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QUANTIFYING DAMAGE POTENTIAL OF THREE RODENT SPECIES ON SUGARCANE

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ABSTRACT

Cotton rats, roof rats, and rice rats collectively inflict significant damage to sugarcane crops in the Everglades Agricultural Area; however, the relative damage inflicted by each species is unknown. A feeding trial experiment showed that some differences existed in the grams of sugarcane consumed per gram of body mass among species (male cotton rats: 0.39 ± 0.03g; female cotton rats: 0.34 ± 0.03g; male roof rats: 0.25 ± 0.04g; female roof rats: 0.26 ± 0.04g; male rice rats: 0.49 ± 0.08g; female rice rats: 0.20 ± 0.06g); however, because mean body mass differed for each species (male cotton rats: 120.5 ± 4.5g; female cotton rats: 111.4 ± 5.3g; male roof rats: 182.3 ± 6.9g; female roof rats: 157.1 ± 5.5g; male rice rats: 81.8 ± 3.8g; female rice rats: 58.1 ± 1.9g), the projected amount of sugarcane consumed will be approximately the same for all rodents. Therefore, overall abundance of rodents in sugarcane fields is an adequate predictor of rodent damage and knowledge of relative abundance of different species is not necessary. Periodic estimates of within field rodent abundance may be used to prioritize locations for rodent control. Integrated pest management that incorporates ecologically friendly methods, such as the elimination of rodent refugia habitat, may reduce the need for chemical rodenticides while maintaining or enhancing the effectiveness of rodent control.

INTRODUCTION

The Everglades Agricultural Area (EAA), located primarily in western Palm Beach County, FL, consists of approximately 160,000 ha (400,000 acres) of sugarcane cropland. Roughly half of the nation's cane sugar originates in the EAA (Baucum et al., 2006). Three species of rodent, cotton rat (*Sigmodon hispidus*), roof rat (*Rattus rattus*), and rice rate (*Oryzomys palustris*), thrive in this agricultural landscape. Cotton rats are the most abundant of the three species (Doty, 1960; Samol 1972b; Holler et al., 1982). Although density of cotton rats may vary among fields because of presence of predators and rodent control programs, this species is a habitat generalist (Whitaker and Hamilton, 1998) that occurs throughout the entire region. Roof rats typically reside in fields, as well as near human structures (Whitaker and Hamilton, 1998). They are likely to have a distribution as wide as that of cotton rats in the EAA; however, roof rats are less fecund so their populations recover more slowly following perturbations and their peak densities are likely to be lower. Rice rats primarily are limited to wet, marshy areas (Whitaker and Hamilton, 1998), so their distribution in the EAA is restricted.

All of these species have been implicated in the destruction of sugarcane crops (Garlough, 1938; Doty, 1960; Samol, 1972a; Samol, 1972b; Walsh et al., 1976; Lefebvre et al., 1978; Holler et al., 1982), but an empirical investigation of the relative impact of each is lacking (Samol 1972b). Current pest control efforts focus on reducing the number of rodents across the entirety of the region by applying rodenticides broadly (Abarca, 1981; Lefebvre et al., 1985; Montague et al., 1990). However, due to the variation in habitat specificity and reproductive capacity described above, both density of individual species and overall species composition of rodents varies among fields (Doty, 1960; Holler et al., 1982; Lefebvre et al., 1982; Lefebvre et al., 1989). If certain species are responsible for a disproportionately large amount of damage to sugarcane crops, the efficiency of management efforts may be improved by focusing pest control efforts on areas where the most problematic species are most abundant. This study investigates and compares the potential impact of cotton rats, roof rats, and rice rats on sugarcane in the EAA using a feeding trial experiment.

