Final Report, QA-1252:

Evaluation of Attractants for Nutria Management in Louisiana

Submitted to:

Andrew Dolan, U.S. Fish and Wildlife Service
Edmond Mouton, Louisiana Dept. of Wildlife and Fisheries
Dwight LeBlanc, USDA/Wildlife Services, Louisiana

Submitted by:

Susan Jojola, Biologist
Gary Witmer, Supervisory Research Wildlife Biologist
USDA/APHIS/WS
National Wildlife Research Center
4101 LaPorte Avenue, Fort Collins, CO 80521

April 24, 2006

CITATION AND ABSTRACT

Jojola, S. M. and G. W. Witmer. 2006. Evaluation of attractants for nutria management in Louisiana. Unpublished Final Report, QA-1252. USDA/APHIS/WS-National Wildlife Research Center, Fort Collins, CO. 18 pp.

Nutria (*Myocastor coypus*) were introduced from South America to the United States in the 1930s for fur farms and, due to releases and escapees, are currently established in 15 states. Nutria are important to the Louisiana fur industry, but also cause extensive damage to coastal marsh ecosystems when populations are high. The Louisiana Department of Wildlife and Fisheries uses a payment-incentive program to increase nutria harvest efforts by hunters and trappers, which helps to control the rapidly growing nutria populations. While this approach is effective, additional management tools are needed to control nutria year-round (i.e., outside of the trapping season) and that, when used in combination with hunting and trapping, would maintain lower densities of nutria. Other potential tools for nutria control include chemical control (toxicants), induced infertility, chemical repellents, and baits and lures. Strong attractants could be used as lures for traps or bait stations. In this study, we evaluated potential lures for nutria in a controlled setting. Lures selected most by nutria are intended to be tested later for efficacy in the field. We evaluated nutria responses to olfactory cues in a Y-maze. The three olfactory cues selected most frequently were: Tom's Nutria #1 (commercial lure), nutria anal gland secretion B, and female nutria fur extract (both synthetic formulations). We also evaluated time spent by nutria at two species of fertilized and non-fertilized marsh plants (maidencane and smooth cordgrass) and at marsh plants raised with soil-based fertilizers versus foliar fertilizers. Nutria did not show a significant preference for either plant species or either fertilizer type, but gave significantly more attention to fertilized plants than to non-fertilized plants or to soil treatments. In a nutria urine trial, we sprayed a trail of female nutria urine along the ground to determine if individual nutria would detect and follow the trail. Results suggested that nutria did not detect the urine trail. In another nutria urine trial, we examined the attractiveness of male urine versus female urine to three separate groups of nutria left overnight in a pen. The mean time per event spent in the male urine zone versus the female urine zone was different only for the mixed sex nutria group; there was no difference in time spent in these zones for the all-male or all-female groups. Additionally, the all-male nutria group most actively investigated the source of odors relative to the other two groups. The materials identified in this study show potential for the development of additional tools to manage impacts on coastal marsh ecosystems by this invasive herbivore.

INTRODUCTION

Nutria (*Myocastor coypus*) are large semi-aquatic rodents native to South America and were first brought to the United States in 1899 to establish a fur farm in California. This initial introduction failed due to lack of reproductive success (Ashbrook 1948). During the 1930s, nutria were imported for fur farms in Louisiana, Ohio, New Mexico, Washington, Michigan, Oregon, and Utah (Kinler et al. 1987). Since then, accidental and intentional releases have resulted in nutria becoming established in wetlands in at least 15 states (Willner 1982).

Nutria are an important economic resource for Louisiana according to the Fur and Alligator Advisory Committee (Linscombe 2001). Even though pelt values have decreased dramatically since the 1970s, nutria continue to benefit the Louisiana fur industry (Marx et al. 2004). During the 2000-2001 trapping season, nutria pelts made up 51% of the total fur harvest in Louisiana, and from 1990 to 2000 nutria and raccoon together brought in approximately $1.1 million to Louisiana (Linscombe 2001). Despite this economic advantage, nutria can be detrimental to areas. Nutria are recognized as at least a contributing factor to the decline of native Louisiana coastal marsh (Shaffer et al. 1992, Grace and Ford 1996, Evers et al. 1998). Nutria herbivory results in decreased vegetative biomass and altered plant species composition of marshes (Ford and Grace 1998, Visser et al. 1999). Management plans to control nutria damage typically involve population reduction or localized eradication (Schitoskey et al. 1972, Gosling and Baker 1989). Currently in Louisiana, the primary approaches to reduce nutria populations are shooting and trapping based on an incentive-payment program during trapping season (November-March). This technique is very effective at removing nutria yet does not intend to eliminate nutria. Furthermore, it is not subject to environmental or regulatory restrictions of some of the other control techniques (Mach 2002).

Other potential control techniques for nutria, such as induced fertility and chemical repellents, have shown limited efficacy (Mach 2002). Current technology of induced fertility of nutria is logistically impractical and is subject to rigorous requirements for registration (Mach 2002). No chemical repellents are registered for nutria and the few products that show some relief from nutria damage would not be effective on a large scale (Mach 2002). Conversely, chemical control with toxicants or anticoagulants is effective for nutria control. Zinc phosphide is the only rodenticide currently registered for nutria control (LeBlanc 1994). Its use is carefully regulated to reduce potential primary (Hegdal and Gatz 1977, Savarie 1991) and secondary (Timm 1994) non-target animal hazards. Application on a large scale is cost-prohibitive but is efficient for nutria control in limited areas (Mach 2002). Bromethalin, an acute toxicant typically used to control mice (*Mus musculus*) and rats (*Rattus spp*.), would pose similar risks to non-targets if applied similarly to zinc phosphide. However, the bait's stability and palatability may be advantageous for making the toxicant a potential alternative for nutria control (Mach 2002). Various anticoagulants described by Mach (2002) appear to show promise for effective control of nutria while minimizing non-target hazards. Similar to other control techniques described, anticoagulants would be most effective when used in combination with another technique.

Development of nutria attractants, such as baits and lures, to increase the effectiveness of kill-traps, live-traps, or rodenticide bait stations is a research priority. Effective lures could significantly improve control efforts of nutria. Results of pen trials by Nolte et al. (2004) suggested that nutria were more attentive to olfactory cues than to visual or auditory cues. In this study, we examined a variety of olfactory cues, such as food flavors and fragrances, commercial nutria lures, and synthetic nutria anal gland secretions and fur extracts, in a Y-maze to screen for materials that could later be tested in the field. We also evaluated the attractiveness to nutria of marsh grasses and fertilizers used for restoration efforts because, based on accounts by field personnel in Louisiana, nutria targeted the hand-reared plants in the marsh (G. Linscombe, pers. comm.). Vegetative or fertilizer cues that attract nutria may be effective lures in traps for removing nutria in areas prior to marsh green-up in spring. Nutria urine was also evaluated as an attractant. The purpose of the current study was to further investigate potential olfactory cues for nutria for the development of effective, operational attractants on Louisiana coastal marsh.

