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A MODIFIED BAIT FOR ORAL DELIVERY OF BIOLOGICAL AGENTS TO RACCOONS AND FERAL SWINE

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ABSTRACT: A field study was conducted on Ossabaw Island (Georgia, USA) in March 1994 to evaluate four different types of bait for delivering orally effective biological agents to raccoons (*Procyon lotor*) and feral swine (*Sus scrofa*). A deep-fried corndog batter bait, which was previously shown to be ingested by both captive and free-ranging raccoons, and a polymer fishmeal bait which had been shown effective for both raccoons and feral swine were compared with a grain-based dog food meal polymer bait topically coated with corn oil and cornmeal or with fish oil and fishmeal. Tracking stations were used to determine the number of each bait type visited and removed by animals visiting stations. We found no significant differences in the numbers of different baits removed by either species. These data support the results of earlier studies which also indicated that an inexpensive grain-based matrix bait surface-coated with attractive flavors can be used to deliver oral biologics to problem species.

Key words: Feral swine, field study, oral baits, *Procyon lotor*, raccoon, *Sus scrofa*.

INTRODUCTION

Research within the last 10 to 15 yr has resulted in effective genetically engineered recombinant or attenuated virus oral rabies vaccines for use in domestic dogs and such wildlife species as raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), and red fox (*Vulpes vulpes*) (Fekadu et al., 1996; Rupprecht et al., 1986, 1989; Tolson et al., 1987; Wandeler, 1991). Efforts also have been made to develop oral vaccines for pseudorabies virus (PRV) and brucellosis in feral swine (*Sus scrofa*) (Nettles, 1991).

The success of baits and baiting systems for the oral rabies vaccination (ORV) of red foxes in Europe (Baer, 1988; Blancou et al., 1988; Perry, 1989; Wandeler, 1991) and Canada (Johnston et al., 1988; Bachmann et al., 1990) has prompted an interest in the wider application of baits and baiting systems for administering orally effective biologics to other species that harbor infectious diseases (Nettles, 1991). Systems for orally administering antifertility agents to problem free-ranging wildlife also will be needed in the future (Linhart et al., 1997a). Effective baits must meet several important requirements. Baits should be (1) attractive to the target species, (2) where feasible, unacceptable or marginally so to nontarget species, (3) easily available and inexpensive, and (4) easily stored (Wandeler, 1991). A variety of baits, including impregnated or wax- and tallow-coated sponge cubes, Canadian sachet baits, Tübingen baits, and polymer fishmeal baits, have been successfully used in Canada, Europe, and the United States to deliver orally effective biomarkers and/or rabies vaccine (Bachmann et al., 1990; Hanlon et al., 1989; Perry et al., 1989; Hadidian et al., 1989; Willhelm and Schneider, 1990; Linhart et al., 1997a).

Bait effectiveness and the methods used to distribute them may vary depending upon environmental factors, as well as target species behavior and population ecology (Linhart, 1993; Kavanaugh, 1998). The extent to which ORV is used also depends upon the cost of vaccine bait manufacture, their purchase price for user groups, and the costs of shipment and aerial bait distribution. Reducing these costs should result in increased use of the technology. Another way to enhance efficacy may be by developing new baiting techniques or modifying existing ones. This might include additional development of specific bait types to increase their uptake by the

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various vector species. For example, the fishmeal polymer bait (currently produced by Bait-Tek, Inc., Beaumont, Texas, USA) has been found effective for administering biomarkers or oral rabies vaccines to raccoons (Hanlon et al., 1989; Linhart et al., 1997a), coyotes (*Canis latrans*) (Fearneyhaugh et al., 1998), golden jackals (*Canis aureus*) (Linhart et al., 1997c), and red foxes in Europe (Brochier et al., 1991). However, fish-flavored baits ranked low in preference for gray foxes (*Urocyon cinereoargenteus*) (Steelman et al., 1998) and domestic dogs (Linhart et al., 1997c). White-tailed deer (*Odocoileus virginianus*) seldom, if ever, disturbed fish-flavored baits placed at tracking stations (S. B. Linhart, unpubl. data), but another ungulate, the feral swine, readily consumed such baits (Fletcher et al., 1990; Kavanaugh, 1998).

