

FOOD HABITS OF REDHEADS (*AYTHYA AMERICANA*)
WINTERING IN SEAGRASS BEDS
OF COASTAL LOUISIANA AND TEXAS, USA

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Diets of wintering redheads (*Aythya americana*) have been studied in the past, but none of the previous studies compared diets of the upper gastrointestinal tract to determine if they differed due to sex, age, location, year, or time of year. We compared diets of redheads collected over seagrass beds at Chandeleur Sound, Louisiana (n = 287) and Laguna Madre, Texas (n = 495) during the winters of 1987–1988 to 1989–1990. We found no significant differences due to location, year, sex, age, or time of year. *Halodule wrightii* (shoalgrass) was the primary food of birds from both locations and comprised 74% (dry mass) of the combined esophageal and proventricular contents. Mollusks were of secondary importance and accounted for 21% (18% gastropods, 3% pelecypods) of the diet. Because wintering redheads depend almost entirely on a single seagrass species and associated fauna, protection and enhancement of *Halodule* beds should be the highest conservation priority within the winter range of this species.

Key words: Chandeleur Sound, diet, *Halodule*, Laguna Madre, snail

INTRODUCTION

Redheads (*Aythya americana* EYTON, 1838) breed in fresh and alkali wetlands in the interior of North America, but they winter almost exclusively in coastal seagrass ecosystems. These seagrass areas are mainly along the Gulf of Mexico (MICHOT 2000), where environmental pressures have been increasing due to human population shifts to coastal areas (CULLITON *et al.* 1990). Because environmental pressures are increasing, effective management of coastal wetlands and seagrass beds will become essential if we are to establish and maintain the waterfowl population goals established by the North American Waterfowl Management Plan (U. S. Fish & Wildlife Service *et al.* 1994). Effective management of wintering waterfowl populations and habitat requires knowledge of requirements for food, for predator avoidance, for thermoregulatory needs, and for other behavioral and physiological processes. The diets of birds may differ among sex and age groups and may shift among and within seasons in response to changing physio-

logical needs or changing food availability. Studies over several time periods and geographic areas are often required to understand diet dynamics. Additionally, variations in food availability between areas can cause differences in quality and quantity of foods consumed.

There have been no studies of redhead food habits on the wintering grounds that tested for differences in diet among sites or among age and sex groups, and no studies have tested for seasonal effects within the wintering period. Food habits of redheads have been studied on breeding (BARTONEK & HICKEY 1969, NOYES & JARVIS 1985, JARVIS & NOYES 1986, WOODIN & SWANSON 1989, KENOW & RUSCH 1996), post-breeding (BERGMAN 1973, BAILEY & TITMAN 1984) and wintering (STEWART 1962, STIEGLITZ 1966, MCMAHAN 1970, CORNELIUS 1977) areas. Most of those studies, however, focused on only one area or on multiple sites within close proximity to each other. In addition, many of the studies were based on gizzard contents, alone or combined with esophageal and proventricular contents, which has been shown to be biased toward hard food items (SWANSON & BARTONEK 1970), and none of the studies had a sample size that was adequate to test for differences among age and sex groups, or to test for a seasonal or time effect within the winter period. Although the previous studies of wintering redheads indicated a reliance on *Halodule wrightii* as a preferred food item, it was not known whether that reliance held true among subgroups within the population or over time within the wintering period. Therefore, it was our interest to identify the foods consumed by redheads wintering at two separate wintering areas and to determine whether the diets differed between and within the two study sites. To accomplish this, we investigated the diets of redheads collected from wintering populations in Louisiana and Texas over three winters. Our objective was to determine if diet varied by age, sex, year, location, or time of year.

MATERIALS AND METHODS

Study areas

Chandeleur Sound (29°50'N, 88°50'W; Fig. 1) is separated from the Gulf of Mexico by the Chandeleur Islands, a 65-km long barrier island chain located about 40 km off the Louisiana coast. This area, which comprises Breton National Wildlife Refuge, typically supports a wintering population of approximately 10,000–20,000 redheads (BELLROSE 1980, MICHOT 1996, 1997, 2000). The area was estuarine [polyhaline] subtidal and intertidal aquatic bed and unconsolidated bottom habitat (classified according to COWARDIN *et al.* (1979)); salinities during our study ranged from 18 to 35 ppt, and redheads seldom used local sources of fresh water (MICHOT 2000).

