OCCASIONAL PAPERS

Museum of Texas Tech University

Number 227 30 September 2003

Food Habits and Selective Foraging of the Nutria (*Myocastor coypus*) in Spring Lake, Hays County, Texas

Kathy Towns, Thomas R. Simpson, Richard W. Manning, and Francis L. Rose

Introduction

The nutria (*Myocastor coypus*) is a large, semi-aquatic rodent native to the southern one-half of South America (Gosling and Baker, 1991). Nutria have been an important fur resource in South America since the 1800s, and were introduced to North America by fur farmers as early as 1899 (Evans, 1970). They were well established in the United States by the 1920s to 1930s. Many fur farm nutria were released into the wild after the market for their fur decreased in the 1940s (Evans, 1970). Populations on the Gulf Coast of Texas may have originated from escapees of E. A. McIlhenney's fur farm on Avery Island, Louisiana. Floods caused by a hurricane in 1940 led to the escape of many animals, and feral populations spread west of Port Arthur, Texas, by 1946 (Simpson, 1980). A decline in the demand for nutria fur led to their promotion as "weed cutters," and the animals were moved inland in Texas by landowners who wanted to clear weed-choked ponds and streams. Nutria now are widespread in the eastern two-thirds of the state (Davis and Schmidly, 1994).

Nutria are regarded as pests where they damage agricultural crops, contribute to marsh fragmentation and loss, and disturb natural plant communities. It also has been suggested that they may compete with waterfowl or muskrats for food (Woods et al. 1992, Davis and Schmidly, 1994). Damage to crops by nutria was reported in Louisiana (Evans, 1970), Texas (Swank and Petrides, 1954, Evans, 1970), Britain (Gosling et al., 1988), and France (Abbas, 1991). In Texas, the main damage occurs in rice fields on the Gulf Coast. The problem is not that the animals eat large numbers of rice plants, but that their burrows damage levees, leading to water loss in the fields (Evans, 1970). In a study of nutria food habits in Chile, researchers found that nutria did not damage crops near the study site, and suggested that damage to cultivated crops would not occur where there are other plants available for food (Murua et al., 1981).

Damage to marshes has been widely documented in Louisiana (Harris and Webert, 1962, Evans, 1970, Johnson and Foote, 1997, Ford and Grace, 1998, Carter et al., 1999). Harris and Webert (1962) found that, while nutria had a large impact on big cordgrass (*Spartina cynosuroides*), they did not have a major effect on marsh vegetation as a whole and did not create extensive bare areas. Later studies (Johnson and Foote, 1997, Carter et al., 1999) reported that nutria reduced above ground biomass by digging for roots and rhizomes, leading to marsh fragmentation and erosion. Ford and Grace (1998) reported that when nutria harvest decreased, there was a substantial increase in wetland loss rates. Nutria also had an impact on swamps in Louisiana by inhibiting regeneration of bald cypress (*Taxodium distichum*) (Wilsey et al., 1991).

Few studies have addressed competition between nutria and other animals. Swank and Petrides (1954) suggested that, where they are sympatric, nutria may compete with muskrats for food. However, Evans (1970) suggested that competition for food between nutria and muskrats was minimal. In Maryland, the principal foods for nutria and muskrats were different (Willner et al., 1979). Davis and Schmidly (1994) reported that nutria may destroy vegetation that is important to both muskrats and waterfowl. In East Texas, Simpson (1980) found that nutria ate plants that were important to waterfowl, but they also ate plants that are considered undesirable for waterfowl management.

Information on food habits is essential to understand the natural history of an animal. Food habits studies not only provide information about an animal's needs, but also about the potential for competitive interactions among sympatric species (Litvaitis, 2000). Competitive interactions are of special interest when trying to determine how the presence of an introduced species might affect native species in the community. Methods for investigating the food habits of animals include direct observation, feeding site surveys, and examination of feces or stomach contents. The method employed depends on the animal and the level of accuracy desired. Stomach contents studies are more accurate than other methods, and they have the advantage that differences between sex or age groups may be investigated (Litvaitis, 2000). The main drawback of stomach contents studies is that usually the animal must be sacrificed (Cooperrider, 1986). This does not present a problem in the present case, as nutria are considered to be an exotic undesirable species at Spring Lake.

Previous studies addressing nutria food habits were done in Texas (Swank and Petrides 1954, Simpson 1980), Louisiana (Atwood, 1950, Warkentin, 1968, Shirley et al., 1981, Wilsey et al., 1991), North Carolina (Milne and Quay, 1966), and Maryland (Willner et al., 1979). Studies outside the United States were done in Argentina (Borgnia et al., 2000), Chile (Murua et al., 1981), and France (Abbas, 1991). Studies that took place before 1970 used direct observation or feeding site surveys to determine the diet of nutria. Later studies used the microscopic examination of stomach contents or fecal pellets to identify the plants eaten. Most of the previous studies took place in marsh environments, both freshwater and brackish. Our study differs from these in that we studied nutria in a large, spring-fed lake with little emergent vegetation. Vegetation surveys were conducted in the field to determine availability of food items. Availability of aquatic macrophytes at the study site was compared with the proportion of those species in the stomach contents to determine if nutria are selective feeders.

The objectives of this study were 1) to describe and quantify the food habits of nutria at Spring Lake and, 2) to determine if nutria are foraging selectively by comparing aquatic macrophyte use to availability at the study site.