MATERIALS AND METHODS

Feeding trials were conducted from 12 Mar to 4 May 2005, 12 Oct 2005 to 4 Jan 2006, and 15 Dec 2006 to 9 Feb 2007. Individuals of each species were opportunistically captured using single-door, collapsible Tomahawk live traps (40.5 x 12.5 x 12.5 cm, Tomahawk Live Trap Co., Tomahawk, WI) in a single sugarcane field of cultivar ‘CP 80-1743’ (Deren et al., 1991) at the Everglades Research and Education Center (EREC), Belle Glade, FL. Traps were opened and baited with rolled oats between 1700-1800 hrs, and then checked the following morning between 0700-0800 hrs. Rats were removed from occupied traps using a cloth bag, and species, sex, and mass were recorded. Individuals then were placed in separate 46 x 46 x 46 cm wire mesh cages with a pre-weighed, two-internode long section of CP 80-1743 sugarcane stalk (mean mass = 160.8 g, range: 103.1 to 280.3, SE = 2.0). No more than 6 rats were captured and tested simultaneously due to limited cage availability. All individuals captured were used in the experiment; therefore, the sample population represented a cross section of the sex and age classes in the field. Approximately two heaping teaspoon of rolled oats were added to each cage to simulate naturally occurring alternative food sources. An additional pre-weighed stalk section was placed in an empty cage for each group of rats tested to serve as a control for mass lost from stalks due to desiccation. All stalk sections were cut from the bottom six internodes of mature stalks harvested from the same field where rats were captured. Cages were placed in the breezeway of a barn away from human activity and were separated from each other with sheets of paper. After 24 hrs, rats were released and all stalks were weighed again. Mass lost from the control stalk was subtracted from mass lost from experimental stalks to determine total grams of sugarcane consumed by each rat. Grams of sugarcane consumed in 24 hrs per gram of body mass was then calculated for each rat. Mean air temperature was obtained for each trial period from the Florida Automated Weather Station located at EREC.

Before data analyses were conducted, data were tested for normality, a square root transformation was applied when data violated the assumption of normal distribution, and outlying data points were removed (Proc Univariate, SAS Institute, 2003). A fixed effect ANCOVA was used to examine impact of the covariates species, sex, mass, mean air temperature, and interactions of these variables on grams of sugarcane consumed per gram of body mass for all rats (Proc GLM, SAS Institute, 2003). Mean grams of sugarcane consumed per gram of body mass were calculated for each sex of each species. Finally, linear regression analyses were used to explore the relationship between mean air temperature and grams of sugarcane consumed per gram of body mass for each species (Proc REG, SAS Institute, 2003). A significance level of $\alpha = 0.05$ was used for all statistical tests. Data are presented as means ± SE.

RESULTS

During this study, 114 cotton rats, 60 roof rats, and 42 rice rats were captured and tested (Table 1). ANCOVA analysis indicated that species, sex, and an interaction between species and mean air temperature influenced the amount of sugarcane consumed by rats during the trials. Sex and the species*mean air temperature interaction term fell just short of statistical significance, but we still considered them relevant factors (Table 2). Grams of sugarcane consumed per gram of body mass was not significantly related to body mass of individuals for any species. No differences existed in grams of sugarcane consumed per gram of body mass between sexes of cotton rats (males: 0.39 ± 0.03 g; females: 0.34 ± 0.03 g) or roof rats (males: 0.25 ± 0.04 g; females: 0.26 ± 0.04 g). Male rice rats consumed a significantly higher percentage of their body mass than female rice rats (males: 0.49 ± 0.08 g; females: 0.20 ± 0.06 g). Cotton rats consumed a higher percentage of their body mass than roof rats. Grams of sugarcane consumed per gram of body mass by female rice rats did not differ from roof rats, but male rice rats consumed a significantly higher percentage of their body mass than any other group (Figure 1). Regression analysis showed a negative relationship between grams of sugarcane consumed per gram of body mass and mean air temperature for rice rats, but there was no relationship between these variables for cotton rats or roof rats (Figure 2).

Table 1. Mass of rodents tested in feeding trials**.**

Species	n	Mean mass ± SE	Range
		------------ g --------------	
Cotton rat (male)	72	120.5 ± 4.5	36-208
Cotton rat (female)	42	111.4 ± 5.3	50-202
Roof rat (male)	36	182.3 ± 6.9	80-270
Roof rat (female)	24	157.1 ± 5.5	90-208
Rice rat (male)	33	81.8 ± 3.8	52-132
Rice rat (female)	9	58.1 ± 1.9	50-66