The Laguna Madre of Texas (27°30'N, 97°30'W; Fig. 1) is a lagoon system about 180 km long and separated from the Gulf of Mexico by Padre Island, which comprises the Padre Island National Seashore. The study site was estuarine [hyperhaline] subtidal and intertidal aquatic bed and uncon-

solidated bottom habitat; salinities during our study were typically > 40 ppt. Ponds adjacent to the Laguna shoreline provided a nearby source of fresh water used frequently by redheads that feed in the Laguna (MOORE 1991, MITCHELL *et al.* 1992, WOODIN 1994, ADAIR *et al.* 1996, CUSTER *et al.* 1997, MICHOT 2000, SKORUPPA & WOODIN 2000, MICHOT *et al.* 2006, WOODIN & MICHOT 2006, WOODIN

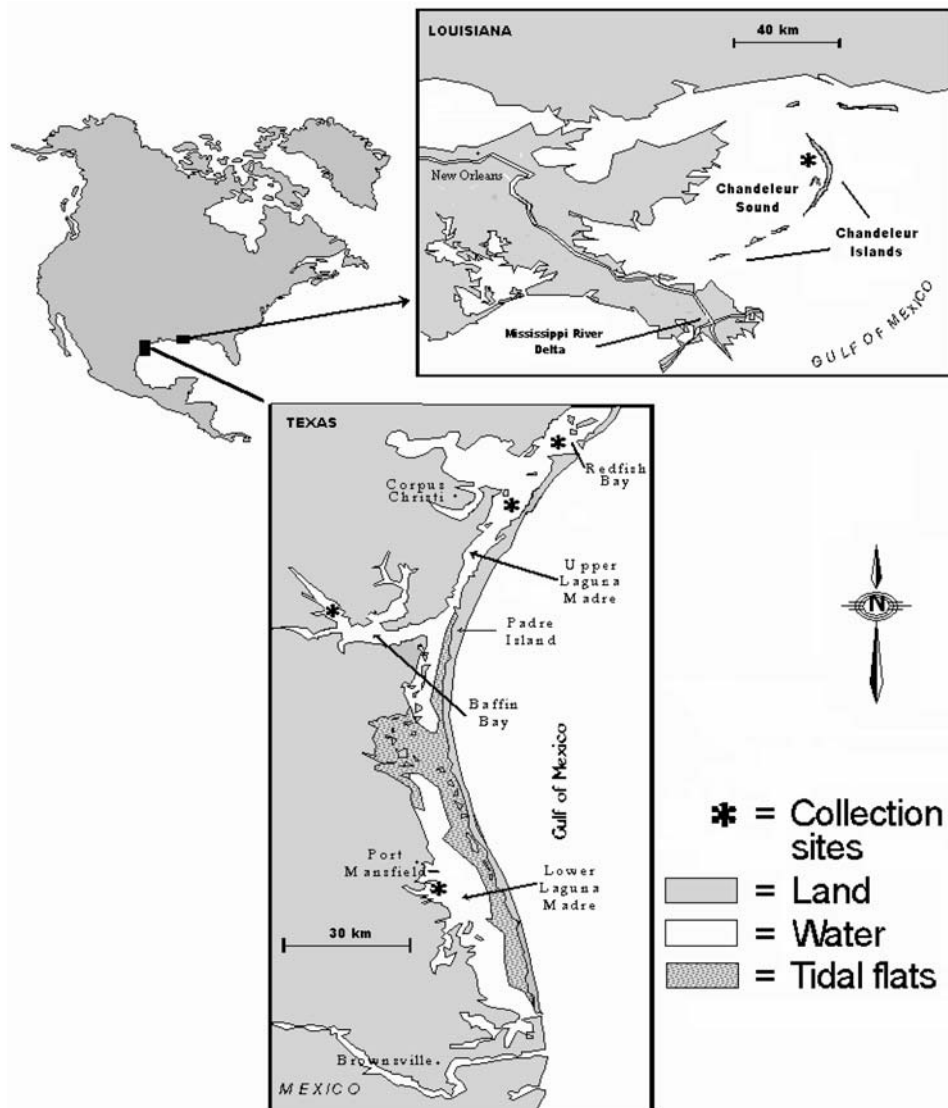


Fig. 1. Map of study areas and collection sites for redheads in Louisiana and Texas, and locations on the North American continent

