Onderstepoort Journal of Veterinary Research, 70:43–48 (2003)

Conditioned feed aversion as a means to prevent tulp (*Homeria pallida*) poisoning in cattle

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ABSTRACT

SNYMAN, L.D., SCHULTZ, R.A., JOUBERT, J.P.J., BASSON, K.M. & LABUSCHAGNE, L. 2003. Conditioned feed aversion as a means to prevent tulp (*Homeria pallida*) poisoning in cattle. *Onderstepoort Journal of Veterinary Research*, 70:43–48

Conditioned feed aversion was investigated as a means to prevent tulp (*Homeria pallida*) poisoning in cattle on tulp-infested grazing. Aversion treatment with a combination of epoxyscillirosidin and lithium chloride together with a tulp-hexane extract, which served as identification factor for tulp, resulted in a significantly lower ($P < 0.001$) proportion of severe tulp poisoning. In a first trial where 21 averted and 21 non-averted control cattle were exposed to a tulp-infested grass pasture, only two of the averted cattle were severely poisoned compared to 13 of the non-averted control cattle. In a second trial, with cattle being exposed to a pure stand of tulp supplemented with maize residues, only two of 21 averted cattle were severely poisoned compared to 14 of 21 non-averted control cattle. Occurrence of mild tulp poisoning, however, did not differ much between averted and non-averted control cattle. The results show that conditioned feed aversion effectively restricted severe poisoning in cattle on tulp-infested grazing.

Keywords: Conditioned feed aversion, grass pasture, maize residues, tulp (*Homeria pallida*) poisoning

INTRODUCTION

Cardiac glycoside-containing plants, of which yellow tulp (*Homeria pallida*) (Fig. 1) is the most important, are the main cause of plant-related poisoning of livestock in South Africa (Kellerman, Coetzer & Naudé 1988). Cattle losses are estimated on more than 12000 head per year (Kellerman, Naudé & Fourie 1996). Poisoning usually occurs when cattle from non-infested areas are newly introduced to tulp-infested grazing. The bufadienolide-containing plants affect the respiratory, cardiovascular, gastrointestinal and nervous systems (Fig. 2) of animals (Kellerman *et al.* 1996). Poisoned animals can effectively be treated with activated charcoal (Joubert & Schultz 1982), but the treatment is expensive, stressful to the animal and needs to be applied soon after ingestion.

Previous workers reported that cattle on veld naturally avert to tulp. Kellerman *et al.* (1996) noted that stock raised on tulp-infested veld can learn to avoid the plant. Strydom & Joubert (1983) noticed that weaner calves newly introduced to a tulp-infested grazing ceased being poisoned after three days as they seemingly learned to avoid the tulp. If natural aversion to tulp could be artificially induced in a controlled manner, naïve animals would be safely averted without the risk of poisoning when exposed to tulp-infested grazing.

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Accepted for publication ??? 2003—Editor

FIG. 1 Yellow tulp (*Homeria pallida*)

FIG. 2 Heifer poisoned with tulp, showing posterior paresis. From Kellerman *et al.* (1988)

The mechanism of aversion to tulp was investigated in a previous study after natural aversion to tulp had been proven experimentally (Snyman, Kellerman, Schultz, Joubert, Basson & Labuschagne 2001). The primary substance responsible for aversion was isolated and characterized as 1α, 2α-epoxyscillirosidin (epoxyscillirosidin), previously isolated by Naudé & Potgieter (1966) as the main toxic principle of tulp. Cattle refused to ingest a tulp-maize meal (1.5:98.5) mixture after being dosed with epoxyscillirosidin plus a tulp-hexane extract that served as identification factor for tulp. Conversely, dosing with epoxyscillirosidin followed by tulp intake resulted in refusal of a tulp-hexane extract mixed with maize meal. The effective aversive dose for epoxyscillirosidin was found to be 60–70 % of the lowest toxic dose and therefore must have contributed towards tulp poisoning of averted cattle on a tulp-infested grazing. In the present study the contributive toxic effect of epoxyscillirosidin was diminished by partial replacement with lithium chloride (LiCl), an effective aversive agent that rapidly induces gastrointestinal distress in ruminants (Ralphs & Olsen 1990). The effectiveness of this aversion treatment was tested under simulated grazing conditions with cattle exposed (1) to tulp on a tulp-infested grass pasture and (2) to a pure stand of tulp supplemented with maize residues.

