohman and Rave 1990), as opposed to use of boats or portable blinds established opportunistically at random shoreline locations (this study). Although data collection from a fixed vs. random location is a rarely considered sampling issue, using fixed locations may bias activity budgets towards a few obvious or site specific behaviors (Green *et al.* 1999) or towards the same individuals that repeatedly use habitats within the area of fixed locations. During this study, birds did not occur at predictable locations. Although these sampling issues could be sourc-

Table 2. Means (%), Standard Errors (SE), and *F* and *P* values from univariate analysis of variance of wintering Canvasback, Lesser Scaup and Ring-necked Duck behaviors between seasons[1] on Toledo Bend, Sam Rayburn and B. A. Steinhagen Reservoirs in eastern Texas (19 November 2003-13 March 2004, 8 November 2004-18 February 2005).[2]

	Canvasback				Lesser Scaup				Ring-necked Duck					
	Season 1 (n = 286)		Season 2 (n = 377)		Season 1 (n = 183)		Season 2 (n = 130)		Season 1 (n = 77)		Season 2 (n = 194)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	F	P
Feeding (%)	11C[2]	1.2	23B	1.4	29AB	2.2	23B	2.3	23B	2.6	33A	1.9	21.15	< 0.001
Locomotion (%)	39A	1.9	42A	1.8	33A	2.3	30A	2.8	26A	3.1	24A	1.7	0.40	0.753
Agonistic (%)	<1A	<0.1	<1A	<0.1	<1A	<0.1	<1A	<0.1	1A	<0.1	<1A	<0.1	1.15	0.329
Loafing (%)	20A	1.5	9C	0.8	11BC	1.3	15AB	1.8	17A	2.6	16A	1.3	18.62	<0.001
Comfort (%)	11A	1.3	10A	1.’	9A	1.4	9A	1.7	7A	1.8	7A	1.1	0.48	0.696
Sleeping (%)	14A	1.9	7C	1.2	7BC	1.7	13AB	2.5	11AB	3.1	8AB	1.6	6.04	<0.001
Courtship (%)	0A	0.0	<1A	0.3	0A	0.0	0A	0.0	0A	0.0	<1A	<0.1	0.41	0.748
Inter-dive loaf (%)	5D	0.6	8BC	0.7	10A	1.0	9BC	1.1	13AB	1.8	11AB	0.9	10.86	<0.001
Alert (%)	1A	0.5	1A	0.3	<1B	<0.1	1A	0.5	2A	0.9	1B	0.3	3.63	0.013

[1]Season 1: 1 November-10 January; Season 2: 11 January-13 March.
[2]Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 3. Means (%), Standard Errors (SE), and *F* and *P* values from univariate analysis of variance of wintering Canvasback, Lesser Scaup and Ring-necked Duck behaviors among Toledo Bend, Sam Rayburn and B. A. Steinhagen (Steinhagen) Reservoirs in eastern Texas (19 November 2003-13 March 2004, 8 November 2004-18 February 2005).

	Canvasback						Lesser Scaup				Ring-necked Duck					
	Toledo Bend (n = 221)		Sam Rayburn (n = 81)		Steinhagen (n = 361)		Toledo Bend (n = 108)		Sam Rayburn (n = 205)		Toledo Bend (n = 233)		Steinhagen (n = 38)			
Behavior	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	F	P
Feeding (%)	23AB	1.8	13D	2.4	17CD	1.3	26A	2.5	27B	2.1	32A	1.7	16BC	3.6	8.84	<0.001
Locomotion (%)	37B	2.2	53A	4.0	40B	1.8	27C	2.9	34B	2.3	24C	1.6	27BC	4.1	4.67	0.001
Agonistic (%)	<1A	<0.1	<1A	<0.1	<1A	<0.1	0A	<0.1	<1A	<0.1	<1A	<0.1	<1A	0.1	0.99	0.411
Loafing (%)	13BC	1.3	12BC	2.1	15AB	1.2	15B	2.1	12BC	1.2	16AB	1.2	20A	3.7	4.05	0.003
Comfort (%)	11A	1.5	8 A	1.9	10A	1.1	9A	1.7	10A	1.4	6A	0.9	15A	3.5	1.14	0.334
Sleeping (%)	7A	1.5	9A	2.9	11A	1.6	13A	2.8	8A	1.6	8A	1.5	15A	4.7	1.62	0.167
Courtship (%)	<1A	<0.1	0A	0.0	<1A	0.3	0A	<0.1	0A	<0.1	<1A	<0.1	<1A	<0.1	0.25	0.909
Inter-dive loaf (%)	9BC	0.9	3D	1.0	6C	0.6	10AB	1.3	9C	0.9	13A	0.9	7C	1.8	7.63	<0.001
Alert (%)	<1A	0.4	1A	0.6	<1A	0.4	<1A	0.2	<1A	0.3	1A	0.4	<1A	0.1	1.43	0.220

Means followed by the same letter within the same row are not different ($P > 0.05$).