One option that may have merit is to mass produce an inexpensive grain-based "generic" bait, and to overcoat this matrix with species-specific odor attractants or preferred flavors either at the point of manufacture or just prior to field distribution. An example of the latter strategy has been the application of a Hills Pet Products, Inc. (Topeka, Kansas, USA) flavor enhancer to hundreds of thousands of coyote baits immediately prior to their aerial distribution (M. G. Fearneyhough, pers. comm.). Application of highly volatile odor attractants to baits just prior to distribution may result in better uptake of baits which were manufactured weeks or months in advance of actual field use. Bait manufacturers or vaccine producers (e.g., Raboral® V-RG vaccine, Merial Limited, Athens, Georgia, USA) may find it less costly to manufacture an identical bait matrix for the various species and to subsequently surface-coat stored baits, as the need arises, with flavors preferred by target species. Use of different odor (lure) and bait types has long been the practice of fur trappers who want to selectively capture the more valuable furbearers. Surface coating of small numbers of generic baits with different flavors would also be an efficient way to evaluate animal responses in the field. Preferred flavors could then be incorporated into bait manufacturing procedures more suitable for the production of large numbers of baits. Tests of flavor-coated dog food polymer baits have now been reported for domestic dogs (Linhart et al., 1997c), gray foxes (Steelman et al., 1998), and coyotes (Farry et al., 1998). Our study sought to compare raccoon and feral swine discovery and removal rates of two flavor-coated dog food polymer baits with baits flavored at the time of manufacture.

STUDY AREA

Ossabaw Island is a coastal barrier island located in Chatham County, (Georgia, USA, 31°46′N, 81°05′W) and owned by the Georgia Department of Natural Resources (Atlanta, Georgia, USA). The island is 10,118 ha, with uplands and freshwater marshes comprising 4,775 ha, the remainder being salt marsh. This study utilized the extensive network of unimproved roads on approximately 2,600 ha of the upland habitat.

There are few small- and medium-sized carnivores and omnivores present on the island when compared to the coastal mainland. Bobcats (*Lynx rufus*), red foxes, gray foxes, coyotes, skunks, and opossums (*Didelphis virginianus*) are absent. Raccoons, feral swine, and white-tailed deer populations are all relatively high in comparison to the mainland. At the time of this study (March 1994), Ossabaw Island also had a population of feral donkeys (*Equus asinus*) exceeding 100 animals, three free-ranging domestic cattle, and 12 to 14 semiferal horses.

MATERIALS AND METHODS

Four bait types were evaluated. Bait A was a polyurethane sleeve coated in a commercial corn-dog batter mix and deep-fried, as originally developed for raccoons (Linhart et al., 1991). Baits B, C, and D were polymer baits (in 1994, produced by E. I. DuPont De Nemours and Company, Inc., Sabine Research

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TABLE 1. Confirmed visits and bait removal from tracking stations on Ossabaw Island, Georgia, 24–28 March 1994.

Species	Bait type			
	A[a]	B[a]	C[a]	D[a]
Raccoon	33/35[b] (94)	32/37 (86)	29/32 (91)	35/37 (95)
Feral Swine	13/14 (93)	12/15 (80)	7/8 (88)	10/12 (83)
Donkey	10/10 (100)	11/13 (85)	5/6 (83)	2/11 (18)

[a] See text for description of bait types.
[b] Baits taken/visits (%).

Laboratory, Orange, Texas, USA). The bait matrix for baits B and C each contained a proprietary mixture of grain-based dog food meal, vegetable oil, and ethylene vinyl acetate (EVA) polymer binder. Mazola® corn oil (4% by weight), heated to 200 C for 15 min, was sprayed on Bait B, and the baits then were coated with corn meal (3% by weight). The same procedure was used on Bait C, except that fish oil (4% by weight) at ambient temperature and fish meal (3% by weight) were the coating agents. Bait D consisted of a proprietary mixture of fish meal, fish oil, and EVA polymer binder that were thoroughly mixed before cooking and extrusion. The latter bait has been widely used for foxes and raccoons to deliver oral rabies vaccine (Linhart et al., 1997b). All baits were cylindrical in shape and approximately 2.0 cm in diameter and 5.0 cm long, except for Bait D which was 3.0 cm × 4.0 cm. Bait D was sectioned lengthwise, and halves were used to reduce any size bias.