MATERIALS AND METHODS

Cattle were averted and then tested for aversion (1) to tulp on a small tulp-infested grass pasture (100 m^2 in size) (Fig. 3); and (2) to a pure stand of tulp established on a small plot (100 m^2 in size) to which maize residues were added (*ad lib.*) at one end as supplementary feed (Fig. 5). Seven replications with three averted and three non-averted control cattle per replication were conducted over three successive years on each grazing.

Ten to 15-months-old cattle reared in non tulp-infested veld were used for this investigation. Prior to aversion treatment the six cattle of each replication were kept in a large pen where they received *Eragrostis curvula* hay *ad lib.* During this period the animals were familiarized with the grass species and maize residues occurring on the tulp-infested grazing by daily exposures (1–2 h) to maize residues or grass growing on sites adjacent to the tulp-infested grazing. After one week three of the cattle were averted to tulp by dosing them with a solution (100 mℓ) of LiCl (*via* a stomach tube) followed by a suspension of propylene glycol (60 mℓ) (*per os*) containing epoxyscillirosidin and the dried residue of a tulp-hexane extract. The hexane extract was prepared by extraction of fresh tulp (60 g/400 mℓ for 8 h) on a shaking machine and by soxhlet extraction of dried tulp (15 g/400 mℓ for 1 h). After aversion treatment the averted and non-averted control cattle were withheld from food and water for 6 h. Cattle of some of the replications thereafter received food and water *ad lib,* while others were fasted until exposure to the tulp-infested grazing the next day. The experimental detail for the various replications on the tulp-infested grass pasture and the plot with tulp and supplemented maize residues are given in Tables 1 and 2, respectively.

Cattle were monitored for tulp poisoning by recording the electrical activity of the heart (Schultz & Pretorius 1972) and by clinical observations according to the parameters shown in Table 3. These were performed on the 2 days prior to aversion treatment, the day after aversion treatment just before

TABLE 1 Experimental detail of aversion treatments of cattle to tulp on a tulp-infested grass pasture at various bloom-stages of the tulp

Treatment	Year and bloom stage						
	2000			2001	2002		
	70 % bloom	80 % bloom	90 % bloom	Pre-bloom (90 % dead)	Pre-bloom (80 % dead)	90 % bloom	100 % bloom
Epoxyscillirosidin (mg/kg BW)	0.020	0.020	0.020	0.035	0.030	0.030	0.030
Lithium chloride (mg/kg BW)	80	80	120	120	120	120	120
Tulp-hexane extract: (tulp equivalent/animal)							
Fresh tulp (g)	20	20	20	20	15	15	15
Dry tulp (g)	0	0	0	0	5	5	5
Time period:							
• Between aversion treatment and exposure to tulp (h)	23	22	24	24	24	24	24
• Withheld from food and water directly after aversion treatment (h)	6	6	6	6	6	6	6
• Withheld from food only prior to tulp exposure (h)	17	16	0	0	0	0	0
• Averted cattle on tulp-infested grazing (days)	2	2	2	16	7	3	7

TABLE 2 Experimental detail of aversion treatments of cattle to tulp (pure stand) supplemented with maize residues

