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Taste Aversion Conditioning in Free Ranging Raccoons (Procyon lotor)

Abstract

A free ranging population of raccoons (*Procyon lotor*) were fed dead LiCl-injected chickens following a demonstrated preference for live chickens over dog food. A preference reversal was demonstrated following treatment, and the live chicken avoidance, by both identifiable and unidentifiable members of the population, continued for more than seven months.

An extensive research literature reports taste aversion conditioning to be an effective manipulation procedure for food preferences in animals (Riley and Baril 1976, Riley and Clarke 1977). At least 30 species, both vertebrate and invertebrate, have been shown sensitive to illness conditioning under laboratory conditions (Gustavson 1977). Aversive conditioning appears to be an important component in the development and maintenance of food preferences in nature (Brower 1969, Martin 1975).

Recently, taste aversion conditioning has been suggested as an alternative to killing for the control of coyote predation upon domestic livestock (Gustavson *et al.* 1974, 1976). Such an alternative, if practical, may obviate objections to predation control not only for coyotes but for skunks, raccoons, and foxes as well. Taste aversion conditioning is more humane, selective, and does not remove predators from their natural role in ecosystems.

Some opposition to the implementation of taste aversion conditioning in predator control has resulted from: (1) the inability of some researchers to produce aversions among coyotes to domestic livestock (Burns 1980, Conover *et al.* 1977, Lehner and Horn 1977, and Griffiths *et al.* 1978) when divergent procedures have been attempted;

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and (2) the difficulty of establishing equivalent experimental controls in field studies on aversive conditioning. No individually free-ranging predator has been observed to first prey upon domestic livestock, then feed upon baits treated with an aversion agent, and then avoid previously acceptable prey. For large wide-ranging predators, collecting such definitive field data would be difficult. However, at least one North American predator, the raccoon, may lend itself to this kind of field study.

Methods

A population containing over 20 raccoons was observed from 7 October 1978 to 13 April 1979 in Jackson County, Oregon. The study site was in a mixed conifer zone, elevation 975 m, 2.7 km from a large reservoir. The raccoons were neither hand-reared nor under restraint but had been habituated to human presence for the last 10 years by local residents feeding the raccoons approximately 600g of dog food nightly.

From 7 October 1978 to 10 November 1978 we habituated the raccoons to a new feeding site and our presence in a vehicle with lights and cameras. The feeding site was located 150 m from a residence near a conspicuous trail used by the raccoons to approach the residence. During habituation we gradually closed the distance of our vehicle to the feeting site from 40 m to 15 m. Among the raccoons observed, seven were identifiable by natural markings: Right-eye (female with two cubs, Juveniles 1 and 2), Three-leg (adult female), Right-ear (yearling), Un-female (adult female), Scar (adult of undetermined sex).

Since raccoons frequently left and returned in a single night, we could not estimate their total number. Unidentified animals were counted only while simultaneously visible. Thus, the number of unidentified individuals listed for any night was the minimum possible number.

Our initial 30 nights of observation were scheduled at random intervals to discourage anticipation of our presence. The nightly observation period extended from .5hr before sunset to .5hr after dog food was completely consumed and raccoons were no longer visible ($\overline{X} = 2.5$ hr $\pm$ .5hr). A 700g ration of dog food was present at the feeding site every night.

Live bantam chickens were tethered .5 m on opposite sides of the feeding box from 27 October to 10 November 1978. After all of the identified animals killed and/or fed on the chickens, lithium chloride-injected bantam chickens were tethered next to the box 11-14 November 1978. These baits were prepared daily. The chickens were sacrificed by cervical fracture and immediately injected with a solution of lithium chloride (82.4g LiCl/liter distilled H_2O) (Gustavson *et al.* 1976). One hundred ml of this solution was injected into a minimum of 80 different sites including subcutaneous, intraperitoneal, and intramuscular injections. Approximately 60 percent of the volume was injected into the musculature.

Baits that were not consumed in our presence were left overnight and inspected the next morning. The area within a radius of 30 m of the feed box was searched for vomitus and parts of uneaten chicken.

From 16 November to 15 December 1978 live chickens, bantams and white leghorns, were tethered and observed in the usual manner. This process was again repeated nightly from 28 March to 13 April 1979 and twice per week from 23 April 1979 through June 1979.

Results and Discussion

Prior to LiCl baiting, a mean of nine individuals per night was observed; 63 percent were identifiable. The raccoons visited the site in groups of three or more, including groups of males and yearlings without females. They defended their feeding position at the box by shouldering each other, vocalizing, and biting. They monopolized the box for 4-42 minutes ($\overline{X} = 14.3$ minutes). They did not feed from the front of the box, avoiding exposure of their backs to us. The other three sides of the box were used in an apparent random fashion while few animals were present (three or less), and evenly spaced when more were present.

The initial introduction of live chickens resulted in 15 kills between 27 October and 10 November 1978 involving all six of the identifiable animals at least once. Both Right-Eye and Three-Leg initiated kills, and their respective juveniles shared the food. Later, the juveniles attempted kills at the back or flanks followed by attacks at the head and neck. Movement or sound from the tethered chickens attracted attention, resulting in attacks and usually in kills. On three occasions chickens remaining motionless at the end of the tethers survived the night. Raccoons ate chickens preferentially to dog food.

