Virginia Journal of Science
Volume 57, Number 3
Fall 2006

Year-round Diet of the Marsh Rice Rat, *Oryzomys palustris*, in Virginia Tidal Marshes

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ABSTRACT

The marsh rice rat, *Oryzomys palustris,* is the dominant semi-aquatic rodent living in tidal marshes of the Virginia coastal plain. Described as highly carnivorous, this species is known to consume a range of animal foods, including crustaceans, mollusks, fish, and arthropods, as well as some plant foods. Analysis of stomach contents from rice rats collected from Eastern Shore tidal marshes throughout an annual cycle revealed that all 103 stomachs contained dicots, 82 percent had monocots, 61 percent had crabs and insects, and 38 percent had snails. Thirty-eight percent of stomachs contained foods in all five categories, no stomach was empty or contained fish, and 84 percent of stomachs had amounts of hair, probably ingested during self-grooming. In sum, Virginia rice rats are carnivorous but consume greater amounts of plant foods compared to populations that have been studied in Georgia and Louisiana.

INTRODUCTION

The marsh rice rat, *Oryzomys palustris*, is a semi-aquatic rodent with its highest abundances in wet fields and marshes, mostly of the southeastern US (Wolfe 1982). Distributed along the eastern seaboard southward from coastal Pennsylvania to the tip of Florida and westward to Corpus Christi, Texas, its range extends northward along the Mississippi River basin into southern Missouri and Illinois. In Virginia, it is common in tidal marshes of the coast and Chesapeake Bay and is present in some grassland habitats as far west as the fall line (ca. Interstate Highway 95; Linzey 1998). The marsh rice rat readily takes to water to forage and escape from predators, and can be caught in floating live traps (personal observation, RKR). Its swimming ability has been studied by Esher et al. (1978) in Mississippi and Carter and Merritt (1981) in Virginia, and inter-island movements of marked rice rats have been documented for the Virginia barrier islands (Forys and Dueser 1993). Medium in size among rodents (up to 80 g), *Oryzomys* is considered to be highly carnivorous, second to North America's most carnivorous rodent, the grasshopper mouse, *Onychomys*, a desert grassland mouse of the western states. The meat-eating proclivities of marsh rice rats were observed by Schantz (1943), who reported them eating the bodies of trapped muskrats, a behavior also observed by RKR (unpublished) on trapped small mammals on Fisherman Island, Virginia. The natural history of the marsh rice rat is summarized in Wolfe (1982).

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The objectives of our year-long study were to learn the kinds and proportions of foods eaten by marsh rice rats taken from tidal marshes of the Eastern Shore of Virginia and their seasonality of food selection. *Oryzomys palustris* is codominant in these tidal marshes with the meadow vole, *Microtus pennsylvanicus* (March 1995, Bloch and Rose 2005), with the latter being almost exclusively herbivorous (Zimmerman 1965, among others). Where the diet of marsh rice rats has been examined in Louisiana (Negus et al., 1961), Florida (Pournelle, 1950) and Georgia (Sharp, 1967), *Oryzomys* consumes both plant and animal materials, in differing proportions. In our study, we learned that Virginia rice rats ate higher proportions of plant material than at other geographic locations, plus varying amounts of crabs, snails, and arthropods (mostly insects).

MATERIALS AND METHODS

The Study Area

This study was conducted over a one-year period, from May 1994-April 1995. The research goal was to collect samples of up to 15 animals each month from two seaside sites in Northampton County, Virginia, one located ca. 300 m south of Oyster and the other 500 m east of Townsend. In October, an opportunity was presented to examine animals from the marshes of nearby barrier islands (Myrtle, Ship Shoal, Smith, and Mockhorn), so the sample size for that month was much larger than the others. For unknown reasons, rice rats were scarce during the summer months of June-August, and only two animals were collected during that time (Table 1), despite an increased trapping effort then compared to other months. March (1995), in earlier studies of the population dynamics of rice rats in similar tidal marshes on the Eastern Shore, had also found density to be low or near zero in June and July, and Negus et al. (1961) caught 13 rice rats in July in 2145 trap-nights and 3 in June of another year in 504 trap-nights, both < 1 rice rat per 200 trap-nights, indicating behavioral or other changes lowering their trappability in summer.