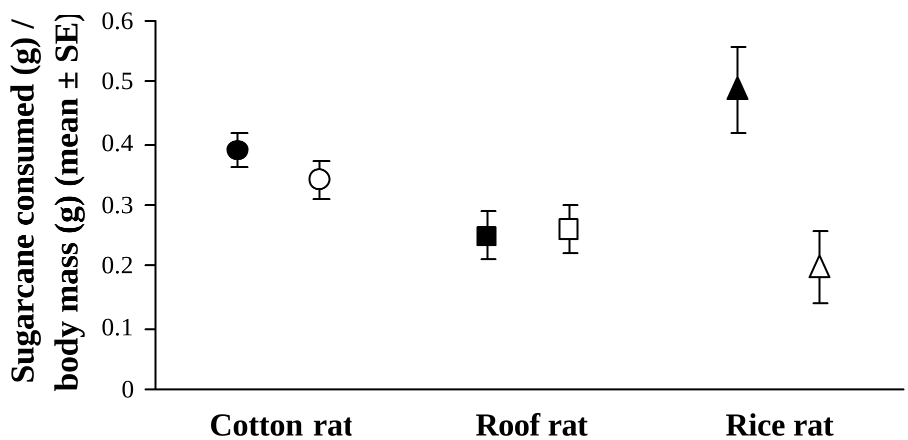
DISCUSSION

Grams of sugarcane consumed per gram of body mass was similar across all body sizes within each of the three species of rodents. Thus, amount of sugarcane consumed in an area can be estimated by multiplying the following three parameters: consumption per gram of body mass of the species, mean mass of individuals, and density. For example, based on the mean mass of cotton rats that were captured in 34 locations throughout the EAA in 17,000 trap nights in 2005-2006 (Martin, unpublished data) and population density estimates from a previous study in the EAA (Lefebvre et al., 1982), our experimental data predict that cotton rats may consume 41.1 to 198.6 kg of sugarcane stalk per ha, or 7,056 to 32,442 metric tons across the entire EAA, during the four months prior to harvest when the annual rodent density cycle is at its peak.

Table 2. ANCOVA analysis examining the influence of species, sex, mass, and mean air temperature on grams of sugarcane consumed per gram of body mass by rats during feeding trials.

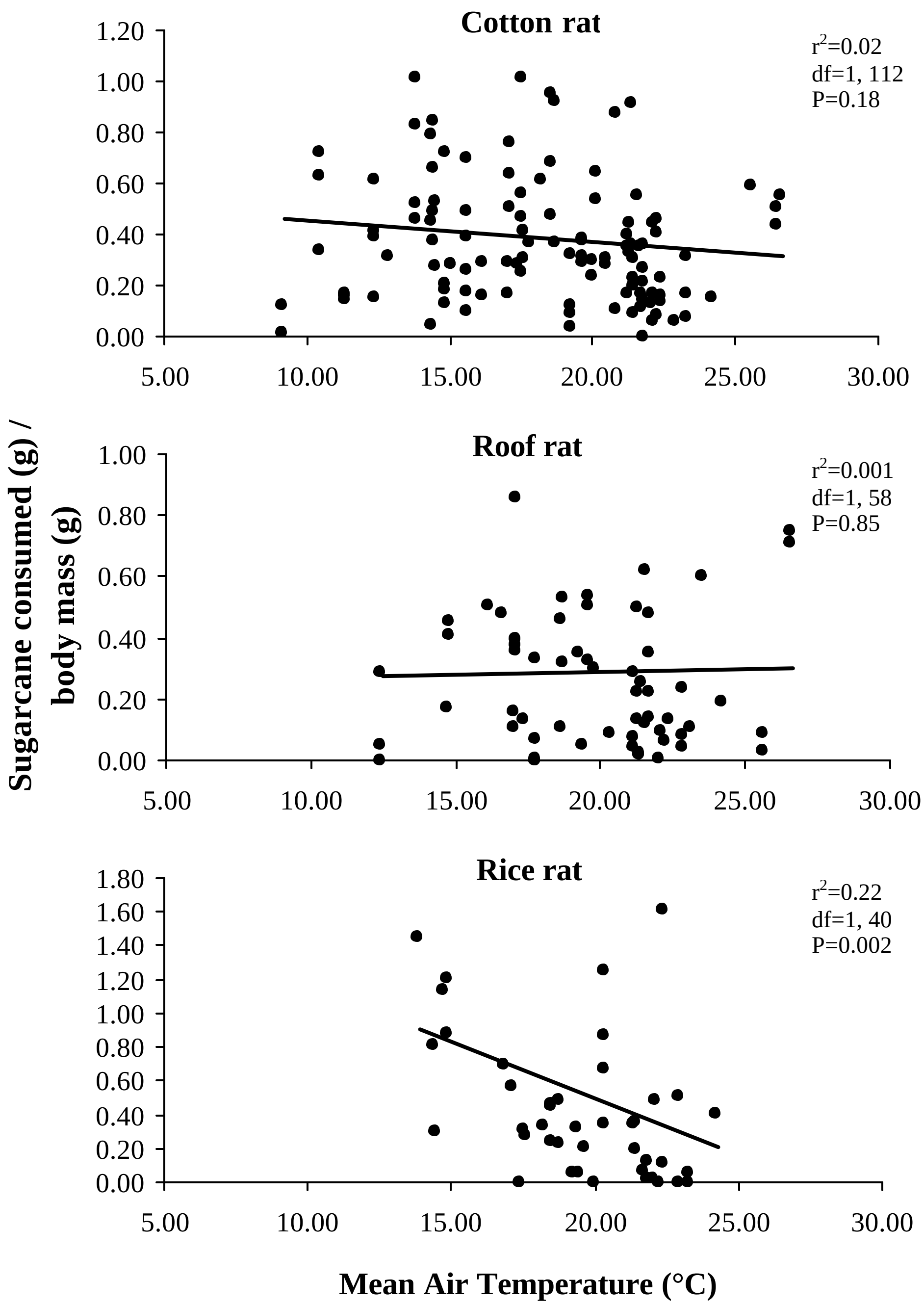
Source	Sugarcane consumed (g) / body mass (g)	
	F	p
species	3.25	0.04
sex	3.52	0.06
species*sex	0.85	0.43
mass	0.90	0.35
species*mass	1.82	0.17
mean temp	0.70	0.84
mean temp*species	2.60	0.08
mean temp*mass	0.33	0.57
mean temp*species*mass	1.15	0.32