Table 4. Summary of diurnal time-activity budgets of wintering Canvasback, Lesser Scaup and Ring-necked Duck in the southeastern United States.

	Behavior[1]				
Location	Feeding	Resting	Locomoting	Comfort	Reference
Canvasback					
Mississippi	23[2]	30	24	20	Christopher and Hill (1988)
South Carolina	33[3]	34	20	11	Alexander (1980)
Louisiana					
Catahoula Lake	13[3]	42	29	13	Hohman and Rave (1990)
Mississippi Delta	23[3]	42	19	9	Hohman and Rave (1990)
Texas					
Toledo Bend	32[3]	20	37	11	This study
Sam Rayburn	16[3]	21	53	7	This study
B.A. Steinhagen	16[3]	26	40	10	This study
Lesser Scaup					
California[4]	24[3]	10	12	6	Poulton et al. (2002)
Mississippi	35[2]	28	17	18	Christopher and Hill (1988)
South Carolina[5]	31[3]	19	31	9	Bergan et al. (1989)
Texas					
Toledo Bend	36[3]	27	27	9	This study
Sam Rayburn	36[3]	19	34	9	This study
Ring-necked Duck					
Florida[5]	35[2]	24	17	15	Hohman (1986)
Mississippi	36[2]	34	16	12	Christopher and Hill (1988)
South Carolina[5]	44[3]	20	18	7	Bergan et al. (1989)
Texas					
Toledo Bend	45[3]	24	24	6	This study
B.A. Steinhagen	23[3]	35	27	15	This study

[1]Percentage of time performing individual behavior.
[2]Feeding behaviors were a combination of diving and tipping without inter-dive loaf.
[3]Feeding behaviors were a combination of diving, tipping and inter-dive loaf.
[4]Mean proportion of time spent in behaviors among five study areas.
[5]Behaviors approximated from figures.

es of variability among studies, our data are generally within the reported ranges (Table 4). We assume there were no behavioral biases associated with our sampling approach and it appears that these species behave similarly among regions.

As feeding is most relevant during winter, many studies focus upon how waterfowl adjust feeding behaviors in response to changes in temperature and other environmental factors (Goudie and Ankney 1986; Paulus 1988; Hohman and Rave 1990; Michot *et al.* 1994; 2006; Woodin and Michot 2006). Generally, ducks wintering in northerly regions tend to feed more than those in southerly regions, due to higher thermoregulatory costs in colder climates (Hohman and Weller 1994; Lovvorn 1994), but deviations occur when feeding costs in extreme cold weather (i.e. <0°C) exceed benefits gained by food consumption (Goudie and Ankney 1986; Paulus 1988). Although weather was not specifically examined in this study, weather will influence feeding activity of diving ducks in southerly regions (Hohman and Rave 1990; Michot *et al.* 1994). However, similarities in time feeding in southerly portions of each species' winter range are not unexpected, as extended periods of extreme cold rarely occur in these regions.

Beyond temperature influences, other activity budget deviations are often related to food selection, food availability (i.e. patchiness or size), dietary switches or energetic quality (Paulus 1988; Michot and Chadwick 1994). In general, waterfowl consuming low water/high energy foods spend less time feeding than birds consuming lower quality foods (Paulus 1988). Reductions in food availability (often in late winter) may force diving ducks to search longer and prolong dives (Hoppe *et al.* 1986; Woodin and Michot 2006). Also, during late winter, ducks may switch food types altogether (i.e. plants to invertebrates, or vice versa), and/or switch to lower quality, but more abundant foods. Although diets are directly influenced by geography and food availability at a given locale (Jones and Drobney 1986; Paulus 1988; Haramis *et al.* 2001), esophagus and gizzard contents collected in the study area confirmed typical plant dominated diets for Canvasback and Ring-necked Duck and animal dominated diets for Lesser Scaup (Crook 2007). Animal matter typically contains more gross caloric energy than plant matter, although energy content depends upon plant parts consumed (i.e. tubers, stems, leaves or seeds) (Driver 1981; Paulus 1988; Michot and Chadwick 1994). Thus, if activity budgets were driven solely by food energy content, Lesser Scaup would spend less time feeding than herbivorous Canvasback and Ring-necked Duck. This prediction was not clearly confirmed, as Canvasback spent the least time and Ring-necked Duck spent the most time in feeding related behaviors (Table 1). Although wintering waterfowl often exhibit mid-winter declines in overall body mass and increase time feeding during late winter (Hohman and Weller 1994), birds in the study area were in comparatively good condition and increased body mass over time (Crook 2007), making discrepancies in time feeding among species difficult to explain based solely upon food energy content, as this was not specifically examined.