MATERIALS AND METHODS

Study Site

The research site was Spring Lake, San Marcos, Hays County, Texas. The lake is an eight hectare, spring-fed reservoir that forms the headwaters of the San Marcos River (Figure 1). The lake is formed by a dam, constructed in the 1840s, which is located approximately 650 m downstream from the main springs (Seaman, 1997). For descriptive purposes, Spring Lake will be divided into two segments, the main lake and the slough.

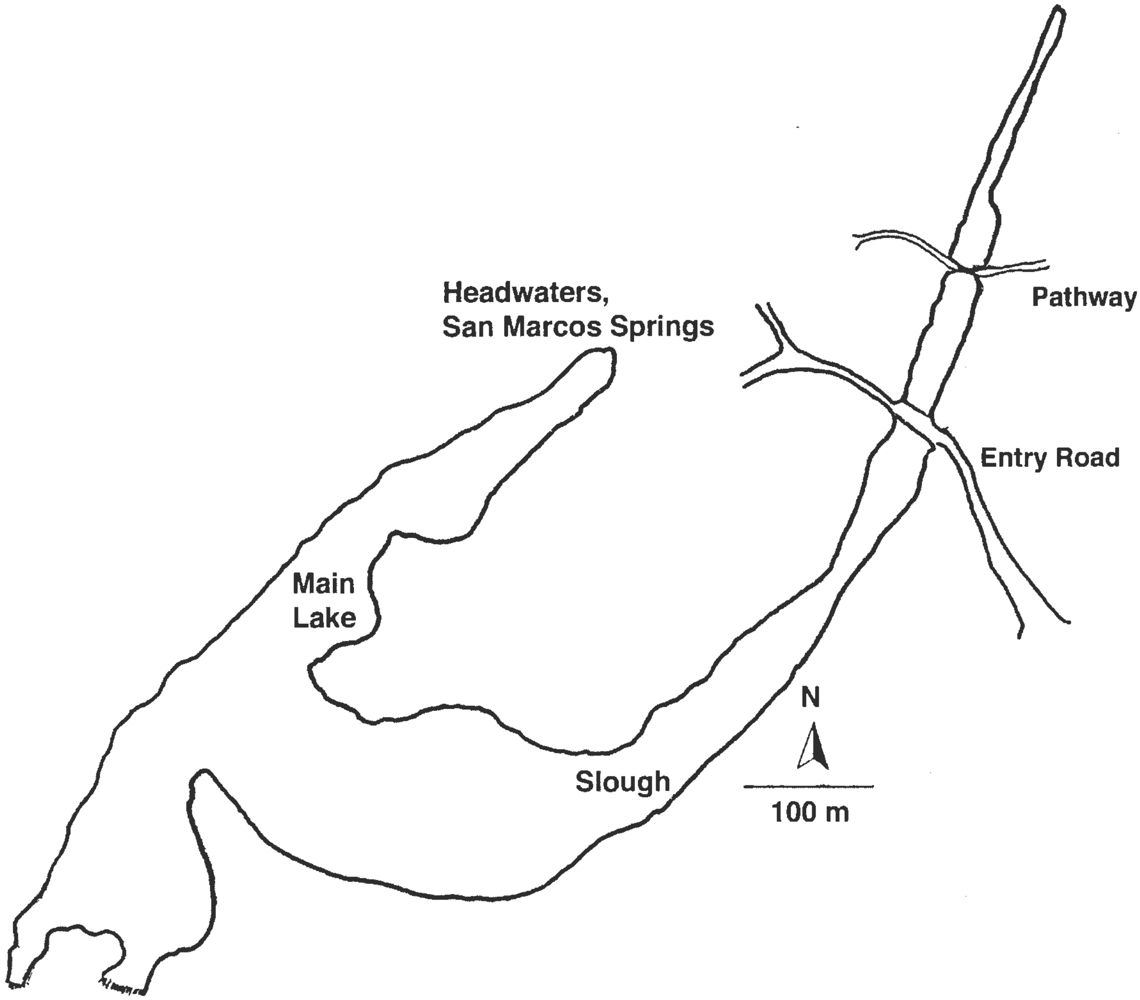

Figure 1. Spring Lake, Hays County, Texas.

The main lake is the center of a former amusement park. Southwest Texas State University acquired the property in 1994, and the emphasis is now on education and research (Seaman, 1997). The eastern shoreline of the upper region, from the main springs to about 350 meters downstream, is partly curbed in concrete and is dominated by buildings, docks and walkways of Aquarena Center. Glass-bottomed boats still operate from this area. Remnants of the former park include a submarine theater and underwater fountain system (Aguirre, 1999). The western shoreline of the upper region is narrow, covered with elephant ear (*Colocasia esculenta*), and rises as a steep hillside. Water depths in this area reach more than six meters (Aguirre, 1999). The lower region of the main lake, from the dam upstream to the point at which the slough joins the lake, is shallower than the upper region and is characterized by thick growths of hydrilla (*Hydrilla verticillata*), coontail (*Ceratophyllum demersum*), and water milfoil (*Myriophyllum* spp.). Dense stands of elephant ear grow along the western shoreline. The eastern shoreline has very little emergent vegetation, but free-floating plants such as water fern (*Azolla caroliniana*), floating fern (*Ceratopteris thalictroides*), and duckweed (*Lemna minor, Spirodela polyrhiza*) are found in sheltered areas. Water from the lake empties into the San Marcos River over two man-made spillways, located approximately 650 meters downstream from the main springs (Aguirre, 1999).