OBJECTIVES

The objectives of the study were to use wild-caught captive nutria to 1) identify potential olfactory cues in Y-maze trials, 2) assess marsh vegetation and fertilizers as attractants in pen trials, and 3) assess nutria urine as an attractant in pen trials.

METHODS

Olfactory Cue Trials. We screened 14 olfactory cues in a small Y-maze [3.5 m (11.66 ft) from the base to the fork, and 1.8 m (6 ft) from the fork to each arm end] from 11-17 March 2005, at the outdoor facilities of the LA Department of Wildlife and Fisheries in New Iberia. A series of 2-choice trials was run in the Y-maze with a test material in one arm and distilled water in the other. Right and left arm assignments of odors and water were randomized. One cc of a test material or distilled water was placed on filter paper in a shallow tin pan and placed at the end of its assigned arm of the Y-maze. An exhaust fan mounted above the start box (base of the maze) pulled air through the maze at 8.3 m/sec. Odor volatiles expelled from the maze by the fan were detectable to the human nose. Nutria were placed in the start box and released into the Y-maze by the observer who lifted a black, plastic, drop door via a pulley system. The observer sat on a platform within a blind near the fork of the Y-maze where the choice point (CP; fork of the maze) and selection points (SP; 2/3 distance from the CP toward the end of the arms of the Y-maze) were visible by direct observation. The trials were conducted at night using red lights.

The 14 odors were categorized as 1) food flavors and fragrances, 2) commercial nutria lures, and 3) synthetic anal gland secretion or fur extract from nutria. Food flavors and fragrances included nutty, pineapple, coconut, sour cheese, and banana (Sigma-Aldrich, Milwaukee, WI). Commercial nutria lures included spearmint oil (Cumberland's Northwest Trappers Supply, Inc., Owatonna, MN), fatty acid (Pocatello Supply Depot, Pocatello, ID), and Tom's Nutria #1 and Tom's Nutria #2 (Lone Oak Trading Company, Salem, OR). Tom's Nutria #1 and #2 are apple-based, contain no animal products, use propylene glycol as a carrier and anti-freeze agent, and food scents (proprietary). The food scents in Nutria #1 are different from those in Nutria #2. Anal gland secretion (AGS) and fur extract lures were AGS A, AGS B, AGS C, male fur extract, and female fur extract. AGS treatments were synthetic formulations based on a chemical profile analysis of one adult male's anal glands. AGS B was a close mimic of the complete chemical profile at the time of the study. AGSs A and C were similar to B except one major component of the chemical profile was excluded from each. Fur extracts were formulated by a chemical "washing" of the fur to extract olfactory volatiles, using the organic solvent pentane. Chemical formulations of AGSs and fur extracts were created and provided by Steve Finckbeiner who was a graduate student at Cornell University at the time.

Twenty-four adult nutria were captured locally and divided into three groups of eight, with 4 males and 4 females per group. Each of the 8 animals within a group was exposed only once to each odor within an assigned odor group. Captive nutria were fed sweet potatoes, carrots, and a commercial rodent chow. Animals were not food deprived prior to trials. We recorded which SP nutria reached during an individual run: that which contained the odor or the distilled water. If, after five minutes, a nutria did not reach a SP, the trial was concluded and recorded as “no selection.” We ran Fisher exact tests on treatment x choice contingency tables for each of the three odor groups to determine if there was significance in selections of treatment odors, water, or no selections. Descriptive bar graphs were used to illustrate male and female selections of olfactory cues.

Marsh Plant Trials. Marsh plant trials were run in a long, narrow pen, [60 m (200 ft) long and 1.4 m (4.5 ft) wide] from 14-27 April 2005, at the same outdoor facilities of the LA Department of Wildlife and Fisheries. Two rows of 15 holes each, 1 m apart, were dug in each end, or arm, of the pen for placement of potted plant containers. Vegetation or fertilizer treatment groups were randomly assigned to a pen arm (left or right), and individual containers were randomly assigned a hole within an arm (1-15 or 16-60) for each trial. For each trial, nutria were released at the center point of the pen.

Individual *Panicum hemitomon* (maidencane) and *Spartina alterniflora* (smooth cordgrass) plants were grown in 125 in^3 containers under greenhouse culture (Dr. Mike Materne, Agronomy Department, Louisiana State University, Baton Rouge). These plants are native marsh grasses that are consumed by nutria as part of their regular diet. The three types of fertilizer treatments for each species were 1) plants fertilized with a soil-based slow-release fertilizer tablet and ozmocoat slow-release pellets placed in the soil every 30 days during preparation, 2) plants fertilized with Miracle-Gro® foliar spray applied once a week, and ozmocoat pellets placed in the soil every 30 days, and 3) plants without fertilizer. Similar treatments of only soil (identical to that used for the plants), with the plant absent, were prepared to determined whether the cues that made fertilized plants attractive to nutria were detected in soil alone. The soil treatments were 1) soil with soil-based slow-release fertilizer tablet and ozmocoat pellets; 2) soil sprayed with Miracle-Gro® foliar spray and ozmocoat pellets, and 3) bare soil. Maintenance (water, light) of potted plants and soil was consistent across treatments.

Twenty-four adult nutria were captured and divided into 8 groups of 3 individuals, each with mixed sexes. Each group was left overnight in the pen and trials were video recorded with infrared cameras. Sample units were individual potted containers of plants or soil. We documented the total time (in seconds) spent at individual containers and the number of visits to individual containers by nutria. Time spent and visitation frequency were used as indicators of the attractiveness to nutria. “Time” spent by nutria at containers included consumption, sniffing, and unknown (behavior that was evident of interest in the container but difficult to categorize from video footage). In experiment 1 trials, we analyzed data from 20:00 – 01:00 hrs. The same nutria were used in experiment 2 trials, which ran from 18:00 – 22:00 hrs or 04:00 – 08:00 hrs. Nutria were not food deprived prior to trials.

In Experiment 1, we examined the significance of the presence or absence (soil only) of plant material, the type of plant species, the presence or absence of fertilizer, and interactions of the above for attracting nutria. Placement of containers in the pen was blocked by plant species (plant species was nested in arm), where *Panicum* or *Spartina* plants were randomly assigned within one of the two arms and soil treatments occurred in both. This was a 2 x 3 factorial design with two levels of delivery (plant present or absent) and 3 levels of fertilizer type: foliar fertilizer (FF), soil-based fertilizer (SB), and no fertilizer (NF). We ran an ANOVA test with the following fixed effects: plant species (arm), delivery, and fertilizer type; and with the following random effects: trial, trial x plant species (arm), trial x delivery, trial x fertilizer type, trial x delivery x fertilizer type, trial x delivery x plant species (arm), and trial x fertilizer type x plant species (arm). Each trial consisted of n=5 pots/treatment for an N=40 pots/treatment over eight trials.

