

Continuous exposure to an aversive mixture as a means of maintaining aversion to vermeerbos (*Geigeria ornativa* O. Hoffm.) in the presence of non-averted sheep

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ABSTRACT

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Continuous exposure to an aversive mixture was investigated as a means of maintaining aversion to vermeerbos in sheep subjected to the social influence of non-averted sheep. The use of an aversive mixture was based on a hypothesis that continuous exposure to an acceptable aversive mixture (containing both the aversive substance and the identification factors of vermeerbos mixed with maize meal) would tempt sheep to consume small quantities of the aversive mixture each day and that this would keep them averted to vermeerbos, despite the social influence of non-averted sheep. Persistent aversion to a vermeerbos-maize meal mixture (1:99 by mass) by sheep continuously exposed to such an aversive mixture, after an initial aversion conditioning with lithium chloride (LiCl, 160 mg/kg BM), was demonstrated. Aversion in adjacent controls not exposed to the aversive mixture only lasted for some time. A similar result was obtained when sheep were challenged for intake of a pure stand of established vermeerbos. Three sheep continuously exposed to an aversive mixture after an initial aversion conditioning totally refused grazing the vermeerbos during a 42-day trial, despite the social influence of three non-averted control sheep grazing vermeerbos on an adjacent site. These results were confirmed by a second replication the following year. Joint grazing for an hour a day by averted and non-averted sheep during the last seven days of this replication also resulted in total avoidance of vermeerbos by the averted animals, despite continued intake of vermeerbos by the control sheep

Keywords: Aversive mixture, conditioned feed aversion, *Geigeria ornativa*, plant poisoning, vermeerbos, vermeersiekte

INTRODUCTION

Vermeerbos (*Geigeria ornativa* O. Hoffm.) (Fig. 1) is a non-aversive toxic plant that occurs in the Northern Cape Province of South Africa (Kellerman, Naude & Fourie 1996). Intake of this plant causes vermeer-

siekte, which amongst other clinical signs such as stiffness, paresis and paralysis, is characterized in sheep by regurgitation of rumen contents through the mouth and nose (Steyn 1949) (Fig. 2). Although it is one of the most important plant poisonings of sheep on the sub-continent (Kellerman, Coetzer & Naude 1988), no effective means for its prevention or treatment has yet been described.

Conditioned feed aversion has been shown to be a potential management tool to prevent livestock from grazing poisonous plants (Ralphs, Provenza, Pfister, Graham, Duff & Greathouse 2001). Six cows in a small pasture field trial were conditioned

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FIG. 1 Vermeerbos (*G. ornativa*) plant



FIG. 2 Vermeersiekte: regurgitation of ingesta

to avoid tall larkspur for three years (Ralphs 1997). However, averted animals had to be grazed separately from non-averted animals as the induced aversion would be broken down by the social influence of non-averted peers (Ralphs & Olsen 1990; Provenza & Burritt 1991; Ralphs *et al.* 2001). This means that conditioned feed aversion has no application to communal grazing systems with sheep of various owners grazing together, mostly on an uncontrolled basis.

The hypothesis was made that continuous exposure to an acceptable aversive mixture, containing both an aversive substance and the identification factors of vermeerbos, mixed with maize meal, would tempt sheep to consume small quantities of the aversive mixture each day and that this would keep them averted to vermeerbos, despite the social influence of non-averted sheep.

The workability of this hypothesis was investigated under controlled conditions: (1) with sheep averted to a vermeerbos-maize meal mixture fed under pen-feeding conditions and (2) with sheep averted to a pure stand of established vermeerbos.

METHODS AND RESULTS

Effect of continuous exposure to an aversive mixture on maintaining aversion to a vermeerbos-maize meal mixture under pen-feeding conditions

Duration of aversion to a vermeerbos-maize meal mixture in averted sheep continuously exposed to an aversive mixture was compared with duration of aversion in averted sheep not exposed to an aversive mixture. Three successive replications, with two sheep of the same race, gender and age used

per replication, were performed. One of the sheep in each replication was exposed to an aversive mixture as described below while the other served as control. The two sheep were kept separately in pens adjacent to each other, except for the sheep in replication 1 where aversion in the control sheep and the sheep exposed to the aversive mixture were studied at different times. All sheep received *Eragrostis curvula* hay *ad lib.* during the study.