The slough is a lentic backwater area bordered by a golf course and softball fields. Water lettuce (*Pistia stratiotes*), water fern, and duckweed are present in sheltered areas along the shoreline. Much of the submersed and floating-leaf vegetation, including hydrilla, water milfoil, and spatterdock (*Nuphar luteum*), was scoured from the bottom of the slough during the flood of October, 1998. Water hyacinth (*Eichhornia crassipes*) and other free-floating plants also were removed by the flood at this time. Vegetation in the slough continued to recover during the period of this study.

Aquatic macrophytes at Spring Lake include both native and introduced species. Common native species are coontail, Carolina fanwort (*Cabomba caroliniana*), cone-spur bladderwort (*Utricularia gibba*), variable-leaved milfoil (*Myriophyllum heterophyllum*), and delta arrowhead (*Sagittaria platyphylla*). The most widespread introduced plant is hydrilla. Other introduced species include floating fern, Eurasian water milfoil (*Myriophyllum spicatum*), elephant ear, and water hyacinth.

Stomach Sample Collection

Forty-three stomach samples were collected from August 1998 to January 2000. Sex of the animals was determined by examination of external genitalia (Willner et al., 1979). Animals with hind foot length less than 110 millimeters were classified as juveniles, and those with hind foot length greater than or equal to 110 millimeters were classified as adults (Adams, 1956). The stomach contents were placed in 10 percent formalin for later microscopic analysis.

Stomach Contents Analysis

Percent composition of aquatic macrophytes in 43 stomachs was determined through microhistological analysis. First, stomach contents were washed through a 35 mesh (0.5 mm) sieve to rinse out formalin and to remove the smallest unidentifiable plant fragments. A small sample of the stomach contents was placed on each microscope slide. The material was cleared as described by Litvaitis et al. (1996). Twenty slide preparations were made from the contents of each stomach. Five fields of view on each slide were picked randomly. Each field was examined at a magnification of 100x, and the epidermal fragment closest to the pointer identified to species. Epidermal characteristics were used in species identification because the epidermis is most resistant to digestion and it contains diagnostic characteristics (Baumgartner and Martin 1939, Dusi 1949, Sparks and Malechek, 1968, Litvaitis et al., 1996). Characteristics that were helpful in identification included cell size and shape, stomata, trichomes, and glands, as well as the general pattern of cells (Baumgartner and Martin, 1939, Litvaitis et al., 1996). Reference slides were used to help with identification of epidermal fragments.

Reference Slides

Reference slides of the leaves and stems of the plants found in Spring Lake were made to aid in identification of the epidermal fragments in the stomach contents. The epidermis was removed from the leaf or stem by scraping away the underlying material with a razor blade. The piece of epidermis was inverted onto a slide, and then cleared with Hertwig's solution and mounted with Hoyer's solution (Litvaitis et al., 1996) in the same manner as the stomach contents slide preparations. Reference slides were made of both the upper and lower epidermis. In cases where it was difficult to remove the epidermis by scraping, leaves and stems were blended in an electric household blender with water. Small samples of the resulting plant fragments were placed on slides, and then cleared and mounted as above. Photomicrographs were taken of the reference slides to aid in comparison with the stomach contents slides.

Vegetation Survey

Vegetation surveys of Spring Lake were conducted quarterly from February1999 to November 1999. Percent cover was estimated for each plant species using the Daubenmire method (Daubenmire, 1959). A modified Daubenmire frame of 20 centimeters by 100 centimeters (0.2 m^2) was used. Twelve transects were located every 100 meters along the shoreline of the main lake and the slough. A calibrated rope was stretched across the water at each transect location, and coverage was estimated for each plant species at five meter intervals. A total of 145 quadrats was used to estimate coverage.

Aquatic Macrophyte Use

Aquatic macrophyte use was defined as percent composition of each plant species found in the stomach contents. Percent composition was determined through microhistological analysis and was calculated in the same manner as Simpson (1980). The number of epidermal fragments counted for each species was divided by the total number of epidermal fragments observed (100 for each stomach) and then multiplied by 100. The percent of stomachs containing a given species was calculated as the number of stomachs in which that species occurred, divided by the total number of stomachs containing aquatic macrophytes, multiplied by 100.

We considered a plant as a principal food item if it comprised greater than or equal to ten percent of the diet and was found in greater than or equal to 50 percent of the stomachs. A chi-squared goodness of fit test was used to test for differences in use of principal food items by sex and by age.

Foraging Selectivity

According to Johnson (1980), usage is selective if components are used disproportionately to their availability. In order to determine if nutria are selective feeders, the proportion of each aquatic macrophyte species in the stomach contents was compared to its availability at Spring Lake. The method used was that suggested by Krebs (1999), Manly et al. (1993), and Neu et al. (1974).