In Experiment 2, we examined the significance of a foliar fertilizer (FF) versus a soil-based (SB) fertilizer, the type of plant species, the presence or absence of fertilizer, and interactions of the above for attracting nutria. Placement of treatments in the pen was blocked by fertilizer type [fertilizer type (FF or SB) was nested in arm], where foliar fertilized and soil-based fertilized plants were placed in opposite arms of the pen and each plant species occurred in both arms. Soil treatments were not used in experiment 2 based on the results of experiment 1. This was a 2 x 2 factorial design with two levels of treatment (fertilized or non-fertilized) and two levels of plant species (*Panicum* or *Spartina*). We ran an ANOVA test with the following fixed effects: fertilizer type (arm), plant species, and treatment; and with the following random effects: trial, trial x fertilizer type (arm), trial x plant species, trial x treatment, trial x plant species x treatment, trial x plant species x fertilizer type (arm), and trial x treatment x fertilizer type (arm). Each trial consisted of n=7 pots/treatment for an N=56 pots/treatment over eight trials.

Urine Trials. Female urine trail. We examined whether nutria would readily detect and follow a trail of female nutria urine. Individual nutria were released in an elongated pen [approximately 18.3 m (60 ft) x 1.4 m (4.5 ft) wide] with three rows of five entry-ways from 5-9 May, 2005. The rows ran perpendicular to the length of the pen and were 4.5 m (15 ft) apart. Entries (A, B, C, D, and E) within rows were approximately 23 cm (9 in) wide and were created by pushing several metal rods vertically into the ground. Female nutria urine, collected from penned individuals, was sprayed through the same entries of the rows in the pattern C, B, D. The trail of urine was applied before each nutria run and the pen was sprayed down with water after each run to minimize confounding odors. Twelve adult nutria (six male, six female) were released, one per trial run, from holding cages 4.5 m (15 ft) from the first row. The nutria urine trail began approximately 1.5 m (5 ft) in front of where nutria were released. The route taken by nutria through each of the three rows was recorded by direct observation. We calculated the percentage of times a nutria passed through an entry marked with the nutria urine.

Urine-soaked burlap bags. We examined whether nutria groups were more attracted to male or female nutria urine. Burlap bags were placed in holding pens with males or females to collect urine from each sex. Three groups of three nutria were each placed overnight from 28 April-3 May, 2005 in the pen used for marsh plant trials. The groups consisted of: 1) all-male nutria, 2) all-female nutria, and 3) mixed sex (two females and one male) nutria. Male and female urine-soaked burlap bags were randomly assigned to each side of the pen for each trial. The pen was rinsed down with water between trials.

Trials were video recorded with infrared cameras. Burlap bags with urine were placed in the ends of the pen arms, or “zones”. Zones were approximately 4.5 m x 2 m (15 ft x 7 ft). Nutria entering this area were considered to be attracted to the urine. An event was defined as the time from where at least one nutria entered a zone to the time where all nutria exited the zone. For each event, we calculated the mean time spent by nutria in each zone, the number of events of direct contacts (walked over, sat on, scratched, bit, etc.) with the burlap bags, and the frequency of the maximum number of nutria in a zone.

RESULTS

Olfactory Cue Trials. In the food flavors and fragrances group, there was no difference in treatment selections, water selections, or no selections (*P*=0.60). Of 40 potential selections, few of the nutria (n=12) reached a SP (i.e., made a selection) within the allotted time. Four selections by nutria were for the treatment, eight selections were for water, and no selection was made on 28 occasions. Nutty, banana, and sour cheese odors were selected at least once by a nutria while pineapple and coconut were never selected (Fig. 1). Three of the four selections for treatment odors by nutria in the food flavors and fragrances group were made by females (Fig. 2). Based on low response by nutria, we do not intend to examine these odors as lures in subsequent field trials at this time.

In the commercial nutria lure group, there was no difference in treatment selections, water selections, or no selections (*P*=0.73). Of 32 potential selections, 16 selections were made by nutria. Nine selections were for the treatment, seven were for water, and no selection was made on 16 occasions. All commercial lures were selected at least once; Nutria #1 was most selected and should be tested in the field. Three, out of four possible, males selected Nutria #1 from the commercial lures group (Fig. 2).

In the synthetic anal gland secretion or fur extract group, there was no difference in treatment selections, water selections, or no selections (*P*=0.06). Of 40 potential selections, 33 selections were made by nutria. Nineteen selections were for the treatment, 14 were for water, and no selection was made on seven occasions. Anal gland secretion B and female fur extract both were selected most frequently and should be examined under field conditions (Fig. 1). All four females exposed to anal gland secretion B selected it over water (Fig. 2). Of the six nutria that selected female fur extract, three were males and three were females (Fig. 2).

Post-hoc Fisher's exact estimates and one-sample proportion tests of the three most selected treatments indicated that proportions of treatment selections versus non-treatment selections did not differ for Nutria #1 (*P*=0.64), AGS B (*P*=0.14), or female fur extract (*P*=0.14).

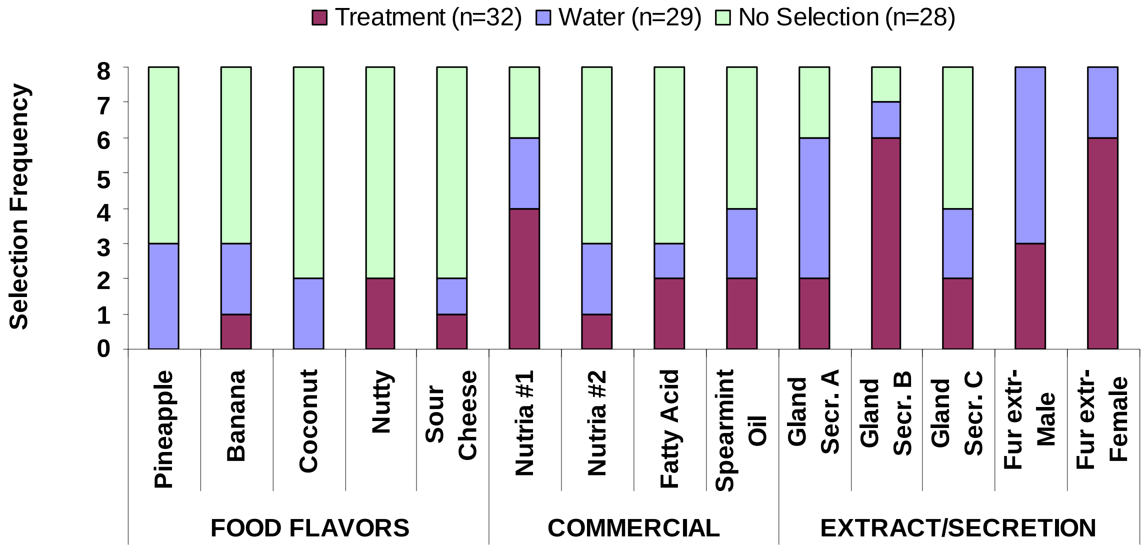


Figure 1. The number of times a treatment selection, water selection, or no selection was made by nutria during Y-maze trials. Three groups of eight nutria (4 female, 4 male) were exposed once to each odor within their group.

