



Short communication

A note on averting goats to a toxic but palatable plant, *Leucaena leucocephala*

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Abstract

Conditioned taste aversions are a useful tool to reduce livestock consumption of toxic plants. The forage legume *Leucaena leucocephala* (leucaena) is both toxic and palatable. The objective of this study was to determine if goats could be aversively conditioned to avoid leucaena. Adult and juvenile female goats, naïve to leucaena, were divided into control and averted groups. Animals were exposed to leucaena, and time(s) spent eating leucaena was measured. During initial conditioning with lithium chloride (LiCl), averted goats spent less time eating leucaena ($P < 0.05$) than did controls. The averted groups maintained their reduced consumption ($P < 0.05$) of leucaena compared to controls during open field tests when goats could choose between leucaena and sugar cane. In final tests (two tests per week), averted goats reduced ($P < 0.05$) the amount of time they spent eating leucaena compared to control animals, but the aversion eventually extinguished. Aversive conditioning was successful in greatly reducing, but not entirely eliminating goats' consumption of leucaena.

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1. Introduction

Conditioned taste aversions are a useful behavioral tool to train livestock to avoid some toxic plants (Ralphs et al., 2001). Livestock losses to toxic plants in Brazil are a serious problem, with 5% of the cattle population and 10% of the goat and sheep populations affected (i.e., death,

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abortions, birth defects, etc.) throughout the country (Tokarnia et al., 2002). Many toxic plants in Brazil are both poisonous and palatable (e.g., *Palicourea*, *Ipomoea*; Tokarnia et al., 2002), thus making it more difficult to keep livestock from ingesting fatal or harmful quantities. *Leucaena leucocephala*, commonly known as leucaena, is a palatable forage legume grown in tropical and subtropical areas worldwide. The major toxin in leucaena is mimosine, a depilatory and potent goitrogen (Hammond, 1995). The purpose of this study was to examine aversive conditioning in goats as a means to reduce consumption of leucaena, thus using leucaena as a possible model for conditioning aversions to other palatable and toxic plants.

2. Materials and methods

The study was conducted at the University of São Paulo Experimental Station, Pirassununga, São Paulo state, Brazil (S21°58', W47°27'). All animal care and handling was done by experienced individuals under veterinary supervision.

2.1. Experimental subjects

Adult female Oberhaslis goats were 11–12 months of age (35–45 kg), while juvenile goats were 4–6 months of age (15–25 kg). Animals were naïve to leucaena. The basal diet of the goats was signal grass (*Brachiaria brizantha*) offered *ad libitum* each day. Animals were divided into two control ($n = 6$ adults and $n = 7$ juveniles) and two treatment groups ($n = 6$ adults and $n = 7$ juveniles). Observations were taken after the animals had been fasted from 17:00 to 08:00 h; fasting increases the animals' motivation to eat (Greenwood and Demment, 1988; Newman et al., 1994), thus providing a more stringent test of aversion and food choice.

2.2. Trial 1: conditioning and first pen test

On the first 2 days of the 4-day trial, the treatment animals were conditioned to avoid leucaena. Leucaena was collected fresh and placed into a feed box in the center of a 12 m × 12 m pen. On the first day, animals in each group were placed individually in the pen for 8 min, and consumption of leucaena was monitored using time spent eating as an estimate of forage intake. Groups were observed in random order. If an animal in the aversion treatment ate leucaena, it was dosed immediately after the session by oral gavage with 130 mg/kg of lithium chloride (LiCl, 10 mL volume). LiCl causes rapid nausea (i.e., ~60 min). Similarly, control animals that ate leucaena were dosed with the equivalent volume of saline (0.9% NaCl) solution.

This initial 8 min session and dosing regime was followed immediately by a 60-min session during which each treatment group was observed together; observers used stopwatches to record the amount of time each animal spent consuming leucaena. On the second day, animals were again offered leucaena in a 12 m × 12 m pen, and the same procedure was followed. The last two days of this trial was used to provide an initial test of the aversion; animals were offered leucaena as detailed above for 60 min, the time spent eating was monitored, and no LiCl or saline was dosed if animals ate the plant.

2.3. Trial 2: first open field test

A small, open field (96 m²) of signal grass (*Brachiaria decumbens*) pasture was used to further test the aversion. The field was divided into two equal parts separated by a wooden fence that virtually eliminated visual or social interaction. Two feed boxes were placed into the center of each open field; one box was filled with freshly cut sugar cane (*Saccharum officinarum*) and the other was filled with freshly cut leucaena. At 08:00 h treatment animals were placed in one half of the field, and controls were placed in the other portion for 60 min. Hidden observers documented the amount of time that individual animals spent feeding on either leucaena or sugar cane. No attempt was made to document grass consumption, as goats eat little grass when

given a choice amongst signal grass, leucaena and sugar cane (S.L. Gorniak, personal observation). This test was conducted once each week on the same day for an 8-week period. Treatment and control groups of the same age class were tested simultaneously; order of testing was determined randomly.