Usage for each plant species was defined as the proportion of that species in the stomach contents (o_i/O) expressed as identified fragments of a species (o_i) and total epidermal fragments (O). This proportion was estimated through microhistological analysis of the stomach contents, as described above. Availability for each plant species was calculated as described by Krebs (1999, and personal comm. Oct. 26, 2001). Availability was defined as m_i/M, where m_i equals the number of observations of available plant species i, and M is the total number of observations of availability (Σm_i) (Krebs 1999). The number of observations for each available plant species (m_i) was counted as the number of quadrats in which the plant made up more than five percent of the cover. M was the sum of the observations for all species (Krebs, personal comm. Oct. 26, 2001).

A log-likelihood chi-squared test was performed (Manly et al. 1993) to test the null hypothesis that usage of aquatic macrophytes does not differ from their availability at Spring Lake. Confidence intervals were constructed for the proportion of each plant species found in the stomach contents (observed use) to determine whether that species was used significantly more or less than its availability in the environment. Availability reflects "expected" use if no selection occurs. A Bonferroni z-statistic was used to calculate the simultaneous confidence intervals (Neu et al., 1974). This scaled down the significance level for each estimate so that an overall significance level of α equal to 0.05 could be maintained (Neu et al., 1974, Alldredge and Ratti, 1992, Manly et al., 1993). To maintain a 95 percent "family" of confidence intervals,α was corrected to 0.0033 to reflect the individual confidence intervals constructed for 15 aquatic macrophyte species. Calculations were based on figures for yearly, or total, use and availability.

RESULTS

Aquatic Macrophyte Cover at Spring Lake

Percent cover of aquatic macrophytes at Spring Lake was estimated quarterly. Overall percent cover for each plant species for the year was estimated by averaging the cover values obtained for each season (Table 1). The species with the greatest overall coverage was hydrilla (40.5% cover, 55.1% of the total aquatic macrophyte community). Muskgrass (*Chara* sp.) was found only in the slough (8.4% cover, 10.4% of the total aquatic macrophyte community). Coontail, a free-floating native species, also was abundant (8.1% cover, 11.3% of the total aquatic macrophyte community).

Table 1. Percent cover of aquatic macrophytes at Spring Lake, Hays County, Texas, during 1999.

Plant Species	Winter	Spring	Summer	Fall	Annual
Hydrilla (*Hydrilla verticillata*)	33.0	51.9	36.9	40.1	40.5
Muskgrass (*Chara* spp.)	0.0	9.9	9.3	14.2	8.4
Coontail (*Ceratophyllum demersum*)	8.7	4.1	8.8	10.9	8.1
Water milfoil (*Myriophyllum* spp.)	4.9	2.6	2.3	5.7	3.9
Bladderwort (*Utricularia gibba*)	0.3	1.9	8.7	0.8	2.9
Elephant ear (*Colocasia esculenta*)	2.9	2.0	2.0	2.1	2.3
Carolina fanwort (*Cabomba caroliniana*)	0.9	1.4	3.7	1.8	2.0
Delta arrowhead (*Sagittaria platyphylla*)	1.6	0.2	2.0	1.7	1.4
Floating fern (*Ceratopteris thalictroides*)	0.5	0.2	0.9	0.7	0.6
Other	3.9	3.5	2.8	6.0	4.1
Substrate	42.2	21.2	22.0	15.3	25.2

Other submersed plants were present in smaller amounts. Two species of water milfoil, one native (*Myriophyllum heterophyllum*), and one introduced (*Myriophyllum spicatum*), had a combined percent cover of 3.9 and comprised 5.4 percent of the aquatic macrophyte community. Fanwort (2.0% cover, 2.6% of the aquatic macrophyte community) was found scattered throughout the lake and slough, usually mixed with other submersed species. Delta arrowhead (1.4% cover, 1.9% of the aquatic macrophyte community) was present in the upper region of the main lake and in the area where the slough joins the main lake. East Indian hygrophila (*Hygrophila polysperma*) had a cover value of 0.7 percent and comprised 1.0 percent of the aquatic macrophyte community.

Small free-floating plants were found along the shoreline and in other sheltered areas. These included water fern, small duckweed (*Lemna minor*), giant duckweed (*Spirodela polyrhiza*), and water meal (*Wolffia papulifera*). Their combined cover was 1.1 percent, and they comprised 1.4 percent of the total aquatic macrophyte community. Larger free-floating plants also occurred in sheltered areas, including floating fern (0.6% cover, 0.8% of the aquatic macrophyte community), water hyacinth (0.1% cover, 0.1% of the aquatic macrophyte community), and water lettuce (0.9% cover, 1.3% of the aquatic macrophyte community).

Bladderwort (2.9% cover, 3.8% of the aquatic macrophyte community) was found mainly in the slough, and often was mixed with filamentous algae (1.3% cover, 1.7% of the aquatic macrophyte community). Filamentous algae also coated other macrophytes in the main lake, especially hydrilla and water milfoil. Elephant ear (2.3% cover, 3.2% of the aquatic macrophyte community) grew along the shoreline, particularly the western shore of the main lake.

Some aquatic macrophyte species present at Spring Lake were not measured in the vegetation survey because they did not occur along the line transects. Common cattail (*Typha latifolia*) grew in a relatively small stand at the northern shore of the lower slough. Red ludwigia (*Ludwigia repens*) occurred in small amounts in the lower region of the main lake, and also was found mixed with hydrilla in the lower region of the slough. Spatterdock occurred mainly in the slough, although a few plants were found in the main lake.