Figure 1. Mean grams of sugarcane consumed per gram of body mass in 24 hrs for cotton rats, roof rats, and rice rats. Solid symbols = males, hollow symbols = females.



Individual cotton rats are capable of consuming at least as much sugarcane as roof rats and rice rats. Because it is the most common of the three rodent pest species, our experimental data suggest that cotton rats collectively are responsible for the greatest proportion of rodent damage to sugarcane crops in the EAA. Roof rats consume as much sugarcane as individual cotton rats; however, because they are less abundant, their collective contribution to sugarcane destruction in the EAA should be less. Rice rats probably consume less sugarcane across the EAA than cotton rats and roof rats because their distribution is restricted to fields with high soil moisture. However, local impact of rice rats may be greater in wetter fields where they are more common.

Figure 2. Linear regression analyses testing if grams of sugarcane consumed per gram of body mass is related to mean air temperature during feeding trials.



The large surface to volume ratios of small animals often result in high metabolic rates and a need for greater amounts of food in colder temperatures in order to maintain body temperature (Geiser et al., 2006). Rice rats, the smallest of the three rodents, exhibited this thermoregulatory feeding behavior during the feeding trials. Fields occupied by rice rats may experience spikes in damage during periods of colder temperatures.

Actual within-field patterns of rodent damage may vary from the results of this experiment because of conditions not measured in this study, such as predator density, moon phase, precipitation, or the availability of alternative food sources. Also, the impact of rodents on sugarcane goes beyond the amount of cane consumed. Even small breaks in the rind of stalks resulting from the gnawing of rodents may result in reduced nutrient flow through the plant and secondary fungal infections which further reduce sucrose yield (Abarca, 1981). The physical structure of the sugarcane fields may influence occurrence of rodent damage. Sugarcane stalks sometimes bend or break when they are tall. This lodging results in stalks leaning against each other, growing at an angle instead of vertically, or lying flat on the ground. Rodents are excellent climbers and are not limited to damaging only the portions of vertical stalks that they can reach from the ground; however, lodged stalks provide easier access to the entire length of the plant. Fields with greater amounts of lodging may have greater amounts of rodent damage.

Practically speaking, the precise rodent community composition within fields is likely to have minimal impact on the overall amount of sugarcane crop damage. Cotton rats, roof rats, and rice rats all consume sugarcane, and the cumulative impact of rodents will be great when rodent densities are high. The amount of damage to crops will increase as the density of rodents increases, regardless of which particular species are present. Density of rodents in sugarcane fields should be monitored periodically to identify areas where rodent control is most critical. Elimination of rodent refugia habitat, such as overgrown fallow fields and weedy drainage ditch banks, may help limit regional rodent abundance. These areas provide safe havens for rodents after agricultural fields have been harvested. Rodent abundance may be further impacted by making farms more attractive to predators. An integrated pest management approach, which incorporates ecologically friendly management techniques such as these, may lessen need for chemical rodenticides while maintaining or enhancing overall control of rodents.

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