et al. 2008). This area is the most important wintering area for redheads in North America, and hosts about 400,000 redheads annually (BELLROSE 1980, WOODIN 1996, MICHOT 2000).

Vegetation coverage (dominant species) for the Chandeleur Sound site was 50% *Thalassia testudinum* BANKS ex KÖNIG (turtlegrass), 17% *Halodule wrightii* ASCHERSON (shoalgrass), 16% *Syringodium filiforme* KÜTZING (manateeegrass), 4% other species, and 13% unvegetated substrate (H. A. NECKLES & T. C. MICHOT, U.S. Geological Survey, unpubl. data). The Laguna Madre was covered with 33% *Halodule*, 27% *Syringodium*, 7% *Thalassia*, and 33% unvegetated substrate (ONUF 1995).

Based on the classification scheme proposed by VOLLENWEIDER and KEREKES (1980), the Louisiana site was oligotrophic (ranging seasonally from ultra-oligotrophic to mesotrophic; MICHOT *et al.* 2004), and the Texas site was eutrophic (mesotrophic to hypertrophic; WHITLEDGE & PULICH 1991). The portion of Chandeleur Sound used by redheads was approximately 6,900 ha, and depth averaged 1 m (range 0 to 4 m). The Laguna Madre was approximately 75,550 ha and averaged about 1 m in depth as well (range 0 to 4 m). Most of the ponds used by redheads in Texas were < 2 ha (range 0.1 to 12 ha) and average depths were usually < 0.3 m (range 1 to 1.5 m). Our study areas in Louisiana and Texas are described in detail by HEDGPETH (1967), PULICH (1980), ADAIR *et al.* (1990), RITCHIE *et al.* (1992), MICHOT & NAULT (1993), MICHOT & CHADWICK (1994), and MICHOT *et al.* (1994).

Methods

We collected redheads at Chandeleur Sound ($n = 287$) during the winters of 1987–88 (collection year 1; hereafter referred to as LA1) and 1988–89 (collection year 2; LA2) by shooting from the shore or from a boat within 2000 m of shore. At the Laguna Madre we collected birds ($n = 544$) by shooting over decoys from blinds in the Laguna or in adjacent ponds during 1988–89 (TX2) and 1989–90 (collection year 3; TX3) (Fig. 1). All birds in Louisiana were collected within about 25 km of each other, and birds in Texas were collected within about 150 km of each other. Although the four collection sites in Texas (Fig. 1) were spread over a larger area and may have had subtle differences, they were almost identical in terms of habitat and collectively represented the coastal Texas wintering area. Therefore, for statistical analysis, we treated the Texas samples as a single site and the Louisiana samples as a single site.

Immediately after collecting Louisiana birds we injected ethanol into the upper gastrointestinal tracts to reduce post-mortem digestion. The birds were put on ice within 2–6 hours of collection, and frozen usually within 1–4 days (max = 6). Birds collected in Texas were not injected with ethanol, but were put on ice immediately and frozen the day of collection (within 8 h). After the field season, we thawed and dissected carcasses, removed food items from the esophagi and proventriculi, and placed the items in 70% ethanol. We later sorted, identified, dried (60 °C), and weighed food samples.

For statistical analysis we combined esophageal and proventricular contents and only birds having food in at least one of those organs were used in the analysis. We calculated food percentages on a dry-mass basis for each duck, then averaged percentages over all ducks in a given group (aggregate percent dry mass) so that the food items of individual ducks were weighted equally (SWANSON *et al.* 1974). Time of year was treated as a continuous variable (days after November 1), whereas age, sex, and stateyr (LA1, LA2, TX2, TX3) were treated as discrete variables in an analysis of covariance (PROC GLM; SAS Institute, Inc. 1987). We set $\alpha = 0.01$ to minimize Type I experimentwise error (DAY & QUINN 1989).