Both study sites were in tidal marshes backed by areas of dense common reed, *Phragmites australis*. The flora of the marshes included *Spartina alterniflora* (salt grass), *S. patens* (salt meadow hay), *Panicum* sp. (panic grasses), *Juncus roemeranius* (black needle-rush), *Salicornia* sp. (glasswort), *Baccharis halimifolia* (saltbush), and *Typha latifolia* (cattail). Both marshes are flooded twice daily in the area of the *Juncus*, whereas the *S. patens* areas are flooded only during monthly high or wind tides. The border between *Baccharis* shrubs and *Juncus* often supported a more substantial wrack line than that between *S. patens* and *Juncus*. This wrack line provided additional structure to a marsh with relatively little structure, except for the *Baccharis* shrubs.

Trapping and Laboratory Procedures

Transects of Fitch live traps (Rose 1994) were placed 2-3 m apart along the borders, i.e., at the normal extent of the daily high tide. Baited with wild birdseed and tended early each morning, these traps yielded mainly marsh rice rats and meadow voles, with lesser numbers white-footed mice (*Peromyscus leucopus*) and house mice (*Mus musculus*), and even fewer least shrews (*Cryptotis parva*) and short-tailed shrews (*Blarina brevicauda*). Only marsh rice rats were collected for this study. Marsh rice rats were returned to the laboratory, euthanized by chloroform anesthesia, and frozen.

TABLE 1. For each sex, sample sizes of the age categories of rice rats, following the criteria of Negus et al. (1961). Age category 1 = juvenile, 2 = subadult, 3 = near adult, and 4 = adult. The months have been grouped into seasons, with June-September SUmmer, October and November AUtumn, December-February WInter, and March-May SPring.

MONTH	TOTAL #	# FEMALES	# MALES	AGE 1	AGE 2	AGE 3	AGE 4
May SP	6	1	5	2	0	0	4
June SU	1	1	0	1	0	0	0
July SU	0	0	0	0	0	0	0
August SU	1	1	0	1	0	0	0
September SU	7	1	6	2	2	1	2
October AU	36	10	26	8	8	3	17
November AU	3	2	1	3	0	0	0
December WI	9	4	5	5	1	3	0
January WI	15	6	9	12	0	2	1
February WI	12	7	5	7	2	2	1
March SP	9	2	7	1	0	4	4
April SP	4	0	4	0	1	0	3
Totals	103	34	69	41	14	15	33

In order to compare what was eaten with what foods were available, samples of all potential food sources in the tidal marshes were collected from the same marshes as the rice rats, returned to the lab, processed, and made into reference slides. After samples of plant and animal materials had been pulverized in a Waring® blender to a consistency comparable to that of stomach contents of rice rats, the material then was washed in water, air-dried, and placed on microscope slides with Kleermount, a mounting medium, and covered with standard coverslips. Reference slides were made of three dicots (*Baccharis, Salicornia,* and *Typha*), four monocots (*Juncus*, *Panicum* sp., *Spartina alternifolia,* and *S. patens*), and four animals: fiddler crab, *Uca minax*; periwinkle, a univalve snail, *Littorina irrorata*; mummichog, a small brackish-water fish, *Fundulus heteroclitus*; and several arthropods, including grasshoppers, crickets, flies, and spiders, hereafter called 'insects'.

After the rice rats were thawed, standard measurements were taken (total length, lengths of tail, foot and ear, body mass) and the reproductive information was recorded for a related research project (Dreelin 1997). The contents of each stomach were removed, washed in water, air-dried, and then placed in separate 10-ml beakers, covered, labeled, and placed in the freezer to avoid contamination. For analysis, two samples from each stomach were placed on two slides with Kleermount, covered with standard coverslips, and compared to reference slides (method modified from Fleharty and Olson 1969). The contents were analyzed using a percent volume method, in which the amount of each type of food was visually estimated using a standard 10 X 10 ocular grid (Whitaker and French 1984). Food items were identified as belonging to one of six categories: dicotylenous plant, monocotyledonous plant, crab, snail, fish, and arthropod. In each of the 10 randomly selected 10 X 10 ocular fields, the volume of each food type was estimated and recorded. The volumes from both slides of each stomach were then summed, and an average was calculated to determine the percent volume of each food type for each stomach.

TABLE 2. Mean percent volumes and standard errors (in parentheses) based on examination of 10 microscopic fields in each of two slides per marsh rice rat, using the technique of Whitaker and French (1984). Values are given for each month of study and for each food category.