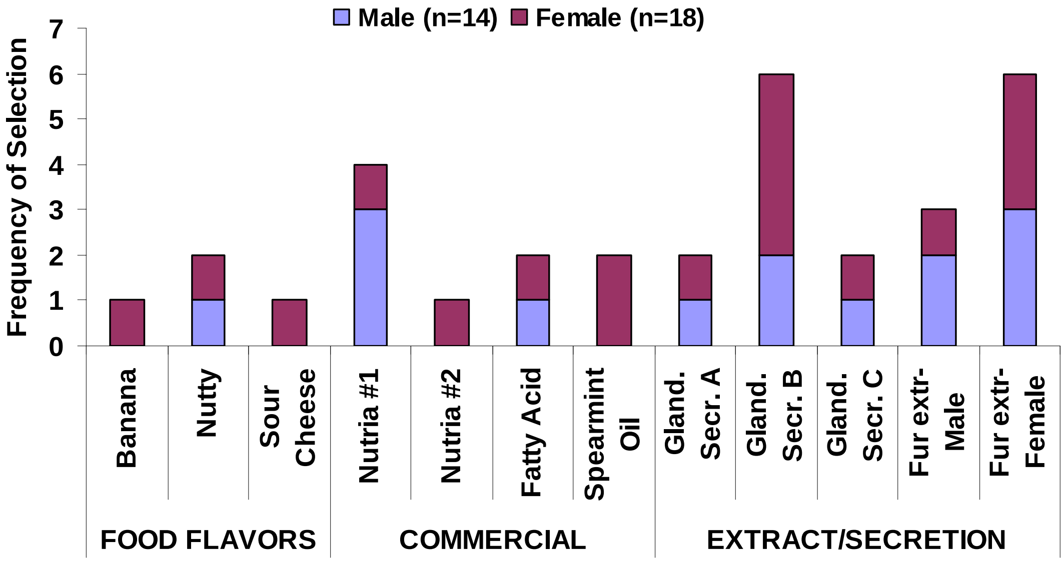


Figure 2. The number of times an odor was selected by male and female nutria during Y-maze trials. Three groups of eight nutria (4 female, 4 male) were exposed once to each odor within their group.

Marsh Plant Trials. Experiment 1. Nutria spent significantly more time, on average, at containers with plant material than without (i.e., soil only) (*P*=0.02; Fig. 3A). However, there was no statistical significance in the time spent at *Panicum* versus *Spartina* plants (*P*=0.19). Nutria did spend more time at fertilized containers than non-fertilized containers (*P*=0.03). There was an interaction between delivery (plant or soil) x fertilizer type (*F*=6.37, *df*=2,12, *P*=0.01) which indicated that nutria spent more time at fertilized plants than non-fertilized plants, or at fertilized and non-fertilized soil (Fig. 3A). Time spent by nutria was not influenced by plant species (arm) x delivery (*P*=0.17), plant species (arm) x fertilizer type (*P*=0.33), or plant species (arm) x delivery x fertilizer type (P=0.22; Fig. 3A).

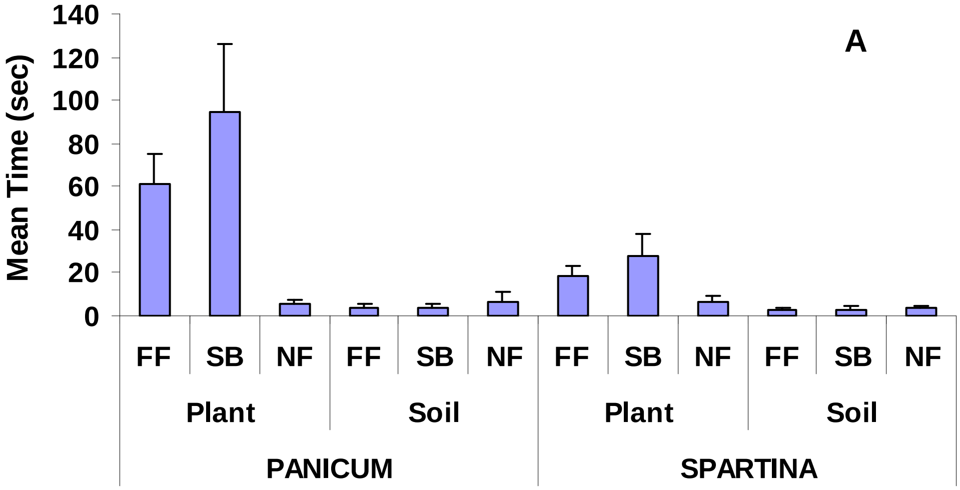
Nutria more frequently visited, on average, containers with plant material than those without plants (soil) (P=0.04). However, there was no significance between visitation frequency to *Panicum* versus *Spartina* plants (*P*=0.18; Fig. 3B). There was an interaction between delivery (plant or soil) x fertilizer type (*F*=5.11, *df*=2,12, *P*=0.03) which indicated nutria visited fertilized plants more than non-fertilized plants, or fertilized and non-fertilized soil (Fig. 3B). Visitations were not influenced by plant species (arm) x delivery (P=0.28), by fertilizer type (*P*=0.14), by plant species (arm) x fertilizer type (*P*=0.52), or by plant species (arm) x delivery x fertilizer type (*P*=0.09; Fig. 3B).

Although the results indicated no statistical significance for time spent at or for visitation frequency of the two plant species, nutria gave approximately three times more attention to, and visited twice more frequently, *Panicum* plants (a total of 6,337 seconds in 124 visits) than *Spartina* plants (2,133 seconds total in 58 visits). The statistical insignificance was likely due to the large variation in time spent at *Panicum* by nutria. For example, nutria spent a total of 20 minutes (in 8 visits) at an individual *Panicum* plant during one trial. The next most amount of time spent at any treatment was 8 minutes (in 4 visits).

So, while 20-minute events at *Panicum* are not typical, there were no such observations for *Spartina*.

Experiment 2. Nutria spent significantly more time at fertilized plants, on average, than at non-fertilized plants (*F*=6.95, *df*=1,6, *P*=0.04; Fig. 4A). However, fertilizer type (FF or SB) did not influence the time spent by nutria at containers (*P*=0.73; Fig. 4A). Plant species approached statistical significance, but was not (P=0.08). Time spent by nutria was not influenced by plant species x fertilizer type (arm) (*P*=0.38), by fertilizer type (arm) x treatment (fertilized or non-fertilized; *P*=0.60), by plant species x treatment (*P*=0.58), or by plant species x treatment x fertilizer type (arm) (*P*=0.20; Fig. 4A).