RESULTS

Fifty-seven percent ($n = 311$) of redheads collected in Texas and 80% ($n = 229$) of those collected in Louisiana had some food in their esophagus or proventriculus (Table 1). The diet was about 76% plant material and 22% animal material. The predominant food item was *Halodule wrightii* (74% of total food; Fig. 2); 465 birds (86% of those with food) had some *Halodule* present in the diet. Of the *Halodule* biomass consumed, 96% was belowground parts (roots and rhizomes) and 4% aboveground (leaves, shoots, and seeds). Three other seagrass species were consumed, but by only 5% of the ducks, and those food items made up < 2% of the diet (Table 1).

Most (83%) animals eaten were mollusks, primarily small (<1 cm) snails and clams (Fig. 2). We found 18 species of gastropods in the diets of 183 redheads from Louisiana and 14 gastropod species in 165 redheads from Texas (taxa listed in Table 1). We found pelecypods in 65 birds from Louisiana, but those clams were not identified to species; we identified 10 species of pelecypods from 70 Texas redheads (Table 1).

Analysis of covariance revealed no differences in percentages of plant and animal matter due to time of year (days; $F = 0.68$; $df = 1, 494$; $P = 0.41$), sex ($F = 0.39$; $df = 1, 494$; $P = 0.53$), age ($F = 1.95$; $df = 1, 494$; $P = 0.16$), combined state and collection year (stateyr; $F = 0.31$; $df = 3, 494$; $P = 0.82$), or any interactions ($P > 0.01$).

DISCUSSION

This study and others (STIEGLITZ 1966, MCMAHAN 1970, CORNELIUS 1977, MARSH 1979, MICHOT & NAULT 1993, WOODIN 1996, MICHOT & REYNOLDS 2000) suggest that wintering redheads are strongly dependent upon *Halodule wrightii* as their primary food source. Most of those studies, like ours, noted belowground material as being predominant in the diet though none differentiated between roots and rhizomes. Because roots dominate the belowground material of available *Halodule* by a factor of about 5 to 1 over rhizomes (i.e., 83% roots, 17% rhizomes; MITCHELL *et al.* 1994), it is noteworthy that 88% of the belowground *Halodule* biomass consumed by redheads in Florida was rhizomes and 12% was roots ($n = 13$; T. C. MICHOT, unpubl. data). Rhizomes also dominated the food samples in this study, but we did not quantify the differences between roots and rhizomes.

Although other seagrass species are available, sometimes more so than *Halodule* (e.g., in Chandeleur Sound, where *Thalassia* was much more abundant), red-

Table 1. Frequency of occurrence and aggregate % dry mass of food items in the upper digestive tract of wintering redheads collected in the Chandeleur Sound, Louisiana (1987–89), and the Laguna Madre, Texas (1988–90), that contained food (Total food > 0 g)

Food group	Frequency			Aggregate % dry mass		
	LA n (%)	TX n (%)	LA+TX Combined n (%)	LA	TX	LA+TX Combined
Plant						
<i>Halodule</i>	177 (77)	288 (93)	465 (86)	67	79	74
<i>Thalassia</i>	8 (3)	0 (0)	8 (1)	2	0	1
<i>Ruppia</i>	1 (<1)	10 (3)	11 (2)	<1	<1	<1
<i>Syringodium</i>	7 (3)	0 (0)	7 (1)	<1	0	<1
Misc. plant	26 (11)	4 (1)	30 (6)	2	<1	1
Total plant ^a	190 (83)	296 (95)	486 (90)	72	79	76
Animal						
Mollusca						
Gastropoda ^b	183 (80)	165 (53)	348 (64)	25	13	18
Pelecypoda ^c	65 (28)	70 (22)	135 (25)	3	3	3
Crustacea						
Isopoda	0 (0)	27 (9)	27 (5)	0	<1	<1
Amphipoda	22 (10)	43 (14)	65 (12)	<1	<1	<1
Decapoda	8 (3)	0 (0)	8 (1)	<1	0	<1
Misc. animal	13 (6)	17 (5)	30 (6)	<1	1	1
Total animal ^a	197 (86)	179 (57)	376 (70)	28	17	22
Unknown food	0 (0)	46 (15)	46 (8)	0	4	2
Total food ^a	229 (100)	311 (100)	540 (100)	100	100	100
Total N	287	544	831			