During the LiCl baiting interval, a mean of 6.7 individuals per night was observed; 44 percent were identifiable. Three-Leg and Juvenile 1 ate baited chickens in our presence. The juvenile vomited 21 minutes after consuming approximately 200g of chicken. Morning inspection of the baits through 14 November indicated there had been substantial consumption and dismemberment in our absence. Gypsum distributed around carcasses before we left the baits overnight showed only raccoon prints. Five vomitus samples containing chicken were recovered near the feeding site during the baiting interval.

During the post-LiCl baiting interval (16 November-15 December 1978), 5.9 raccoons were observed per night; 42 percent were identifiable. None of the identifiable animals attacked the chickens during this interval and no non-identifiable individuals attacked tethered chickens, except on 9 December 1978.

After the baiting interval, the predatory behavior of both identifiable and non-identifiable raccoons changed markedly. Not only did attacks abruptly cease, but other behaviors consistent with successful aversive conditioning were noted. The raccoons avoided the sides of the feeding box where chickens were tethered. This behavior frequently resulted in a "pile-up" of raccoons behind the box, each attempting to get to the food. Sudden movements of the chickens caused the raccoons to flee, with the juveniles climbing trees. The raccoons tended to feed for shorter intervals ($\overline{X} = 8.3$ minutes), and to remove food from the box by holding it in their forepaws and moving away with tri-pedal or bi-pedal walking. The frequency of these movements before LiCl baiting was 1.6 times per animal per night, and the mean frequency after the baiting interval was 6.3 movements per animal per night. After LiCl baiting, the raccoons frequently approached the chickens in the defensive head-down attitude to about 20-40 cm, then jerked backward to take a roundabout way to the feed box ($n = 8$).

Six unidentified animals killed chickens on 9 December, as did Un-Female on 13 December 1978. These kills were made in the usual manner. The reduced visitation frequency of initially identified raccoons, and the sudden appearance of easily distinguishable but unfamiliar animals in mid-December, suggests an influx of non-averted individuals. This observation is further substantiated by the absence of Un-Female or other animals willing to resume attacks on tethered chickens in March and April 1979.

Aversion was re-tested (28 March to 13 April 1979). During the spring test a mean of 5.8 animals was seen per night; 65 percent were the initially identified raccoons. Behavior remained as described for the post-baiting test period. Now, however, the juveniles were larger and moved more independently about the feeding site. Right-Eye and Three-Leg appeared less tolerant of their juveniles.

On two occasions, 29 March and 11 April 1979, the feeding box was moved back from the tethered chickens. Approximately 30g of iodized table salt (NaCl) was mixed in with the dog food in the box. The raccoons, including all six of the identifiable and at least six of the non-identifiable animals, fed at the sides as well as the back of the box and consumed all of the food. This particular behavior suggests that neither a "box" nor a "salt" aversion was established.

Continued weekly spot-checking of the population through June 1979, seven months after the mid-November baiting period, showed continued aversion among identifiable and most non-identifiable animals.

Predatory behavior may be grouped into two phases of activity. The first involves environmental tracking as the predator selectively scans for relevant environmental stimuli according to its current specific search image. When successful, this phase leads to the second phase: prey consumption. If consumption has high hedonic value, low risk, or low energy output, then this positive feed-back reinforces the predator's specific search image (Tinbergen 1960). If the consumptive phase is punishing, then the specific search image is suppressed and alternate prey is sought. The usefulness of taste aversion conditioning in predator control depends on the onset of illness following consumption of the prey. The resulting shift in the hedonic value of the food flavor (taste aversion) results in discontinuance of tracking, attacking, or killing the aversive prey and initiates search for alternative food sources.

If alternate foods are unavailable, aversions may be more difficult to establish. Aversive conditioning may be reduced during periods of seasonal stringency. Raccoons are omnivorous, but total availability of food items declines in the fall, possibly increasing the dependence of our raccoons on the food we provided, including chickens at the feeding site. Our results suggest, however, the established taste aversion in raccoons may have been sufficiently robust so that the seasonal fluctuations in food availability were not reflected in continued post-baiting tests. Yearlings through the weaning period of March and April and adult nursing females through May and June continued to avoid the chickens.

The chicken aversions were apparently not limited to the strain of chicken used during training. Prior to and during the baiting interval, only bantams were used, all dark brown. Aversion was tested with chickens of different breeds varying in color, size, and sex. Identification of chickens appeared to be through olfaction. The feeding site not only had live chickens but was also heavily littered with feathers from past kills. Chicken scent at the site may explain the observed decline in frequency of visitation of raccoons immediately after baiting interval.

Successful aversive conditioning of this population of raccoons under field conditions substantiates laboratory predations of Gustavson *et al.* (1979). Since the methods used were designed for aversion of canids (wolves and coyotes) and successfully applied without major modification to Procyonids (raccoons), aversive conditioning may have application in the manipulation of food preferences for other predators.

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