During each of the replications sheep were conditioned and tested for aversion according to the following procedure:

1. Sheep were made accustomed to maize meal by feeding them 100 g each morning for at least a month before commencement of the trial.
2. On day 0 sheep were fed 100 g of a vermeerbos-maize meal mixture (1:99 by mass) (vermeerbos dried and milled through a sieve with 1 mm aperture size) in the feeding trough.
3. Directly after consumption of the vermeerbos-maize meal mixture, which took less than an hour, the sheep were dosed with 160 mg lithium chloride (LiCl) per kg body mass (BM) *via* a stomach tube.
4. Dosing with LiCl was followed by giving a tablespoon of dry milled vermeerbos in the sheep's mouth. This was done to accomplish a strong taste association with the adverse effect of LiCl.
5. One of the sheep in each replication was continuously exposed to an aversive mixture from day 1. The aversive mixture, consisting of LiCl (AR grade crystals of c. 0.5 mm diameter) mixed with milled, dry vermeerbos and maize meal (5:1:94 by mass), was presented *ad lib.* in a separate feeding-trough. The LiCl-vermeerbos

portion of this mixture was started at one fifth this concentration and increased with another fifth every time more than 100 g of the aversive mixture was consumed within a day's time. Consumption of the aversive mixture was measured on a daily basis and replenished accordingly.

6. Aversion was tested on a daily basis from day 2 onwards by challenging both the control sheep and the sheep continuously exposed to the aversive mixture for intake of the vermeerbos-maize meal mixture (1:99 by mass). This was achieved by presenting 100 g of the vermeerbos-maize meal mixture in the cleansed feeding-trough (the same trough in which the vermeerbos-maize meal mixture was presented on day 0) each morning and determining the amount ingested after 1 h. Total intake of the mixture was arbitrarily taken as criterion that aversion was broken.
7. The aversive mixtures in replications 1, 2 and 3 were withdrawn on days 21, 36 and 103, respectively, which is at least twice the time that aversion in the corresponding control animals lasted.
8. Daily presentation of the vermeerbos-maize meal mixture to both the control sheep and the sheep exposed to the aversive mixture of replications 2 and 3 was continued after withdrawal of the aversive mixture until totally consumed by the sheep exposed to the aversive mixture. Presentation of the vermeerbos-maize meal mixture to the control sheep of replication 1 was stopped after total consumption on day 3.

The effect of continuous exposure to an aversive mixture on the duration of aversion in sheep of replications 1, 2 and 3 is shown in Table 1.

The results indicate that aversion to the vermeerbos-maize meal mixture in sheep continuously exposed to the aversive mixture lasted for at least as long as the sheep were exposed to the aversive mixture, although it was noticed that sheep of replications 2 and 3 started to eat some of the vermeerbos-maize meal mixture before removal of the aversive mixture. This presumably happened due to social facilitation by the control sheep after starting to eat their vermeerbos-maize meal mixture. Aversion was abolished within days after removal of the aversive mixture as indicated by total consumption of the vermeerbos-maize meal mixture. Aversion in the corresponding control sheep, on the contrary, only lasted for some time. Aversion of these sheep in replications 2 and 3 might have been prolonged due to the social influence of the sheep exposed to the aversive mixture. The overall results indicate that continuous exposure to the aversive mixture resulted in persistent aversion to the vermeerbos-maize meal mixture, despite the social influence of the control sheep.

Lithium chloride ingestion (as a consequence of consumption of the aversive mixture) by the sheep exposed to the aversive mixture in replication 3 is shown in Fig. 3. The histogram in Fig. 3 shows a large fluctuation in daily LiCl ingestion due to varying consumption of the aversive mixture. The learned-safety status and palatability of the maize meal in the aversive mixture tempted the sheep to consume the aversive mixture on a daily basis. Over-ingestion, which regularly took place, resulted in an increased adverse effect with diminished intake thereafter. Hereby the negative association formed with the taste of vermeerbos on day 0 was continuously reinforced, preventing intake of the vermeerbos-maize meal mixture presented in the same feeding-trough as during aversion treatment on day 0.