Non-breeding waterfowl exhibit stereotyped feeding patterns as related to month or season (Paulus 1988), and typically increase time feeding during late winter (Paulus 1988; Hohman and Weller 1994). However, if food resources change spatially or decline in quality during winter, time spent feeding or searching for food should also increase, independently of month or season (*sensu* Bergan *et al.* 1989). Without estimates of food resources, we cannot confirm these predictions; although Canvasback and Ring-necked Duck did spend more time feeding and Lesser Scaup spent more time loafing over time (Table 2). Apart from food resources, variability in time spent feeding among species may result from water depth variation among reservoirs and/or species differences in morphology. For example, diving ducks should spend more time feeding and have longer inter-dive loaf (i.e. dive recovery) intervals in deeper water (Lovvorn and Jones 1991). Moreover, larger diving ducks are more efficient at overcoming buoyancy costs and thermoregulating during dives than smaller ducks (Lovvorn and Jones 1991). Combined, these predictions cursorily support observed interspecific and reservoir-related variability in time feeding and in inter-dive loaf behaviors. For example, inter-dive loaf intervals were longer on the deepest reservoir (Toledo Bend) for all three species (Table 3), and irrespective of diet, smaller Lesser Scaup and Ring-necked Duck tended to spend more time feeding and inter-dive loaf behaviors than larger Canvasback (Table 1). We cannot extricate the specific influences of food resources from water depth and species morphology on behaviors in this study, but realize that food resources should be quantified in future work to directly assess their influence on diving duck activity budgets during winter.

As previously mentioned, substantial deviations from "normal" activity budgets are often noteworthy as they may have biological and/or management relevance. Few deviations occurred during this study, but there was one notable exception. All three species spent more time in locomotion behaviors than previously reported (Table 4). For example, Canvasback spent 40% of their time in locomotion behaviors (Table 1), 2-2.5 times higher than previously reported (Table 4). Similarly, Lesser Scaup and Ring-necked Duck spent 24-32% of their time in locomotion (Table 1), 3-17% more than previously reported (Table 4). Disproportionate time spent in locomotion may indicate unbalanced energy budgets, as costs associated with movements, particularly flight, may nullify energetic benefits of feeding and compromise focal species' ability to maintain or acquire adequate body fat for overwinter survival (Haramis *et al.* 1986; Serie and Sharp 1989; Barzen and Serie 1990; Kahl 1991). However, neither substantial deviations in time spent feeding (Table 4) nor poor body condition estimates (Crook 2007) were estimated for any species during this study.

Although not specifically quantified, human disturbance may have influenced locomotion behaviors. Human disturbances (i.e. boat traffic; see Korschgen *et al.* 1985; Korschgen and Dahlgren 1992; Kenow *et al.* 2003) likely influenced time spent in locomotion behaviors, as boats traveling at high speeds forced birds to swim and/or fly away, while more slowly moving boats usually forced birds to swim away (SLC, personal observation). It seems as if boat speed influenced bird response, but such responses may have been reservoir-specific as time spent in locomotion varied among reservoirs (Table 3). For example, more open water existed on Sam Rayburn where boats could travel at higher speeds across spatially larger portions of the reservoir as compared to Toledo Bend, where high speed boat traffic was restricted to defined boat lanes. The influence of human disturbance was not an *a priori* focus of this study. However, we provide some evidence that human activities influenced locomotion behavior of focal species, but not necessarily time spent in food acquisition behaviors (Table 4) nor body condition (Crook 2007).

Time activity budgets of diving ducks wintering on east Texas reservoirs were quite similar to previous studies throughout the southeast, indicating that behaviors are generally static throughout the southerly portion of these species' winter ranges. Although slight variations in time feeding and inter-dive loaf intervals occurred, we cannot directly link spatial or temporal variation in food resources with time spent in feeding behaviors. Similarly, slight variations in feeding and inter-dive loaf behaviors may be more specifically linked to reservoir depth and/or individual species morphology as related to diving costs. Although all three species engaged in locomotion behaviors at rates substantially higher than previously reported, none dramatically increased time feeding to apparently compensate for increased time locomoting; focal species tended to be in good physiological condition (Crook 2007) and engaged in food acquisition behaviors in concordance with previous studies (Table 4). We suspect that food resources were not limiting nor were focal species exceeding a yet undetermined carrying capacity on study site reservoirs. However, this supposition needs to be more clearly examined in future work that links spatiotemporal patterns of food and habitat quality with activity budgets. Similarly, as focal species dive for food, they are more susceptible to disturbances by boats approaching from greater distances as are foraging-then-resting waterfowl (see Mori *et al.* 2001). Successful reduction of waterfowl disturbances has been achieved via voluntary waterfowl avoidance areas where public education efforts reduced waterfowl disturbances threefold, despite large increases in overall boating traffic (see Kenow *et al.* 2003). Future efforts to specifically measure the impacts of boating activities (i.e. disturbance frequency and specific diving duck responses) on study reservoirs should provide managers with clear evidence as to the potential viability of voluntary boating restrictions on study site reservoirs to minimize disturbance and provide feeding and resting locations for wintering diving ducks.

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