Treatment	Year and replication						
	2000		2001			2002	
	1	2	1	2	3	1	2
Epoxyscillirosidin (mg/kg BW)	0.020	0.020	0.020	0.020	0.035	0.035	0.030
Lithium chloride (mg/kg BW)	80	80	120	120	120	120	120
Tulp-hexane extract: (tulp equivalent/animal)							
Fresh tulp (g)	20	20	15	15	15	15	15
Dry tulp (g)	0	0	5	5	5	5	5
Time period:							
• Between aversion treatment and exposure to tulp (h)	23	23	24	24	24	27	27
• Withheld from food and water directly after aversion treatment (h)	6	6	6	6	6	6	6
• Withheld from food only prior to tulp exposure (h)	17	17	0	0	0	0	0
• Averted cattle on plot with tulp supplemented with maize residues (days)	3	3	3	3	3	7	7

TABLE 3 Criteria for classifying severity of tulp poisoning in cattle

Clinical sign	Severity of poisoning (one or more clinical signs)	
	Mild	Severe
Posterior paresis	Remain standing	Unable to remain standing
Impaired cardiac electrical activity	Isolated cases of AV dissociation	Runs of AV dissociation
Inhibition of ruminal movements	1–2 movements per 5 minutes	Rumen stasis

FIG. 3 Averted and non-averted control cattle exposed to a tulp-infested grass pasture

FIG. 5 Averted and non-averted control cattle exposed to a pure stand of tulp supplemented with maize residues

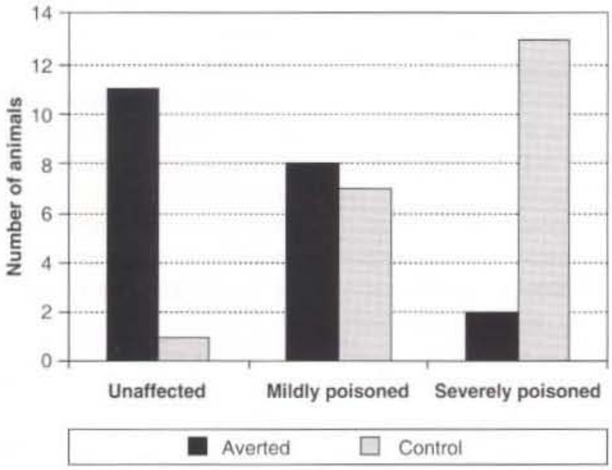

FIG. 4 Number of averted and non-averted control cattle poisoned with exposure to a tulp-infested grass pasture

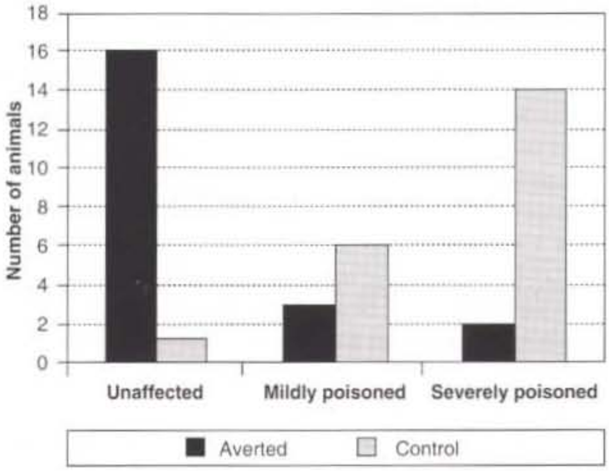

FIG. 6 Number of averted and non-averted control cattle poisoned with exposure to a pure stand of tulp supplemented with maize residues

exposure to the tulp-infested camps and daily afterwards for at least 2 days until no clinical signs of poisoning were seen. The degree of tulp poisoning was classified according to the parameters shown in Table 3.

Severely poisoned animals were dosed with activated charcoal (by stomach tube) at a dosage of 2 g/kg body mass and removed from the grazing. All control cattle were removed from the grazing after 12 h as they became averted to tulp within that time. Averted cattle not poisoned were kept on the grazing for a number of days.

Aversion to tulp on the tulp-infested grass pasture was performed at various bloom stages of tulp.

Each trial at a specific bloom stage served as a replication. Two of the replications, however, were carried out with tulp at the pre-bloom stage of which 80–90% of the plants had died due to a fungal (*Embesillia* sp.) infection. All replications performed on the plot with tulp and supplemented maize residues were carried out during the pre-bloom stage of tulp. Tulp in these trials was the only vegetation and maize residues (*ad lib.)* the only non-toxic feed available to the cattle.