2.4. Trial 3: second field test

Twelve feed containers (30 cm wide by 37 cm long) with fresh leucaena in them were placed at 10 m intervals through the center of a 1760 m² field of signal grass pasture. Groups were sequentially released in random order into this field for 60-min periods and observers documented the amount of time each animal consumed leucaena. If any individual animal in either of the averted groups spent >100 s eating leucaena during a test session, the aversion was considered to have been extinguished in this animal, and that specific group, and the corresponding control group (i.e., adult–adult and juvenile–juvenile), was not tested further. This test was conducted on two consecutive days each week for 2 weeks unless the criterion for stopping was met.

2.5. Statistical analysis

The dependent variable was the mean amount of time spent eating leucaena by the treatment and control groups within the two age groups. Descriptive statistics were calculated, and 95% confidence intervals were used to determine significant differences between treatments and age groups.

3. Results

3.1. Trial 1: conditioning the aversion and first pen test

Averted and control goats differed ($P < 0.05$) in amount of time spent eating leucaena (Fig. 1a and b). Juveniles in the averted treatment spent less time eating leucaena as the trial progressed (overall trial mean = 461 ± 110 s; Fig. 1), whereas juvenile controls ate leucaena during the entire trial (overall trial mean = 1812 ± 102 s).

All adult animals ate leucaena during the initial exposure, and two of six averted adults required a second dose of LiCl on day 2 to form an aversion to leucaena. Control adults ate leucaena each day (overall trial mean = 1165 ± 174 s); averted animals ate for much less time (overall trial mean = 323 ± 130 s).

3.2. Trial 2: test aversion—first field trial with sugar cane and leucaena

Averted animals spent less time ($P < 0.05$) eating leucaena than did controls (Fig. 1c and d). Averted juvenile goats spent a small and decreasing amount of time eating leucaena over the 8-week trial (overall trial mean = 56 ± 12 s). None of the averted juvenile goats completely abstained from eating leucaena during every test. Control juvenile goats spent a large amount of time eating leucaena (overall trial mean = 1253 ± 103 s). Averted juveniles spent a greater amount of time eating sugar cane. Juvenile goats readily ate leucaena, and two of seven juveniles were not successfully averted with two doses of LiCl than controls (overall trial means = 1154 ± 105 s and 304 ± 37 s, respectively).

Three adult goats did not completely abstain from eating leucaena during the trial (overall trial mean = 25 ± 5 s). Control adults spent a large amount of time eating leucaena (overall trial mean = 951 ± 103 s). Both averted and control adults spent substantial amounts of time eating sugar cane (overall trial means = 971 ± 116 s and 603 ± 58 s, respectively).