^aFrequency values for total plant, total animal, and total food represent the number of ducks with any plant, animal, or food items in the diet; thus a number on this line does not represent a sum of the values presented above it in the table. Mean aggregate percent dry mass values for total plant, total animal, and total food represent the mass of all plant, animal, or food items in the diet divided by the mass of all food items in the diet for each duck, and the mean of this value calculated over all ducks with food present; thus a number on this line does not represent a sum of the values presented above it in the table.

^bTaxa found: *Acteocina canaliculata*, *Acteon punctostriatus*, *Anachis avara*, *A. obesa*, *Caecum nitidum*, *Calliostoma* sp., *Cerithidea pliculosa*, *Cerithium lutosum*, *Crepidula convexa*, *Diastoma varium*, *Melanella* sp., *Mitrella lunata*, *Nassarius acutus*, *N. vibex*, *Natica* sp., *Neritina virginea*, *Odostomia trifida*, *Olivella minuta*, *O. watermani*, *Polinices* sp., *Pyramidellidae*, *Pyrgocythara plicosa*, *Rissoina catesbyana*, *Sayella livida*, *Turbonilla* sp., *T. interrupta*, *Vitrinella* sp.

^cTaxa found (Texas only): *Amygdalum papyria*, *Anomalocardia auberiana*, *Braehidontes exustus*, *Laevicardium mortoni*, *Lyonsia hyalina*, *Macoma* sp., *Mulinia lateralis*, *Nuculana acuta*, *Polymesoda maritima*, *Tellina* sp.

heads prefer *Halodule*, even though that species was not found to be nutritionally superior (MICHOT & CHADWICK 1994). Redheads feed mainly in shallow water at both study sites (MITCHELL 1992, MICHOT *et al.* 1994, MICHOT 2000, WOODIN & MICHOT 2006), but will also feed in deeper, offshore areas at Chandeleur Sound (MICHOT & NAULT 1993) and at Apalachee Bay, Florida (MICHOT 2000). Their greater consumption of *Halodule* relative to other seagrass species might reflect its greater abundance in shallow water areas (H. A. NECKLES & T. C. MICHOT, U.S. Geological Survey, unpubl. data; IVERSON & BITTAKER 1986) where redheads can feed without diving and, thus, retrieve foods with less energy expenditure than if the birds were required to dive in deeper water areas for other seagrass species.

Animal matter was a much smaller fraction of the wintering redhead diet than plant matter, and gastropods accounted for most animal foods. Gastropods might serve as grit for grinding fibrous *Halodule* rhizomes in the gizzard, but the many snails found in each duck (mean = 306 snails per redhead gizzard, $n = 16$ gizzards, range = 50 – 1000 + snails per gizzard; T. C. MICHOT, unpubl. data) suggest that snails were actively sought by redheads. The mollusk species found in the diet have been found on leaf blades, on the sediment surface, and in the sediment, and most are probably more numerous in seagrass beds than in unvegetated substrates (HECK & CROWDER 1991, ORTH *et al.* 1984, HECK *et al.* 1997, CORNELIUS 1975).