MONTH	DICOT	MONOCOT	CRAB	SNAIL	INSECT
May	77.2 (0.11)	8.1 (0.07)	7.1 (0.08)	3.7 (0.07)	4.0 (0.07)
June	95.8 (----)	4.2 (----)	0.0 (----)	0.0 (----)	0.0 (----)
July	--- (----)	--- (----)	--- (----)	--- (----)	--- (----)
August	73.4 (----)	10.9 (----)	4.2 (----)	0.0 (----)	11.5 (----)
September	79.5 (0.05)	9.2 (0.02)	6.1 (0.06)	2.9 (0.04)	2.1 (0.03)
October	66.1 (0.04)	12.0 (0.04)	6.8 (0.03)	3.9 (0.03)	11.3 (0.04)
November	76.8 (0.08)	4.9 (0.05)	11.6 (0.11)	3.6 (0.07)	3.2 (0.05)
December	85.4 (0.08)	6.8 (0.06)	4.6 (0.06)	1.7 (0.02)	1.5 (0.03)
January	75.8 (0.05)	10.5 (0.04)	6.6 (0.04)	6.0 (0.04)	1.1 (0.01)
February	75.7 (0.06)	16.9 (0.05)	3.7 (0.03)	2.3 (0.03)	1.4 (0.02)
March	62.3 (0.07)	30.1 (0.05)	0.2 (0.09)	7.0 (0.01)	0.4 (0.01)
April	70.2 (0.11)	25.5 (0.12)	0.2 (0.02)	0.9 (0.01)	3.2 (0.06)

RESULTS

Eastern Shore rice rats consumed dicots, monocots, crabs, snails, and insects (Table 2), but no fish were detected in any stomach. Dicot food was always most important, with most monthly values in the 70-85 percent range and the extremes being 62.3 percent (March) and 95.8 percent (June). The highest values for monocots were from the spring months of March (30.1 percent) and April (25.5 percent), months with low values for dicots (Table 2). The lowest value for monocots was in June, also the only month when no animal foods were detected in the stomach of the one rice rat that constituted the sample for that month. The monthly consumption of each animal food class was highly variable, ranging from fractional amounts to high values of 11.6 percent (November) for crabs, 7.0 percent (March) for snails, and over 11 percent for insects (August and October). The total amounts of animal foods likewise were highly variable, with lows of 4.3 percent in April and just over 7 percent in February and March and highs in August and October (16 and 22 percent, respectively).

During the period when breeding begins, late winter/early spring, monocot foods were relatively more important than at other times. However, because of the great monthly variation in proportions of consumption of each food class, no other patterns were evident. Eighty-four percent of stomachs contained some amount of hair, hairs of a type possessed by marsh rice rats and house mice. However, because no evidence of bone fragments was found in any stomach, we believe the hairs were the result of self-grooming rather than from cannibalism or predation on house mice.

DISCUSSION

Negus et al. (1961) determined that total length was the best surrogate of age. Using their criteria for four age classes, the percentages of animals we observed in each age category were 40 (for juveniles), 14, 15, and 32 percent, respectively (Table 1). The study of Negus et al. (1961), which included seven intervals of trapping ranging from one to four months spread over 30 months, reported percentages of rice rats in the same age categories of 17, 24, 14, and 46 percent, respectively. Thus, our population

had a larger proportion of juveniles and a smaller proportion of adults compared to the Louisiana populations.

Most of the available kinds of food in the study area were found in the stomachs of marsh rice rats. Plant material was found in all stomachs, with 100 percent containing dicots and 82 percent with monocots. Crabs, snails, and insects were found in 61, 38, and 61 percent, respectively, of stomachs. Thirty-eight percent of stomachs had foods from all five food categories, no stomach was empty, and no fish remains were detected.

Dicots were the staple in the diet of marsh rice rats in Virginia tidal marshes, ranging from 62.3-95.8 percent (Table 2). Of the dicot foods, *Salicornia* was found mostly in patches on tidal flats, whereas *Typha* and *Baccharis* were located farther landward. Across the year, dicots constituted a mean percent volume of 76.2 percent of the contents of the 103 stomachs. This consumption rate of dicots was much higher than that reported for marsh rice rats in Louisiana (43%; Negus et al. 1961) or in Georgia (24%; Sharp 1967). For reasons that are not immediately evident, we conclude that dicots are relatively much more important to Virginia animals than to more southerly populations of marsh rice rats.