Bare substrate and open water comprised 25.2 percent of the total cover for the year. The cover value for bare substrate was highest for the slough in winter (68.3%). The flood of October 1998 scoured most of the submersed vegetation from this area, and much of the bottom was still bare when the winter vegetation survey was conducted in February. The bare substrate cover value for the slough decreased in each of the following seasons, with 35.9 percent in the spring, 21.0 percent in the summer, and 15.3 percent in the fall.

There was little seasonal variation in the coverage and composition for most aquatic macrophytes at Spring Lake. Muskgrass was not present in the winter survey, but this was attributed to the flood mentioned above, and not to seasonal variation. Three species showed some seasonal variation. Bladderwort was much more abundant in the summer (8.7% cover, 11.2% of the aquatic macrophyte community) than in other seasons. Fanwort also was more abundant in the summer (3.7% cover, 4.8% of the aquatic macrophyte community). Coontail was less abundant in the spring (4.1% cover, 5.3% of the aquatic macrophyte community) than in other seasons.

Aquatic Macrophyte Use

More than 90 percent of the annual diet of nutria was composed of five species of aquatic macrophytes (Table 2). Coontail was present in the greatest amount (39.3%), followed by hydrilla (26.0%), Carolina fanwort (17.4%), elephant ear (6.0%), and water milfoil (4.2%). Four species of aquatic macrophytes were present in smaller amounts in the stomach contents. Water hyacinth comprised 2.9 percent of the diet. It was found in 9.3 percent of the stomachs, with 62.1 percent coming from one stomach. Floating fern comprised 2.6 percent of the diet. It was found in 11.6 percent of the stomachs, with 81.3 percent coming from one stomach. Red ludwigia comprised 1.3 percent of the diet. It was found in 7.0 percent of the stomachs, with 68.5 percent coming from one stomach. Smooth water hyssop (*Bacopa monnieri*) was found in only one stomach and made up 0.2 percent of the diet.

Table 2. Annual diet of nutria (N=43) collected at Spring Lake, Hays County, Texas, during 1999.

	Percent composition in the diet	Percent of stomachs containing species
Coontail (*Ceratophyllum demersum*)	39.3	74.4
Hydrilla (*Hydrilla verticillata*)	26.0	79.1
Carolina fanwort (*Cabomba caroliniana*)	17.4	58.1
Elephant ear (*Colocasia esculenta*)	6.0	25.6
Water milfoil (*Myriophyllum* spp.)	4.2	18.6
Water hyacinth (*Eichornia crassipes*)	2.9	9.3
Floating fern (*Ceratopteris thalictroides*)	2.6	11.6
Water primrose (*Ludwigia repens*)	1.3	7.0
Water hyssop (*Bacopa monnieri*)	0.2	2.3

There was some seasonal variation in the percent composition of food items in the diet, but the principal food items remained the same. Three plants, coontail, hydrilla, and fanwort, were important in every season. They comprised 73.6 percent of the winter diet, 100 percent of the spring diet, 84.0 percent of the summer diet, and 90.4 percent of the fall diet (Table 3).

Table 3. Percent composition of aquatic macrophytes in the diet of nutria collected at Spring Lake, Hays County, Texas, during 1999.

Plant Species	Winter N=17	Spring N=4	Summer N=13	Fall N=9	Annual N=43
Coontail (*Ceratophyllum demersum*)	42.9	56.5	32.8	34.3	39.3
Hydrilla (*Hydrilla verticillata*)	19.5	38.3	32.9	22.9	26.0
Carolina fanwort (*Cabomba caroliniana*)	11.2	5.3	18.3	33.2	17.4
Elephant ear (*Colocasia esculenta*)	12.5	0.0	3.4	0.1	6.0
Water milfoil (*Myriophyllum* spp.)	10.2	0.0	0.0	0.9	4.2
Water hyacinth (*Eichornia crassipes*)	2.8	0.0	0.0	8.6	2.9
Floating fern (*Ceratopteris thalictroides*)	0.2	0.0	8.4	0.0	2.6
Water primrose (*Ludwigia repens*)	0.0	0.0	4.2	0.0	1.3
Water hyssop (*Bacopa monnieri*)	0.6	0.0	0.0	0.0	0.2

The winter sample consisted of 17 stomachs and included the following aquatic macrophytes: coontail (42.9%), hydrilla (19.5%), elephant ear (12.5%), fanwort (11.2%), water milfoil (10.2%), water hyacinth (2.8%), smooth water hyssop (0.6%), and floating fern (0.2%). Smooth water hyssop and floating fern were each present in only one stomach in the sample.

The spring sample consisted of four stomachs and included the following aquatic macrophytes: coontail (56.5%), hydrilla (38.3%), and fanwort (5.3%).

The summer sample consisted of 13 stomachs and included the following aquatic macrophytes: hydrilla (32.9%), coontail (32.8%), fanwort (18.3%), floating fern (8.4%), red ludwigia (4.2%), and elephant ear (3.4%).

The fall sample consisted of nine stomachs and included the following aquatic macrophytes: coontail (34.3%), fanwort (33.2%), hydrilla (22.9%), water hyacinth (8.6%), and water milfoil (0.9%). Water hyacinth and water milfoil each were present in only one stomach in the sample.