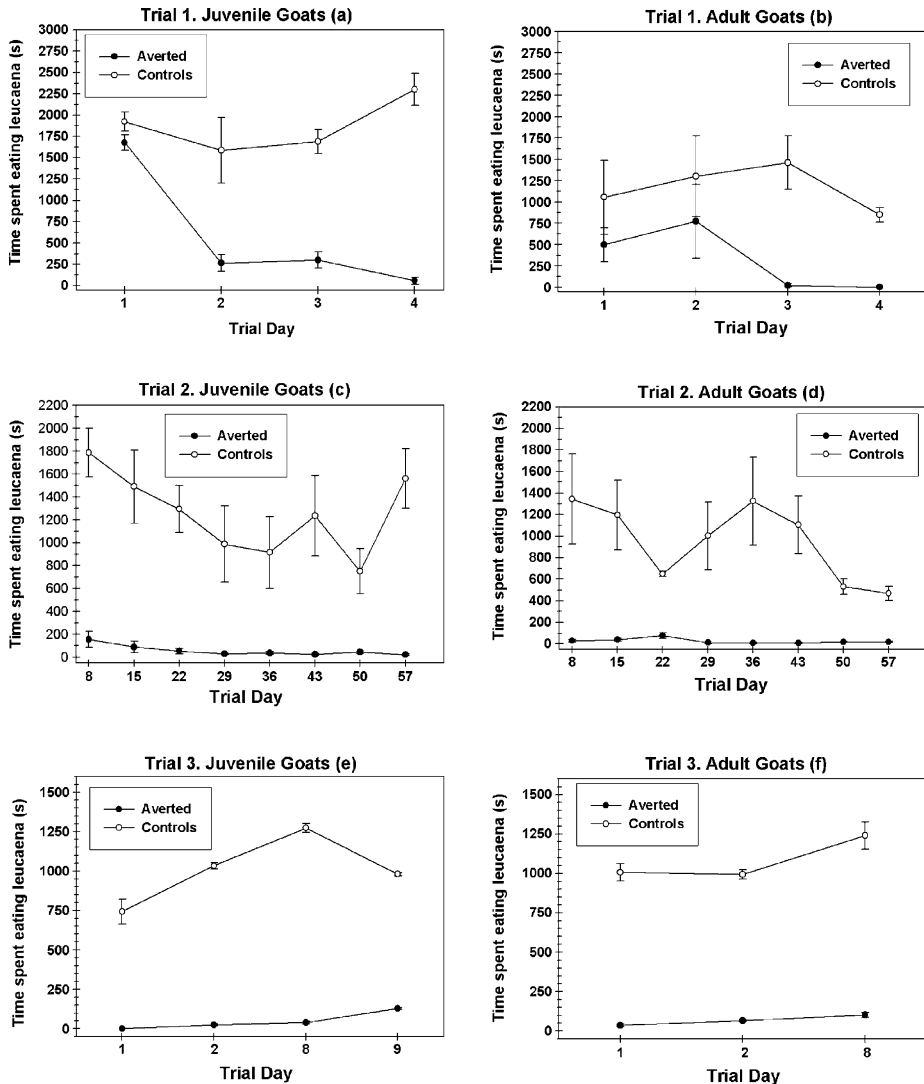


Fig. 1. Time spent eating leucaena (overall trial mean(s) \pm S.E.) by adult (11–12 months) and juvenile (4–6 months) goats. The two treatment groups were averted and controls, where averted subjects were conditioned to avoid leucaena by pairing leucaena consumption with oral dosing of LiCl at 130 mg/kg body weight; controls were given an equivalent volume of saline solution. In Trial 1, animals were offered leucaena in a pen on days 1 and 2 and averted animals that ingested leucaena were dosed with LiCl; controls that ingested the plant were dosed with saline. Days 3 and 4 were a pen test of the aversion. Trial 2 was a field test with goats offered both leucaena and sugar cane. Trial 3 was a field test with goats offered only leucaena, and testing terminated when any animal in the averted group spent more than 100 s eating leucaena during a test session.

3.3. Trial 3: test aversion—second field trial with leucaena only

Averted goats reduced ($P < 0.05$) the amount of time they spent eating leucaena compared to controls (Fig. 1e and f). Juvenile goats were tested for 4 days (Fig. 1e) before the aversion was considered extinguished in any animal. Adult goats were tested on three

occasions before consumption exceeded the target time and the aversion considered extinguished (Fig. 1f).

4. Discussion

Aversive conditioning using LiCl was successful in greatly reducing, but not entirely eliminating goats' consumption of the palatable, but toxic shrub, leucaena as estimated by time spent eating. Many averted goats spent small amounts of time eating leucaena during the first field test, but their time spent eating leucaena was minor in comparison to control animals. Aversions that are relatively strong, but not absolute, have been termed "partial aversions" (Kyriazakis et al., 1998; Duncan et al., 2000). Partial aversions occur often under grazing situations where negative feedback influences the grazing animal to reduce, but not entirely eliminate, the toxic plant from the diet (Pfister et al., 1997).

For most goats in our study groups, the aversion to leucaena persisted throughout the initial 8-week field test, but eventually extinguished during the second week of the second field test. This second field test was a very stringent test as the food boxes contained only leucaena, with no alternative food boxes with sugar cane; grass consumption was negligible. These results are consistent with previous studies showing that, even though averted animals may have greatly reduced intakes compared to controls, consumption of any amount of the toxic target plant will probably lead to eventual extinction of the aversion (Ralphs and Provenza, 1999). Extinction occurs because there is no negative reinforcement (i.e., gastrointestinal malaise) for sampling the plant, whereas there is positive reinforcement from plant nutrients (Provenza, 1995). Leucaena toxicity is chronic (i.e., develops slowly over several weeks) not acute, thus goats can eat diets of 100% leucaena over a 3-week period before clinical signs are evident (Jones and Megarritty, 1983). Reducing consumption through aversive conditioning for plants with slowly developing toxicity, like leucaena, may allow consumption of such toxic plants, as long as it is intermittent or remains below a toxic threshold (Srivastava and Sharma, 1998). Further, reinforcing the aversion with periodic doses of LiCl may allow safe consumption of reduced amounts of leucaena over a long period of time. On the other hand, for acutely toxic plants (e.g., *Palicourea* in Brazil), aversions to these plants need to be of sufficient strength so that averted animals completely avoid the plant (Ralphs, 1997).

5. Conclusions

Aversive conditioning in adult and juvenile goats was successful in greatly reducing, but not entirely eliminating goats' consumption of leucaena. The partial, but not absolute, aversions eventually extinguished as animals sampled leucaena with no negative gastrointestinal feedback. These results suggest that aversive conditioning alone, while useful to reduce risk of chronic and fatal intoxications, will not solve toxic plant problems when the target plant is very palatable.

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