Experimental data was statistically analyzed by the contingency table method, i.e. the Chi-squared test for a R x C contingency table. The Chi-squared test for the R x C (2 x 3) contingency table was done to test whether the proportions of poisoning varied over the treatment and control. Data were analyzed using the statistical program GenStat (2000).

RESULTS AND DISCUSSION

The numbers of averted and non-averted control animals that were unaffected, mildly poisoned and severely poisoned when exposed (1) to tulp on a tulp-infested grass pasture; and (2) to a pure stand of tulp supplemented with maize residues, are shown in Fig. 4 and 6, respectively.

Exposure to tulp on a tulp-infested grass pasture

A significant ($P < 0.001$) Chi-squared test indicated that the proportion of poisoning varied over the treatment and control. In other words the proportion of animals affected was dependent on treatment (Rayner 1969). Therefore, the proportion of severely poisoned cattle was less with averted (10%) than with the non-averted controls (62 %) and consequently the proportion of unaffected cattle was greater with the averted (52%) than with the non-averted controls (5 %). Two of 21 averted cattle were severely poisoned as compared to 13 of 21 non-averted controls, while 11 of the averted cattle were unaffected as compared to only one of the control cattle (Fig. 4). Mild tulp poisoning, however, occurred in almost equal numbers among averted ($n = 8$) and non-averted control ($n = 7$) animals.

The results show that the preceding artificial aversion almost prevented severe tulp poisoning in cattle on the tulp-infested grass pasture but did not prevent mild poisoning. Aversion therefore seemed to prevent excessive consumption but not total avoidance of tulp. Ingestion of small amounts of tulp after aversion treatment, however, may be necessary for inducing strong natural aversion to tulp. Mild poisoning is not of major concern as animals so affected generally recover without treatment within a day or two. It can be expected that tulp poisoning of averted animals in practice will be lessened by joint grazing with previously averted cattle, which will discourage tulp intake. Averted animals in this trial on the contrary were subjected to the peer group pressure of non-averted animals (Ralphs & Olsen 1990; Provenza & Burritt 1991) to ingest tulp. The results, notwithstanding, suggest successful application of this technique in practice whereby animal losses due to tulp poisoning on tulp-infested grass pasture may be restricted to a minimum.

Exposure to a pure stand of tulp supplemented with maize residues

A significant ($P < 0.001$) Chi-squared test indicated that the proportion of poisoning varied over the treatment and control (proportion of animals affected was dependent on treatment) (Rayner 1969). The proportion of severely poisoned cattle, therefore, was less with averted (10%) than with non-averted controls (67%) and consequently the proportion of unaffected cattle was greater with averted (76 %) than with non-averted controls (5%). Only two of 21 averted cattle were severely poisoned compared to 14 of the controls ($n = 21$) (Fig. 6). In agreement with these figures, 16 of the averted cattle were unaffected while only one of the control cattle was unaffected. Three of the treated cattle were mildly poisoned compared to six of the controls.

The results indicate that the cattle were successfully averted to minimize severe poisoning when exposed to a pure stand of tulp to which maize residues were added as supplement. For the reasons mentioned above, even less poisoning of averted animals can be expected under practical farming conditions. These results are of importance to maize farmers buying cattle from non tulp-infested areas to utilize maize residues on tulp-infested maize lands after harvesting.

CONCLUSION

Successful application of conditioned feed aversion to minimize poisoning of cattle exposed (1) to tulp on a tulp-infested grass pasture; and (2) to a pure stand of tulp supplemented with maize residues, had been proven. The results suggest that this technique may be useful in preventing severe tulp poisoning of cattle on tulp-infested grazing in practice.

ACKNOWLEDGEMENTS

We thank Ms Liesl Morey of the ARC-Biometry Unit for the statistical analysis on the data.

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