Aquatic Macrophyte Selection

Aquatic macrophyte use by nutria was compared to availability to determine if nutria fed selectively. Log-likelihood chi-squared analysis showed that the proportion of aquatic macrophytes in the diet differed significantly from the proportion available at Spring Lake ($X^2 = 102.6$, $p < 0.001$) (Table 4). The null hypothesis that use does not differ from availability was rejected.

Confidence intervals on observed use indicated which plants were selected based on their availability. Plants with availability values that were not included in the confidence intervals for observed use were used significantly more or significantly less than expected. Plants with availability values that fell within the confidence intervals were used within their expected ranges.

Fanwort and coontail each were used significantly more than expected based on their availability in the environment. Both had availability values that were below the lower confidence limit on observed use. Aquatic macrophytes that were consumed as expected based on their availability included elephant ear, floating fern, and water hyacinth. Each of these species had availability values that fell within the confidence intervals for observed use. Hydrilla was used significantly less than expected. It had an availability value above the upper confidence limit on observed use. Use of water milfoil was slightly less than expected. It had an availability value that was slightly above the upper confidence limit (Table 4).

Two aquatic macrophyte species each had an expected use of greater than or equal to five percent, but were not present in the stomach contents. Muskgrass had an expected use of 8.9 percent, and bladderwort had an expected use of 5.3 percent. These plants were included in the calculations because they were considered potential food items, even though no fragments were found in the stomach contents. Murua et al. (1981) found muskgrass in the diet of nutria in Chile. Milne and Quay (1966) and Shirley et al. (1981) found bladderwort in nutria diets in North Carolina and Louisiana, respectively.

Table 4. Proportion of aquatic macrophytes in the diet of nutria compared to the proportion available at Spring Lake. Hypothesis of proportional use was rejected (X^2=102.6, p<0.001). Selectivity indicated by [1] (used more than expected), and [2] (used less than expected). Others used in proportion to availability.

Plant Species	Expected use (availability)	Observed use (in diet)	95% confidence interval on observed use
Coontail (*Ceratophyllum demersum*)[1]	0.1514	0.3994	$0.2545 < p < 0.5443$
Hydrilla (*Hydrilla verticillata*)[2]	0.4471	0.2642	$0.1337 < p < 0.3947$
Carolina fanwort (*Cabomba caroliniana*)[1]	0.0400	0.1768	$0.0639 < p < 0.2897$
Elephant ear (*Colocasia esculenta*)	0.0286	0.0610	$0.0000 < p < 0.1318$
Water milfoil (*Myriophyllum* spp.)[2]	0.1029	0.0427	$0.0000 < p < 0.1025$
Water hyacinth (*Eichornia crassipes*)	0.0043	0.0295	$0.0000 < p < 0.0795$
Floating fern (*Ceratopteris thalictroides*)	0.0100	0.0264	$0.0000 < p < 0.0739$

DISCUSSION

Nutria Food Habits

Food habits of an animal may vary with geographic location and time (Cooperrider, 1986). Nutria thrive in areas where they have been introduced (Evans, 1970, Gosling and Baker, 1991), and they eat a wide variety of plants. At a given location, however, nutria diets tend to be dominated by only a few plants (Willner et al., 1979, Murua et al., 1981, Wilsey et al., 1991, Borgnia et al., 2000). Willner et al. (1979) found that one species of rush (*Scirpus olneyi*) made up almost 80 percent of the annual diet. Borgnia et al. (2000) reported a diet dominated by spikesedge (*Eleocharis bonariensis*) in the winter and duckweed in the summer. Duckweed also dominated the diet of nutria in a study in Louisiana (Wilsey et al., 1991).

The yearly diet of nutria at Spring Lake was dominated by three species of aquatic macrophytes. Coontail was the most important food item, comprising 39.3 percent of the diet and occurring in 74.4 percent of the stomachs. Hydrilla also was an important food item. It comprised 26.0 percent of the diet and was found in 79.1 percent of the stomachs. Fanwort comprised 17.4 percent of the diet and was found in 58.1 percent of the stomachs. Each of the other plants in the diet were present in less than 30 percent of the stomachs, and comprised less than seven percent of the diet.

Nutria did consume a few terrestrial plants, but these comprised only a small portion (less than 5%) of the overall diet. Milne and Quay (1966) reported that nutria rarely fed on land in places where submersed and floating vegetation was available. Borgnia et al. (2000) also found that the probability of plant use decreased exponentially with distance from water.

Swank and Petrides (1954) found that common cattail was a favored food of nutria in East Texas, and that they ate few other plants where cattail was available. However, it was not found in the stomach contents of nutria at Spring Lake. There was no evidence of nutria feeding activity in the stand of cattails located in the slough.

Seasonal variation in food habits was reported in previous studies (Atwood, 1950, Willner et al., 1979, Murua et al., 1981, Shirley et al., 1981, Abbas, 1991, Wilsey et al., 1991, Borgnia et al., 2000). Our study found no seasonal variation in those plants which were most important in the diet. Further comparisons of seasonal food habits cannot be made because of small sample sizes, which ranged from a low of four stomachs in the spring to a high of 17 in the winter. However, the diet of nutria at Spring Lake probably would not vary as much as diets in areas with large amounts of emergent vegetation. Milne and Quay (1966) reported that the greatest change in diet was a result of emergent vegetation dying in the winter. Nutria at Spring Lake ate mostly submersed and free-floating plants, which are not vulnerable to freezing in winter.