TABLE 1 Duration of aversion to a vermeerbos-maize meal mixture (1:99 by mass) in sheep after an initial conditioning with LiCl (Control) and in sheep initially conditioned with LiCl followed by continuous exposure to an aversive mixture

Measurements	Replication 1		Replication 2		Replication 3	
	Control	Aversive mixture	Control	Aversive mixture	Control	Aversive mixture
Duration of exposure to the aversive mixture (days)	0	21	0	36	0	103
Day on which the vermeerbos-maize meal mixture was totally consumed	3	28	11	37	51	108
Mean lithium chloride ingestion (mg/kg BM/day)	0	9	0	28	0	19

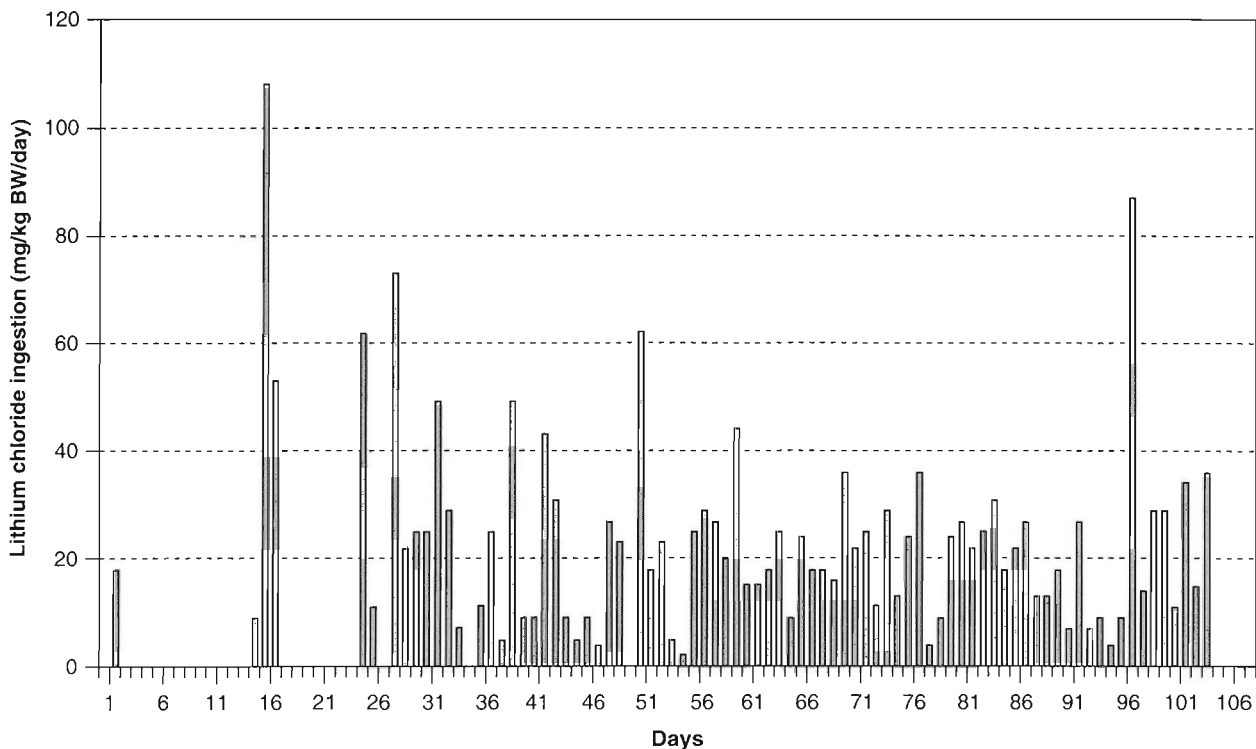


FIG. 3 Daily lithium chloride ingestion by the sheep continuously exposed to the aversive mixture in replication 3

The challenge for staying averted to the vermeerbos-maize meal mixture was extremely high as 99% of the mixture consisted of maize meal. Maintaining aversion to this mixture for the periods investigated show that the technique of continuous exposure to an aversive mixture in principle was working and therefore might be usable in maintaining aversion to the less palatable vermeerbos on a pasture.