Monocots were next in importance, with monthly volumes ranging from 4.2-30.1 percent. All monocot foods were found in patches throughout the marshes, with *Juncus* being present in greatest abundance, followed by *Spartina patens, S. alternifolia,* and *Panicum* in that order. These four plants constituted a mean percent volume of 12.6 percent of the diet across the year. Seasonal mean percent volumes for monocots were lower during summer (6.1%) and autumn (4.5%) than in winter (11.4%) and spring (21.3). The high values in winter and spring suggest that monocots provide the calories for increased heat production during these seasons when large amounts of heat are lost to the environment and other foods either may be energetically more costly to obtain (crabs and snails) or are not as available (insects) as during other seasons.

Fiddler crabs were present in the diet in 10 months, i.e., in every month with a sample size >1. Fiddler crabs were present throughout the marsh, with highest numbers on the tidal flats. Volumes of crabs in the diet ranged from 2.5 percent in spring to 9.2 percent in autumn, with summer and winter volumes of 2.6 and 5.0 percent, respectively, and the total mean percent volume for crabs from all stomachs was 4.6 percent. Similar volumes were consumed in all seasons.

Snails likewise were eaten in every month when sample size exceeded 1. Snails were found throughout the marsh but also had highest numbers on tidal flats, where they cling exposed on standing vegetation during the hours when the tide is out. Thus, they are especially vulnerable to predators at this time. Volumes of snails in the diet ranged from 0.7 percent during summer to 3.9 percent in spring. The mean percent volume of snails for all stomachs was 2.9 percent, the lowest of all food categories.

Insects also were consumed every month with sample size >1, with volumes ranging from 0.5 (summer) to 7.3 (autumn) percent among seasons; winter and spring volumes were 1.3 percent and 2.5 percent, respectively. This variation among seasons no doubt reflects availability patterns. The overall mean percent volume of insects was 3.6 percent, making insects just slightly higher in importance than snails as consumed foods.

The marsh rice rat chooses a diet higher in energy (insect food) as it loses more heat to the environment when temperatures decline. This may help explain why crabs ranked second in importance for November, an autumn month, and why crabs remained the most important animal food during the winter months too. Overall, the bulk of calories consumed by Virginia marsh rice rats were derived from plant foods but animal foods were particularly important during the colder months. Although Negus et al. (1961) contend that Louisiana rice rats consume mostly insects and fungi, and few vegetative parts in winter, their Figure 10 shows highest amounts of insects in May and August, comprising 65 and 75 percent, respectively, of the diet. Negus et al. (1961) found substantial amounts of mycelial threads of the fungus *Endogone* in the stomachs of February, May, and November samples, as well as fish and snails in December. Thus, rice rats living in sedge meadows in Louisiana are more carnivorous and have more catholic diets than those living in Virginia tidal marshes.

Sharp (1967), who examined the stomach contents of *Oryzomys palustris* collected in summer from Georgia salt marshes, found that rice rats fed almost exclusively on insects and small crabs. Of 13 rice rats from July and August, insects were dominant in 10 and crabs in three animals; except for one stomach with a trace of plant material, all other stomachs had no plant remains. Larvae of the rice-borer (*Chilo* sp.), extracted from the hollow stems of *Spartina* grasses, and *Uca* and *Sesarma* crabs constituted the bulk of foods in the stomachs (Sharp 1967). In the lab, Sharp found that *O. palustris* could not survive when given only vegetable foods, indicating the need for a varied diet.

The hairs in the stomachs of Virginia rice rats were probably from self-grooming activities. Svihla (1931) described in detail the body-cleaning and grooming activities of rice rats and Hamilton (1946) observed rice rats engaging in the longest bouts of personal grooming he had ever seen in small mammals. This attention to the pelage likely is related to its water-repellant properties. When a rice rat dives and swims, a bubble of air separates its pelage from the water, and when the animal emerges its pelage quickly sheds water droplets, revealing a dry and prime coat.

In conclusion, marsh rice rats in Virginia tidal marshes have diets consisting mainly of plant foods which they supplement in every month and season with varying amounts of crab, snail, and insect foods, but no fish. Animal foods vary in availability throughout the year, and are relatively more important in the diet in autumn and winter than at other seasons. Dicots are the most important class of food in every month, with the proportions of monocots being greatest in late winter and spring.

ACKNOWLEDGMENTS

We thank Old Dominion University and The Nature Conservancy for a small grant that helped to pay part of the costs of this research project, The Nature Conservancy for their permission to use their marshes for study, and fellow graduate students Erin Dreelin, Safianu Rabiu, and Anne Emerick, as well as John McGurk, for help in the field and lab. This paper is derived from the M. S. thesis of the junior author, for the degree awarded by Old Dominion University.

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