Aquatic Macrophyte Selection

Selection and preference are terms that sometimes are used interchangeably in food habits studies, but it is important to distinguish between the two. According to Johnson (1980), selection is the process of choosing a resource, and preference is the likelihood of a resource being chosen if offered on an equal basis with others. Usage is selective if resources are used disproportionately to their availability.

Nutria at Spring Lake were selective in their feeding. Coontail and fanwort each were consumed significantly more than expected based on their availability. Hydrilla and water milfoil were consumed significantly less than expected based on their availability. All other plants were consumed within their expected ranges. Previous studies also reported selective feeding by nutria (Willner et al., 1979, Shirley et al., 1981, Wilsey et al., 1991, Borgnia et al., 2000).

The two aquatic macrophytes that were consumed more than expected are native species. Fanwort also was selected by the Texas River Cooter (*Pseudemys texana*) in Seaman's (1997) study on their food habits. The fact that nutria selected the same species is of interest because of the potential competition between nutria and the native turtles. Coontail also was consumed by these turtles, but not out of proportion to its availability at Spring Lake (Seaman, 1997).

Hydrilla, an introduced species, was the most abundant plant in the lake and was an important food item for nutria. Although hydrilla was important in the diet, it was consumed significantly less than expected based on its availability. This supports the view that, as a means of removing undesirable vegetation, nutria have only limited value (Evans, 1970, Davis and Schmidly, 1994).

CONCLUSION

Our findings were consistent with others (Willner et al., 1979, Murua et al., 1981, Wilsey et al., 1991, Borgnia et al., 2000) in that a small number of plant species made up the bulk of the annual diet of nutria. Three aquatic macrophyte species comprised 82.7 percent of the diet. Two of these species, coontail and Carolina fanwort, were native plants which were selectively eaten by nutria. The importance of hydrilla in the diet may be only a factor of the abundance of this exotic species at Spring Lake.

In addition to determining what nutria consume, our study assessed selectivity in foraging by nutria. This adds to the knowledge of their impact on native vegetation and wildlife and reveals management concerns. Selective foraging of native plants by nutria may accelerate the replacement of these species by the invasive exotic, hydrilla. Any program of exotic plant control or restoration of native wetlands must take action against both exotic species, hydrilla and nutria, to be successful.

ACKNOWLEDGMENTS

The authors thank J. Ott for field assistance. We gratefully acknowledge C. Krebs and B. Manly for suggestions in analyzing data. Permits were provided by Texas Parks and Wildlife Department (SPR-0993-638) and the Institutional Animal Care and Use Committee of Southwest Texas State University (Permit # 1030).

LITERATURE CITED

Abbas, A. 1991. Feeding strategy of coypu (*Myocastor coypus*) in central western France. Journal of Zoology, 224:385–401.

Adams, W. H., Jr. 1956. The nutria in coastal Louisiana. Proceedings of the Louisiana Academy of Sciences, 19:28–41.

Aguirre, P. 1999. Space use patterns of the common snapping turtle, *Chelydra serpentina serpentina*, at the headwaters of the San Marcos River, Hays County, Texas. Unpublished M.S. Thesis. Southwest Texas State University, San Marcos, Texas. vi + 38 pp.

Alldredge, J. R. and J. T. Ratti. 1992. Further comparison of some statistical techniques for analysis of resource selection. Journal of Wildlife Management, 56:1–9.

Atwood, E. A. 1950. Life history studies of nutria, or coypu, in coastal Louisiana. Journal of Wildlife Management, 14:249–265.

Baumgartner, L. L. and A. C. Martin. 1939. Plant histology as an aid in squirrel food-habit studies. Journal of Wildlife Management, 3:266–268.

Borgnia, M., M. L. Galante, and M. H. Cassini. 2000. Diet of the coypu (nutria, *Myocastor coypus*) in agrosystems of Argentinean pampas. Journal of Wildlife Management, 64:354–361.

Carter, J., A. L. Foote, and L. A. Johnson-Randall. 1999. Modeling the effects of nutria (*Myocastor coypus*) on wetland loss. Wetlands, 19:209–219.

Cooperrider, A. Y. 1986. Food habits. Pp. 699–710. In: Cooperrider, A. Y., R. J. Boyd, and H. R. Stuart, editors. Inventory and monitoring of wildlife habitat. U.S. Bureau of Land Management. Denver, Colorado., xviii + 858 pp.

Daubenmire, R. 1959. A canopy-coverage method of vegetational analysis. Northwest Science, 33:43–64.

Davis, W. B. and D. J. Schmidly. 1994. The Mammals of Texas. Texas Parks and Wildlife Press. Austin, Texas. x + 338 pp.

Dusi, J. L. 1949. Methods for the determination of food habits by plant microtechniques and histology and their application to cottontail rabbit food habits. Journal of Wildlife Management, 13:295–298.

Evans, J. 1970. About nutria and their control. Bureau of Sport Fisheries and Wildlife. Resource Publication no. 86. 65 pp.

Ford, M. A. and J. B. Grace. 1998. Effects of vertebrate herbivores on soil processes, plant biomass, litter accumulation and soil elevation changes in a coastal marsh. Journal of Ecology, 86:974–982.