Nutria more frequently visited fertilized plants than non-fertilized plants (*F*=28.55, *df*=1,6, *P*=0.00; Fig. 4B). However, there was no significance in visitation frequency relative to fertilizer type (*P*=0.19; Fig. 4B). Visitations relative to plant species approached statistical significance, but were not (*P*=0.08). Visitations were not influenced by plant species x fertilizer type (*P*=0.39), by treatment x fertilizer type (arm) (*P*=0.74), by plant species x treatment (*P*=0.97), or by plant species x treatment x fertilizer type (arm) (*P*=0.78; Fig. 4B). It appears from the two marsh plant trials that fertilized plants are very attractive to nutria and, thus, should be tested in the field as potential lures.



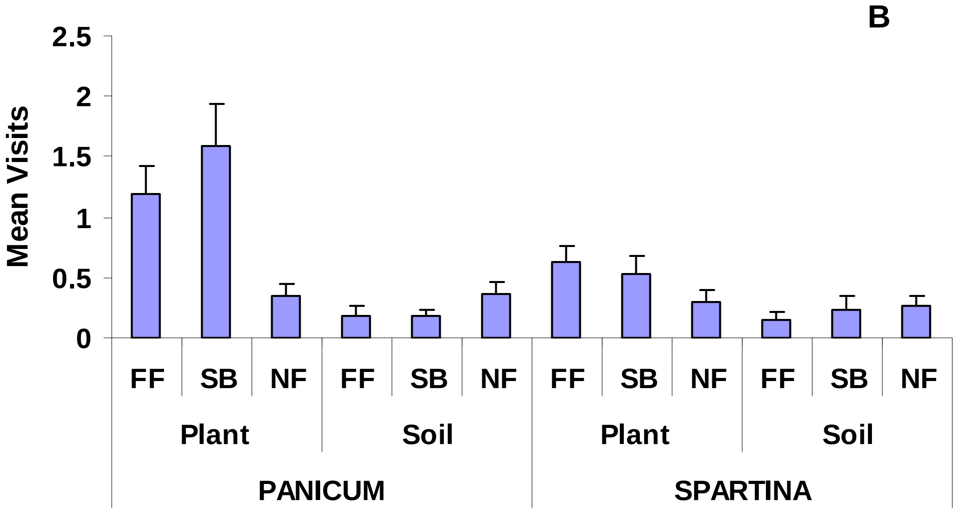


Figure 3. Experiment 1 plants and soil treated with foliar fertilizer (FF), soil-based fertilizer (SB), or no fertilizer (NF). (A) Mean time spent in seconds (±SEM) by nutria at plant or soil treatments. (B) Mean visits (±SEM) by nutria to treatments.

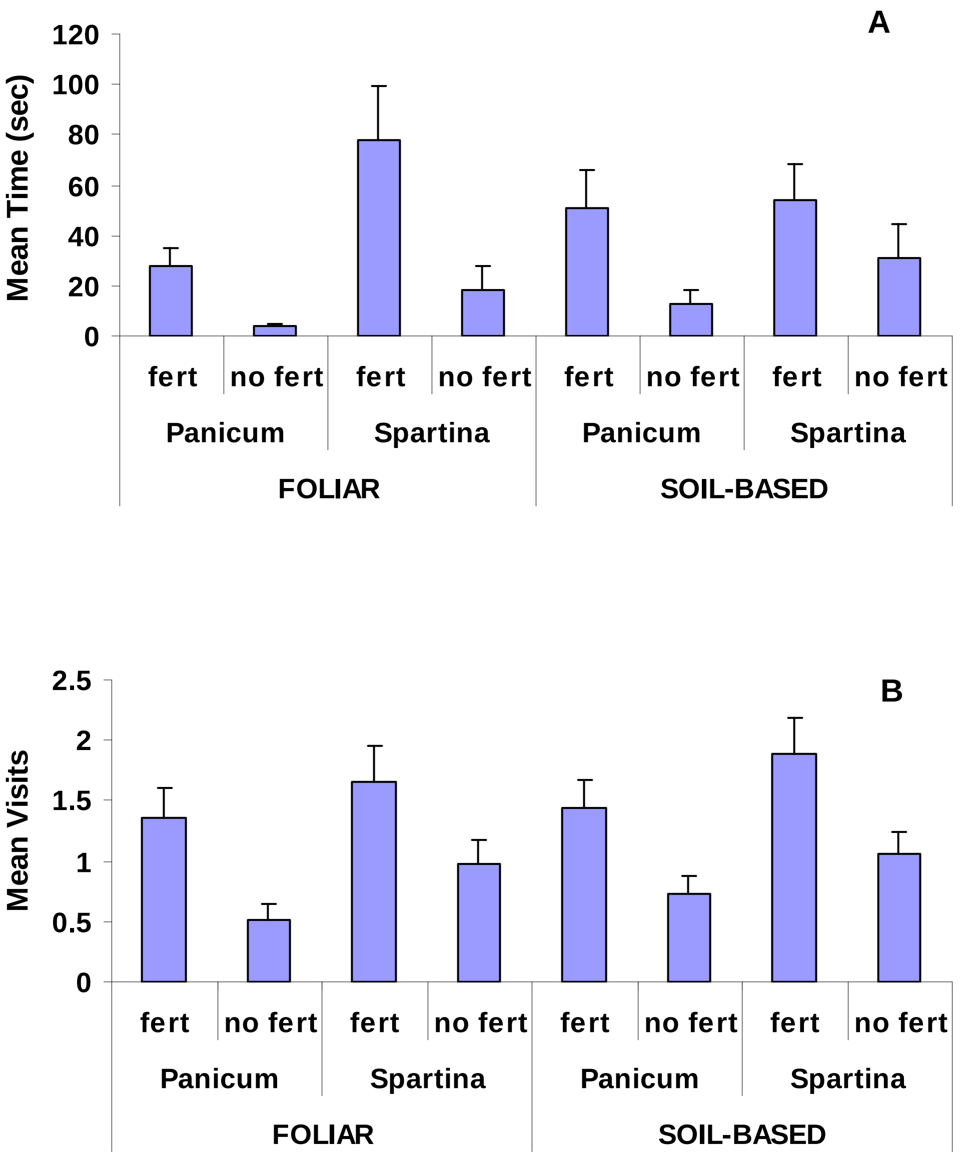


Figure 4. Experiment 2 plants treated with foliar fertilizer (FF), soil-based fertilizer (SB), or no fertilizer (NF). (A) Mean time spent in seconds (±SEM) by nutria at treatments. (B) Mean visits (±SEM) by nutria to treatments.

Urine Trials. Female urine trail. One of 12 nutria (8.3%) passed through entry C in row 1 where female nutria urine was sprayed (Table 1). Six (50%) nutria passed through entry B in row 2, and no (0%) nutria passed through entry D in row 3 where urine was present. One nutria, a male, entered two correct entry-ways: C of row 1 and B of row 2. Of the six nutria that entered B of row 2 (urine present), three were female and three were male (Table 1).

Table 1. Entry-ways taken by male and female nutria where a trail of female urine was sprayed on the ground through entries C, B, D of rows 1, 2, and 3, respectively.