Some researchers (*e.g.*, CUSTER & CUSTER 1996) subtracted the shell mass of mollusks from the total body mass when calculating diet percents. We did not do this because we wanted to estimate the proportion of total ingested food that each

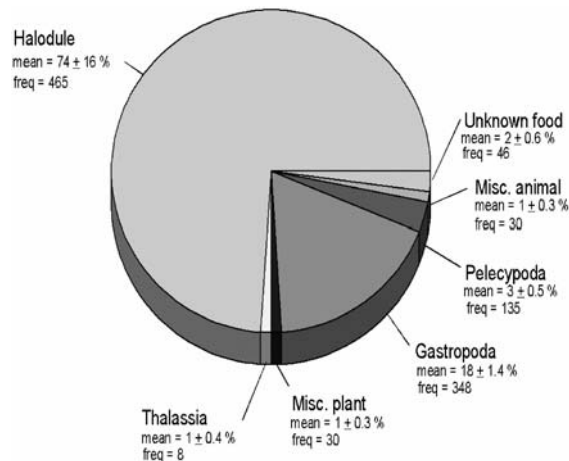


Fig. 2. Percentages (aggregate percent dry mass, means and standard deviations) of food items from esophagi and proventriculi (combined) of redheads collected in coastal Louisiana and Texas, 1987–1990 ($n = 540$; freq = number of birds with that food item present in esophagus or proventriculus)

food item accounted for, and we did not attempt to determine which portions of each ingested food item were used in metabolism, and which portions were passed through the digestive tract. A rough estimate of digestible portions for all plant and animal food items, however, can be estimated from published and unpublished data. If we applied values of 95% shell for gastropods and 88% shell for pelecypods (M. C. WOODIN, unpubl. data from ashing Texas redhead food items at 530 °C for 4.5 h), and 55% neutral detergent fiber for *Halodule* roots and rhizomes (MICHOT & CHADWICK 1994), to our means (from Table 1), the percent plant matter would change to 97%, and percent animal to 2%.

Though *Halodule* is undoubtedly the dominant component in the redhead diet, the importance of the molluscan component should not be understated. MARSH (1979) found that the marine mollusks consumed by wintering redheads in coastal Texas contained higher levels of calcium and protein, but lower levels of carbohydrates and phosphorus, than *Halodule*. Furthermore, his analysis of 16 amino acids showed that seven of those were considerably higher in snails, three were higher in *Halodule* rhizomes, and five were about the same in both food items. Other studies (STEWART 1962, QUAY & CRITCHER 1962, STEIGLITZ 1966, CORNELIUS 1977, PERRY & UHLER 1982, MICHOT & REYNOLDS 2000) found wintering redheads to consume a small but significant amount of snails.

Ours was the first study to test for sex, age, seasonal, or site differences in diet among wintering redheads, and we found none. Differences among some of those groups were also investigated and not found for wintering eiders (NYSTRÖM & PEHRSSON 1988, NYSTRÖM *et al.* 1991), canvasbacks (HOHMAN *et al.* 1990), and gadwalls (PAULUS 1982), whereas differences were shown among groups for wintering pochards (NILSSON 1969), northern shovelers (TIETJE & TEER 1996), mallards (HEITMEYER & FREDRICKSON 1981), pintails (BALLARD *et al.* 2004, EULISS & HARRIS 1987), green-winged teal (EULISS & HARRIS 1987).

The Chandeleur Islands are relatively free of human disturbances because of their distance from the mainland. They are threatened, however, by hurricane impacts and have been severely reduced in size by Hurricane Ivan in 2004 and Hurricane Katrina in 2005 (MICHOT *et al.* 2007). In the Laguna Madre channelization, deposition of dredged sediments, and causeway construction continue to alter salinity and light regimes and water circulation, which affect seagrass beds. Coverage of *Halodule* in the Laguna Madre has decreased significantly over the last few decades (QUAMMEN & ONUF 1993, ONUF 1995). The proposed extension of the Gulf Intracoastal Waterway into the Laguna Madre de Tamaulipas in Mexico, also a major redhead wintering area, may have similar impacts on *Halodule* beds there. Also, the presence of a brown tide (*Aureoumbros lagunensis* STOCKWELL *et al.* DEYOE) in the Laguna Madre of Texas from 1990–1995 significantly reduced the distribu-

tion and biomass of *Halodule* in the Laguna (ONUF 1996). Because of *Halodule*'s importance to redheads, management efforts should be geared toward protection and enhancement of *Halodule* beds and toward avoidance of actions that would decrease the abundance or distribution of this valuable habitat.

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