Gosling, L. M. and S. J. Baker. 1991. Family Myocastoridae. Pp 267–275. In: Corbet, G. B. and S. Harris, editors. The handbook of British mammals. Blackwell Scientific Publications, Oxford. x + 588 pp.

Gosling, L. M., S. J. Baker, and C. N. Clarke. 1988. An attempt to remove coypus (*Myocastor coypus*) from a wetland habitat in East Anglia. Journal of Applied Ecology, 25:49–62.

Harris, V. T. and F. Webert. 1962. Nutria feeding activity and its effect on marsh vegetation in southwestern Louisiana. United States of the Interior, Fish and Wildlife Service, Special Scientific Report., Wildlife No. 64. 53 pp.

Johnson, D. H. 1980. The comparison of usage and availability measurements for evaluating resource preference. Ecology, 61:65–71.

Johnson, L. A. and A. L. Foote. 1997. Vertebrate herbivory in managed coastal wetlands: a manipulative experiment. Aquatic Botany, 59:17–32.

Krebs, C. J. 1999. Ecological methodology. 2nd ed. Addison-Wesley Educational Publishers, Inc., Menlo Park, California. Xii + 620 pp.

Litvaitis, J. A. 2000. Investigating food habits of terrestrial vertebrates. Pp 165–190. In: Boitani, L. and T. K. Fuller, editors. Research techniques in animal ecology. Columbia University Press, New York. xxx ii + 442pp.

Litvaitis, J. A., K. Titus,and E. M. Anderson. 1996. Measuring vertebrate use of terrestrial habitats and foods. Pp 254–274, In: Bookhout, T. A., editor. Research and management techniques for wildlife and habitats. 5th ed. The Wildlife Society, Inc., Bethesda, Maryland. xiii + 740 pp.

Manly, B., L. McDonald, and D. Thomas. 1993. Resource selection by animals. Chapman and Hall. London. xi + 172 pp.

Milne, R. C. and T. L. Quay. 1966. The foods and feeding habits of the nutria on Hatteras Island, North Carolina. Proceedings of the Annual Conference of Southeastern Association of Game and Fish Commissioners, 20:112–123.

Murua, R., O. Neumann, and I. Dropelmann. 1981. Food habits of *Myocastor coypus* in Chile. Pp 544–558, In: Chapman, J. A. and D. Pursley, editors. Worldwide furbearer conference proceedings. Frostburg, Maryland. xvii+2056 pp.

Neu, C. W., C. R. Byers, and J. M. Peek. 1974. A technique for analysis of utilization-availability data. Journal of Wildlife Management, 38:541–545.

Seaman, J. R. 1997. Food habits of the Texas river cooter (*Pseudemys texana*) at Spring Lake, Hays County, Texas, Unpublished M.S. Thesis. Southwest Texas State University, San Marcos, Texas. vi + 57 pp.

Shirley, M. G., R. H. Chabreck, and G. Linscombe. 1981. Foods of nutria in fresh marshes of southeastern Louisiana. Pp 517–530, In: Chapman, J. A. and D. Pursley, editors. Worldwide furbearer conference proceedings. Frostburg, Maryland. xvii+2056 pp.

Simpson, T. R. 1980. The influence of nutria on aquatic vegetation and waterfowl in east Texas Unpublished Dissertation. Texas A&M University, College Station, Texas. ix + 55 pp.

Sparks, D. R. and J. C. Malechek. 1968. Estimating percentage dry weight in diets using a microscopic technique. Journal of Range Management 21:264–265.

Swank, W. G. and G. A. Petrides. 1954. Establishment and food habits of the nutria in Texas. Ecology, 35:172–176.

Warkentin, M. J. 1968. Observations on the behavior and ecology of the nutria in Louisiana. Tulane Studies in Zoology and Botany, 15:10–17.

Willner, G. R., J. A. Chapman, and D. Pursley. 1979. Reproduction, physiological responses, food habits, and abundance of nutria on Maryland marshes. Wildlife Monographs, No. 65. 43 pp.

Wilsey, B. J., R. H. Chabreck, and R. G. Linscombe. 1991. Variation in nutria diets in selected freshwater forested wetlands of Louisiana. Wetlands, 11:263–278.

Woods, C. A., L. Contreras, G. Willner-Chapman, and H. P. Whidden. 1992. Myocastor coypus. Mammalian Species, 398: 1–8.

Addresses of Authors:

Kathy Towns

Department of Biology
Southwest Texas State University
San Marcos, Texas 78666
e-mail: ktts@ecpi.com

Thomas R. Simpson

Department of Biology
Southwest Texas State University
San Marcos, Texas 78666
e-mail: r_simpson@swt.edu

Richard W. Manning

Department of Biology
Southwest Texas State University
San Marcos, Texas 78666
e-mail: rm11@swt.edu

Francis L. Rose

Department of Biology
Southwest Texas State University
San Marcos, Texas 78666
e-mail: fr02@swt.edu

Publications of the Museum of Texas Tech University

Subscriptions are available through the Museum of Texas Tech University, attn: NSRL Publications Secretary, Box 43191, Lubbock, TX 79409-3191. Individuals may also purchase separate numbers of the Occasional Papers directly from the Museum of Texas Tech University.

ISSN 0149-175X

Museum of Texas Tech University, Lubbock, TX 79409-3191