Nutria	**Sex**	**Trail taken by nutria**		
		Row 1	**Row 2**	**Row 3**
1	M	B	C	C
2	M	B	**B**	B
3	M	**C**	**B**	C
4	M	B	**B**	B
5	M	D	C	C
6	M	D	D	E
7	F	D	C	B
8	F	B	**B**	B
9	F	D	D	E
10	F	D	**B**	C
11	F	B	**B**	B
12	F	D	C	C
Correct passages:		1	6	0
Percent correct:		8.3	50	0

<u>Urine-soaked burlap bags.</u> The all-male nutria trial lasted 7:33:01. Each event in the male urine zone lasted an average of 2.24 min (SE=0.63; sum=1:58:44) and 2.0 min in the female urine zone (SE=0.37; sum=2:02:05; Fig. 5). The all-female nutria trial lasted 8:05:22. Each event in the male urine zone lasted an average of 2.6 min (SE=0.45; sum=1:06:06) and 10.2 min in the female urine zone (SE=4.79; sum=5:45:55; Fig. 5). The mixed sexes of nutria trial lasted 7:42:04. Each event in the male urine zone lasted an average of 3.4 min (SE=0.77; sum=1:05:36) and 0.83 min in the female urine zone (SE=0.12; sum=0:13:20; Fig. 5). *Post hoc* analyses (one sample t-test) of the means for the all-male and all-female nutria groups indicated no significance in the mean time per event spent by nutria in the male urine versus female urine zone (*P*=0.52 and *P*=0.12, respectively). However, the time per event spent by the mixed sexes of nutria group in the male urine versus female urine was significant (*P*=0.00).

The total number of events in the all-male group was 114; 53 events in the male urine zone and 61 events in the female urine zone (Fig. 6). The total number of events in the all-female group was 59; 25 in the male urine zone and 34 in the female urine zone (Fig. 6). There was a total of 35 events in the trial of mixed sexes; 19 events in the male urine zone and 16 events in the female urine zone (Fig. 6). *Post hoc* analyses (Fisher's exact estimates and one-sample proportion tests) of the three nutria groups indicated no significance between the number of male urine and female urine events within the all-male nutria group (*P*=0.26), the all-female nutria group (*P*=0.15), or the mixed sexes of nutria group (*P*=0.37). Furthermore, *post hoc* analyses (Fisher's exact estimates and two-sample proportion tests) indicated no significance in proportions of female urine events versus male urine events between the all-male nutria and all-female nutria groups (*P*=0.63), the all-male nutria and mixed sexes groups (*P*=0.45), or the all-female nutria and mixed sexes groups (*P*=0.29).

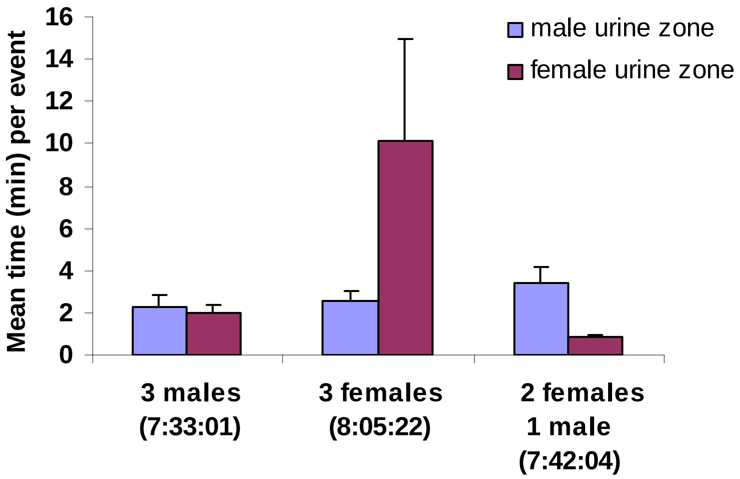


Figure 5. Mean time (± SEM) per event spent by nutria in the male urine or female urine zone where at least one nutria was present in a zone. Three overnight trials were run with three separate groups of three nutria. Total trial time is indicated in parentheses.

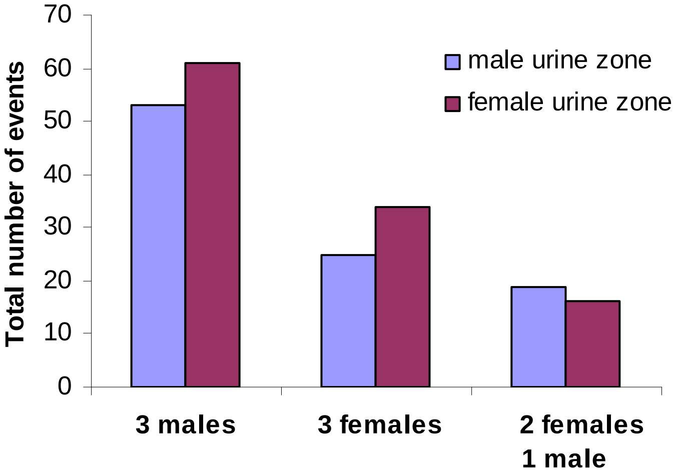


Figure 6. Total number of events in male urine and female urine zones during overnight trials with three groups of nutria.

Of the total number of events in the all-male group, 13 (25%) were direct contacts the male urine burlap and 17 (28%) were direct contacts with female urine burlap (Fig. 7). In the all-female group, 4 (16%) events were direct contacts with male urine burlap and 7 (21%) events were direct contacts with female urine burlap (Fig. 7). In the mixed sexes of nutria group, 3 (16%) events were direct contacts with male urine burlap bags and 3 (19%) events were direct contacts with female urine burlap bags (Fig. 7). *Post hoc* analyses (Fisher's exact estimates and one-sample proportion tests) indicated no significance between direct contacts with male urine versus female urine burlap bags within the all-male nutria group (*P*=0.29), the all-female nutria group (*P*=0.27), or the mixed sexes group (*P*=0.66). Furthermore, *post hoc* analyses (Fisher's exact estimates and two-sample proportion tests) indicated no significance in direct contacts for female urine burlap bags versus male urine burlap bags between the all-male nutria and all-female nutria groups (*P*=0.74), the all-male nutria and the mixed sexes groups (*P*=1.00), and the all-female and mixed sexes groups (*P*=0.64).

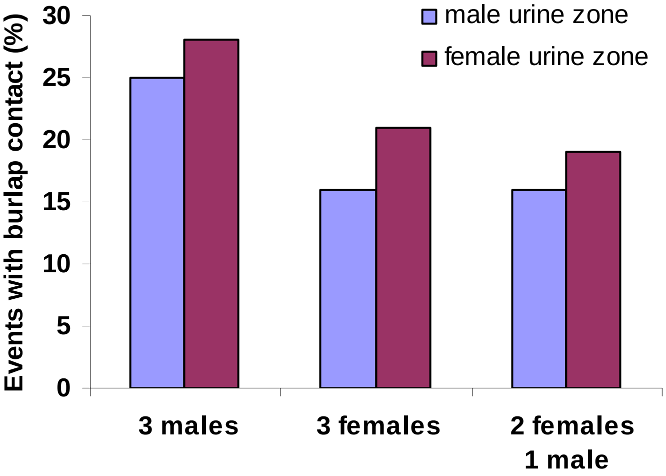


Figure 7. Percentages of events during overnight group trials where nutria made direct contact with male or female urine-soaked burlap bags.