Effect of continuous exposure to an aversive mixture on maintaining aversion to a pure stand of established vermeerbos

Three averted sheep continuously exposed to an aversive mixture were tested for grazing vermeerbos under the social influence of three non-averted control sheep grazing vermeerbos on an adjacent site. Two replications performed in two different years were conducted.

A pure stand of established vermeerbos (22 m x 6 m in extent) was fenced off and longitudinally partitioned into two halves. A 2 m x 3 m area at the same end of each of the partitioned plots, cleansed of vermeerbos, was partitioned from the rest of the pasture by movable frameworks. The frameworks were such that sheep could put their heads through

the railings and graze a half metre strip of the vermeerbos on the other side. On day 0, two groups of three sheep each were randomly allocated to each of the 2 m x 3 m partitions. The sheep were allowed to graze the vermeerbos growing within the half metre strip on the other side of the frameworks, which took them 6 h. One of the groups was then assigned to aversion treatment and each of the sheep in this group dosed with LiCl (160 mg/kg *via* stomach tube) plus 3 g sodium chloride (NaCl), dissolved in a warm water extract prepared from 33 g fresh vermeerbos. Sodium chloride, known to the sheep, was given in an attempt to confuse the animals with the taste of LiCl.

From day 2 onwards, the treated group that had been made accustomed to maize meal before the time was continuously exposed to an aversive mixture, consisting of an aversive concentrate (5 g LiCl, 1 g NaCl and a hexane extract prepared from 15 g fresh vermeerbos) mixed with 94 g maize meal. The aversive mixture presented on day 2 contained only a quarter of the above-mentioned aversive concentrate, but was gradually increased over a 10-day period to contain the full amount on day 12. The sheep of both groups were tested for vermeerbos intake from day 4 onwards by moving the frameworks half a metre further each morning, provided



FIG. 4 Averted (left) and non-averted (right) sheep at the start of the trial (day 4)



FIG. 5 Averted (right) and non-averted (left) sheep at the end of the trial (day 46)



FIG. 6 Averted (at the back, not grazing) and non-averted (in front, grazing vermeerbos) sheep exposed simultaneously to the same vermeerbos grazing

that all accessible vermeerbos plants within the 0.5 m strip on the other side of the framework had been grazed down. Consumption of the aversive mixture was measured and replenished on a daily basis. Both groups received *Eragrostis curvula* hay and water *ad lib*.

The averted sheep completely avoided vermeerbos when exposed to the vermeerbos on day 4, but was avidly grazed by the control sheep (Fig. 4). After 42 days (day 46) all the vermeerbos on the control's site had been grazed down while the averted sheep still stood at the starting point, with their framework not having been moved once (Fig. 5). They refused to graze vermeerbos despite the social influence of the control sheep grazing vermeerbos on the site next to them. Mean daily LiCl ingestion due to consumption of the aversive mixture by the averted sheep was 11.4 mg/kg BM/day.

A replicate of this trial conducted in the following year yielded similar results. In this trial averted and non-averted control sheep additionally were placed together on the same vermeerbos site (site of the averted sheep) for an hour a day during the last six days of the trial, which lasted 49 days. Despite the increased social pressure they were subjected to, the averted sheep persistently refused to eat vermeerbos (Fig. 6). The mean daily LiCl ingestion as a consequence of aversive mixture consumption by the averted sheep was 20.9 mg/kg BM/day.

CONCLUSION

The results of this study indicate that continuous exposure to an aversive mixture accomplished persistent aversion to vermeerbos under the circumstances investigated, despite the social influence of non-averted control sheep.

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