Tracking stations consisted of 1 m^2 of raked soil (Linhart and Knowlton, 1975), placed at 320 m intervals along the roadside to determine bait contact by target/nontarget species. One hundred forty-eight stations were set on 23 and 24 March 1994. A single bait was placed in the center of each station. Removal of baits and species visiting the stations were determined by track impressions left in the soil.

The four bait types (A–D) were placed out in random order in a series of four bait station segments. That is, bait B was placed at station number one, bait D at station two, bait A at station three, and bait C at station four. This random placement was continued along the roadway until 37 consecutive segments, each containing the four bait types, were established (i.e., 148 stations in total). Baits were placed on stations between 08:00 and 18:00 the first two days and between 08:00 and 14:00 on subsequent days. Baits were checked the following day between 08:00 and 14:00. If the bait was removed, the visiting species was recorded, the station was cleared of tracks, and the bait was replaced with the same type. No data were used for analysis when the tracks of two or more species were present at a station on a given day since it was impossible to determine which had removed the bait. If the station was visited but the bait was not removed, the species was recorded, the station cleared of tracks, and the bait repositioned. Baits that were partially eaten were removed and replaced with a new bait after clearing the station. Heavy rain on night two damaged baits and washed out any sign of visitation, necessitating the replacement of all baits. Removal rates were determined by the number of each bait type taken divided by the number of stations visited.

Statistical comparisons between the removal rates of the four baits were evaluated using the chi-square statistic with Yate's correction (Dean et al., 1994).

RESULTS

We made 102 observations for each bait type during the four days of the study. We recorded the removal of 68 (67%) of Baits A, 67 (66%) of Baits B, 66 (65%) of Baits C, and 66 (65%) of Baits D. The tracks of either raccoons, swine, or donkeys, or a combination thereof, were present at all stations where baits had been removed. The only exceptions we observed were the removal of a bait coating on a bait A by a wild turkey (*Meleagris gallopavo*) and the removal of two additional Bait A's, one Bait B, and one Bait C by unidentified animals.

The raccoon was the only species that had 30 or more confirmed visits to each of the four different bait types. Raccoon bait removal rates ranged from 86% for Bait B to 95% for Bait D (Table 1). A chi-square statistic with Yates' correction revealed that the difference in uptake of baits was not significant ($P < 0.05$) among any of the bait types.

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The visitation rate for feral swine was low, ranging from eight confirmed visits to Bait C to 15 visits to Bait B. Bait removal rates ranged from 80% for Bait B to 93% for Bait A. As expected with this small sample size, there was no significant difference in acceptance between any of the four baits. The feral donkey was the only nontarget species that showed significant interest in the baits. Confirmed visitation by donkeys was nearly identical to that of feral swine, ranging from six for Bait C to 11 for Bait D. Donkeys demonstrated the only significant difference ($P > 0.05$) in the acceptance of a bait, by consuming only two Bait D's of 11 visits and consuming 10 of 10, 11 of 13, and five of six, for Baits A, B, and C, respectively.

DISCUSSION

Raccoons on Ossabaw Island demonstrated equal acceptance of topically flavor-enhanced grain-based polymer baits and baits that had flavor/odor mixed throughout by the manufacturer. Feral swine also did not appear to discriminate between bait types. The small sample sizes we obtained from feral swine were probably caused by another unrelated research project which had reduced the population on the study area by approximately 650 animals in the six weeks prior to this study.

The removal of baits by donkeys raises several questions. The lack of acceptance of Bait D is supported by the findings of our previous bait studies on the island, however, the increased overall visitation of the stations by donkeys is not (D. M. Kavanaugh, unpubl. data). Seasonal conditions and unavailability of natural food may have influenced the attractiveness of the baits to this nontarget species. The consumption of the corn-flavored baits by donkeys is understandable, but the reason for the removal of the fish oil/fish meal coated baits is unknown.

Although this initial study provided modest data, results nonetheless suggested that generic grain-based baits topically coated with different attractants may offer an alternative or optional method of bait production. Use of a generic bait matrix involves only the addition of an exterior flavor coating to easily modify baits for specific circumstances or species. More and larger scale field trials are needed to examine the acceptance of such baits by other small- and medium-sized carnivores and omnivores not found on the island, as well as by nontarget domestic species. Such field trials, and investigation into other flavor and odor attractant coatings that could be used for different species, seasons, and geographic regions, may result in higher levels of baiting efficacy and possibly reduced costs to both manufacturers and user groups.

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