The frequency of the maximum number of nutria in a zone per event can be thought of as the likelihood of one nutria in a zone to influence other nutria to enter the zone. Of the 53 events in the male urine zone by the all-male group, 49 of these consisted of a single male in the zone, and 4 of these consisted of two males in the zone at one time. At no time were all 3 males in the male urine zone simultaneously (Fig. 8). Of the 61 events in the female urine zone for this group, 49 of these were a single male in the zone, 11 of these were two males in the zone at one time, and only one time were all three males simultaneously in the female urine zone. Of the 25 events in the male urine zone by the all-female group, 16 of these consisted of a single female in the zone, and 9 of these consisted of two females in the zone at one time. At no time were all 3 females in the male urine zone at the same time (Fig. 8). Of the 34 events in the female urine zone for this group, 17 of these were a single female in the zone, 12 of these were two females in the zone at one time, and 5 of these events were made up of all three females in the zone at once (Fig. 8). Of the 19 events in the male urine zone by the mixed sexes group, 10 of these consisted of a single nutria in the zone, 5 consisted of two nutria in the zone, and 4 of these consisted of all three nutria in the zone at once (Fig. 8). Of the 16 events in the female urine zone for this group, 12 of these consisted of a single nutria in the female urine zone, 3 consisted of two nutria in the zone, and only once were all three nutria simultaneously in the zone (Fig. 8).

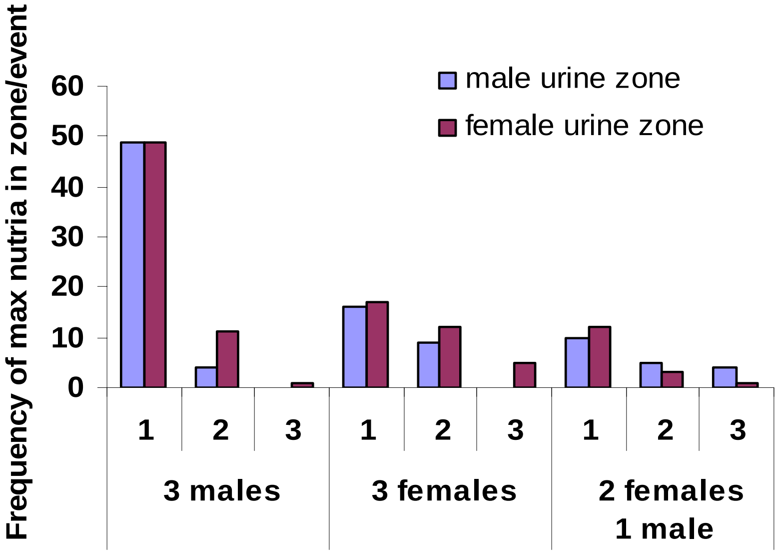


Figure 8. The frequency of the maximum number of nutria in a zone per event at any one time during overnight trials.

DISCUSSION

The purpose of this study was to screen potential olfactory cues and evaluate marsh vegetation, fertilizers, and nutria urine as attractants for nutria on Louisiana coastal marshes. Attractants could serve as lures for traps or bait stations, and, hence, increase trap success for management of targeted nutria populations.

In Y-maze trials, statistical analysis within the three odor groups (food flavors and fragrances, commercial, and extract/secretion lures) indicated no significance between treatment selections, water selections, or no selections. Low sample size (n=8/odor) was likely the major factor for no detectable difference. However, for purposes of this study, the data sufficiently identified three odors that nutria responded to more than others. Thus, the three odors, Tom's Nutria #1, AGS B, and female fur extract, should be tested in the field. If effective in the field, these lures may assist management efforts when used in combination with current trapping efforts, or future rodenticide bait station efforts.

Males and females both actively selected odors in the Y-maze. In general, there does not appear to be a strong indication that one sex selected a specific odor more than the other. It is ideal to use a lure in the field that would be effective for both sexes. Future Y-maze trials could focus on attractant properties of lures that target control of a specific sex.

Time spent by nutria at potted containers in experiment 1 of the marsh plant pen trials indicated that nutria spent more time where plant material was present. Nutria also spent more time at fertilized plant material than non-fertilized plant material. Experiment 2 confirmed that fertilized plants were preferred over non-fertilized, but that the type of fertilizer (foliar or soil-based) did not matter. In both experiments, the species of plant was insignificant, which indicated that nutria were similarly attracted to both of these marsh plants.

Visitation frequencies by nutria at plants in experiment 1 indicated that nutria most frequently visited fertilized plant material. This suggests that nutria identified olfactory cues of fertilized plants, discriminated locations of fertilized plants from non-fertilized plants, and repeatedly targeted only fertilized plants throughout the trial. Experiment 2 confirmed the significance of fertilized plants over non-fertilized plants, and that the specific fertilizer type did not matter. Plant species was also insignificant relative to frequency of visitations, which indicated nutria were attracted to both of these marsh plants. Based on the marsh plant trials, nutria were equally attracted to *Panicum* and *Spartina* plants, and to foliar fertilizer and soil-based fertilizer. Unfortunately, this means plants used for marsh restoration efforts will continue to be targeted. However, hand-reared plants placed in the marsh as a lure inside traps prior to spring marsh green-up would reduce nutria in an area and consequently, increase the likelihood of marsh plant survival when transplanted.

The female urine trail trial did not appear to influence the route taken by nutria. Of 36 total possible correct entry-ways, only 7 (19%) were taken by nutria. In most cases, it appeared that nutria went through the three rows in a relatively straight line. This was the only series of trials run during the daytime, which most likely influenced nutria routes since they are more crepuscular and nocturnal. It is likely that nutria were more concerned with finding cover rather than attending to odor cues in this trial.

In the urine-soaked burlap bag trials, only the mixed sexes of nutria group spent significantly more time per event in one urine zone (male) versus the other (female). This may be due to the fact that males of mixed sexes groups typically spend much of their time attempting to copulate with females, and females spend much of their time evading males (per our video observations). It is likely that the females of this group spent extended amounts of time in areas of the pen where the male was not (e.g., a zone or the corridor between zones) as a means of evasion versus an indication of attraction to the urine. The all-female nutria group results had a large variance in the mean time per event spent in the female urine zone. This was due to individuals resting for long periods (1 and 2 hrs) within the zone on two occasions. The extended rests do not necessarily indicate persistent attraction to the female urine, although, no such rests were observed in the male urine zone. The all-male group spent the same amount of time per event, on average, in both zones, which suggested equal attraction to male and female urine. In general, there was not an overwhelming difference in the average time spent in the male or female zone by the groups.

The proportion of events of direct contact with burlap bags was the same among the three groups although the total number of direct contacts was slightly higher in the all-male nutria group relative to the all-female or mixed sexes of nutria groups. This suggests that in an enclosed area, males more actively and persistently investigated odor cues and their source relative to females or mixed sexes groups.

The frequencies of the maximum number of nutria in a zone per event suggested that males inspect odor cues in an enclosure more independently than females. Females appeared to influence other females to enter an occupied zone more frequently than males influenced other males to do the same. Very rarely was a third nutria influenced to enter a zone occupied by two individuals, regardless of sex. Because adult males can be aggressive toward other males, it is expected that males would not occur in close proximity (i.e., in maximum numbers of 2 or 3 per zone) to one another in this trial. However, the very high frequency of individual males occurring in zones suggests that, in the absence of a female nutria, males more actively (i.e., repeatedly) inspect urine odors of both males and females. This may be useful information for targeting male nutria in areas of low population densities.

In summary, several materials were identified in this study with good potential to improve the management of nutria populations and to reduce marsh ecosystem damage by this introduced herbivore. The study identified attractive olfactory cues for nutria that warrant further assessment in the field. Two olfactory cues were synthetic formulations of nutria biochemicals. Further research on nutria biochemicals as attractants may improve the development of effective nutria lures. Hand-reared, fertilized marsh plants may be a useful lure on coastal marshes prior to new spring growth. When used inside multiple capture traps, several nutria could potentially be removed from an area with relatively low loss to hand-reared marsh plants used in restoration efforts. Nutria urine is worth examining under field conditions even though our results did not indicate a strong attraction because, it is another nutria biochemical that would be relatively easy and inexpensive to acquire for use as a lure in the field. The use of these attractants for removing a few individuals in areas of low nutria population densities would also be an area of future research worth pursuing.

ACKNOWLEDGMENTS

We thank Andrew Dolan of the U.S. Fish and Wildlife Service for funding the study. We also thank Greg Linscombe (retired), Ed Mouton, and staff of the Louisiana Dept. of Wildlife and Fisheries for the use of their facilities to conduct attractant research and for capturing nutria for our pen studies. Dwight LeBlanc of Wildlife Services, Louisiana, provided technical and field assistance. Dale Nolte, USDA/Wildlife Services-NWRC, initiated the nutria studies by NWRC and encouraged our efforts. Jared Leger, Wildlife Services, cared for study animals, implemented research trials, and viewed video film. Steve Kendrot, Wildlife Services, Maryland, provided research materials and information for the report. Suzie Rizor and Kelly Perry, Wildlife Services-NWRC, Washington, helped with nutria handling and video systems. Bruce Kimball and Greg Phillips, Wildlife Services-NWRC, Colorado, assisted with statistical aspects. Steve Finckbeiner, formerly of Cornell University, provided research materials. Mike Materne, Louisiana State University, provided plant materials. Chloe Autran and Joel Grove, Colorado State University students, viewed many hours of nutria video film.

LITERATURE CITED

Ashbrook, F.G. 1948. Nutrias grow in United States. Journal of Wildlife Management 12:87-95.

Evers, D.E., C.E. Sasser, J.G. Gosselink, D.A. Fuller, and J.M. Visser. 1998. The impact of vertebrate herbivores on wetland vegetation in Atchafalaya Bay, Louisiana. Estuaries 21:1-13.

Ford, M.A., and J.B. Grace. 1998. The interactive effects of fire and herbivory on a coastal marsh in Louisiana. Wetlands 18:1-8.

Gosling, L.M. and S.J. Baker. 1989. The eradication of muskrats and coypus from Britain. Biological Journal of the Linnean Society 38:39-51.

Grace, J.B. and M.A. Ford. 1996. The potential impact of herbivores on the susceptibility of the marsh plant *Sagittaria lancifolia* to saltwater intrusion in coastal wetlands. Estuaries 19:13-20.

Hegdal, P.L., and T.A. Gatz. 1977. Hazards to pheasants and cottontail rabbits associated with zinc phosphide baiting for microtine rodents in orchards. Unpubl. Rep. U.S. Fish and Wildlife Service, 60 pp.

Kinler, N.W., G. Linscombe, and P.R. Ramsey. 1987. Nutria. Pages 327-342 *in* M. Novak, J.A. Baker, M.E. Obbard, and B. Malloch (eds). Wild furbearer management and conservation in North America. Ministry of Natural Resources, Ontario, CAN.

LeBlanc, D.J. 1994. Nutria. Pages B71-B80 *in* S.E. Hygnstrom, R.M. Timm, and G.E. Larsen (eds.). Prevention and control of wildlife damage. Cooperative Extension Division, Institute of Agriculture and Natural Resources, University of Nebraska, Lincoln, NE.

Linscombe, G. 2001. 2000-2001 Annual Report. Louisiana Fur and Alligator Advisory Council. Louisiana Department of Wildlife and Fisheries, New Iberia, LA.

Mach, J.J. 2002. Nutria control in Louisiana. Proceedings of the Vertebrate Pest Conference 20:32-39.

Marx, J., E. Mouton, and G. Linscombe. 2004. Nutria harvest distribution 2003-2004 and a survey of nutria herbivory damage in coastal Louisiana in 2004. Coastwide nutria control program CWPPRA Project (LA-03b). Louisiana Deptartment of Wildlife and Fisheries, New Iberia, LA.

Nolte, D.L., A.E. Barras, S.E. Adams, R.G. Linscombe, D.J. LeBlanc. 2004. Assessing potential for using zinc phosphide bait to control nutria on Louisiana coastal marsh. Proceedings of the Vertebrate Pest Conference 21:150-157.

Savarie, P.J. 1991. The nature, modes of action, and toxicity of rodenticides. Pp. 589-598 *in*: D. Pimentel (ed.), CRC Handbook of Pest Management in Agriculture, Vol. II. CRC Press, Boca Raton, FL.

Schitoskey, F. Jr., J. Evans, and G.K. LaVoie. 1972. Status and control of nutria in California. Proceedings of the Vertebrate Pest Conference 5:15-17.

Shaffer, G.P., C.E. Sasser, J.G. Gosselink and M. Rejánek. 1992. Vegetation dynamics in the emerging Atchafalaya Delta, Louisiana, USA. Journal of Ecology 80:677-687.

Timm, R.M. 1994. Description of active ingredients. Pp. G23-G61 *in*: S.E. Hygnstrom, R.M. Timm, and G.E. Larsen (eds.), Prevention and Control of Wildlife Damage. Nebraska Cooperative Extension Service, University of Nebraska, Lincoln, NE.

Visser, J. M., C. E. Sasser, R. H. Chabreck, and R. G. Linscombe. 1999. Long-term vegetation changes in Louisiana tidal marshes, 1968-1992. Wetlands 19:168-175.

Willner, G.R. 1982. Nutria. Pp. 1059-1076 *in* J.A. Chapman and G.A. Feldhamer (eds). Wild mammals of North America: biology, management, and economics. Johns Hopkins University Press, Baltimore, MD.