

# Conditioned aversion to minimize *Ferula communis* intake by orphaned lambs

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## Abstract

The circum-Mediterranean perennial *Ferula communis* L. (giant fennel) has anticoagulant constituents. Mortality from poisoning can affect 5% of the sheep grazed in infested areas and most casualties are ewe-lambs at the onset of the grazing season. In intensive sheep production systems, ewe-lambs are "orphaned", artificially reared, and have no opportunity to acquire safe dietary habits by imitating their mothers. The aim of the present study was to evaluate the intake of *F. communis* in such lambs and to assess the potential of using conditioned aversion as a managerial tool to decrease the frequency of *F. communis* poisoning. Six lambs weighing approximately 28 kg were averted to *F. communis* using 2 administrations of 4g LiCl in aqueous solution, given immediately after a meal of *F. communis*; 6 similar lambs served as unaverted controls. The intake of *F. communis* and the persistence of aversion were assessed over 7 observation days using a simulation of an infested field where freshly cut bunches of *F. communis* were tied to stakes at 10-m intervals in ryegrass (*Lolium multiflorum* Lam.) paddocks at the late vegetative stage. Averted lambs grazed separately from unaverted counterparts. Time spent by lambs foraging on *F. communis* was in the range of 0–0.015 min/hour (not significantly different from nil) in averted, and 0.15–0.24 min/hour in unaverted lambs, respectively ( $P = 0.002$ ). Consequently, the rate of disappearance of *F. communis* was greater when grazing was by unaverted than averted lambs (0.29 and 0.15 g/min,  $P = 0.01$ ). The aversion persisted for 25 days after the LiCl treatment, at which time observations were discontinued. Assuming that the amount of *F. communis* that disappeared is close to actual intake by lambs, intake by unaverted lambs was high enough to endanger the lambs, whereas averted lambs consumed safe amounts of the poisonous plant. It is concluded that conditioned aversion has the potential to alleviate the problem of *F. communis* poisoning in orphaned ewe-lambs.

**Key Words:** Sheep grazing; poisonous plants; conditioned food aversion

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## Resumen

La especie perenne circunmediterranea *Ferula communis* L. ("Giant fennel") tiene constituyentes anticoagulantes. La mortalidad por envenenamiento con esta especie puede afectar hasta el 5% de los borregos apacentando áreas infestadas, la mayoría de las bajas son corderos hembras y ocurren al final de la estación de apacentamiento. En sistemas de producción intensiva de ovinos, los corderos hembras son destetadas y alimentados artificialmente por lo que no tienen la oportunidad de adquirir hábitos de alimentación segura a través de imitar a sus madres. El objetivo de este estudio fue evaluar el consumo de *F. communis* en corderos destetados y el potencial de uso de la aversión condicionada como una herramienta de manejo para disminuir la frecuencia de envenenamiento con *F. communis*. Seis corderos de aproximadamente 28 kg de peso fueron condicionados adversamente a *F. communis* mediante 2 administraciones de 4 g de LiCl en solución acuosa suministrada inmediatamente después de una comida de *F. communis*, seis corderos similares sin aversión fueron utilizados como control. El consumo de *F. communis* y la persistencia de la aversión a esta especie fueron evaluados durante 7 días mediante la simulación de un terreno infestado. La simulación se realizó en una pradera de ryegrass (*Lolium multiflorum* Lam.) donde manojos recién cortados de *F. communis* se ataron a estacas con una separación de 10 m, la pradera estaba a finales de la etapa vegetativa. Los corderos con aversión apacentaron separadamente de los corderos sin aversión. El tiempo utilizado en apacentar *F. communis* estuvo en el rango de 0 a 0.015 min/hr (Sin diferencia significativa de nil) para los corderos con aversión y de 0.15 a 0.24 min/hr para los corderos sin aversión ( $P = 0.002$ ). Consecuentemente, la tasa de desaparición de *F. communis* fue mayor con el apacentamiento de corderos sin aversión que con aversión (0.29 y 0.15 g/min,  $P = 0.01$ ). La aversión persistió por 25 días después del tratamiento con LiCl, tiempo en que se suspendió la observación de los animales. Asumiendo que la cantidad de *F. communis* que desapareció es cercana al consumo actual por los corderos, el consumo de los corderos sin aversión fue suficientemente alto para ponerlos en peligro, mientras que los corderos con aversión consumieron cantidades de esta planta tóxica que no fueron peligrosas. Se concluye que la aversión condicionada tiene potencial para disminuir el problema de envenenamiento de corderos hembra por *F. communis*.

The circum-Mediterranean perennial *Ferula communis* L. (giant fennel) is known to contain anticoagulant constituents in healthy, fresh plant material (Shlosberg and Egyed 1985). Mortality can affect 5% of the sheep grazed on infested areas. Most casualties are ewe-lambs at the onset of the grazing season within 30 days of being turned out, probably because at that time *F. communis* is prominent and lush whereas alternative herbaceous vegetation is still scarce (Egber et al., unpublished data). In the intensive lamb meat production system practised in Israel, ewe-lambs are separated from their mothers at birth (i.e., "orphaned"), raised artificially using an automatic milk dispenser, and weaned to solid food at 25–30 days of age and 12–15 kg body weight (BW). While learning from adults is considered of major importance in acquiring safe dietary habits (Thorallsdotir et al. 1990, Provenza et al. 1993), there is little opportunity for adults to influence the dietary habits of young animals in this type of production system. Also, autumn-born lambs can be first turned to green pasture when 3-months old but do not interact socially with adult ewes during the first grazing season (Egber unpublished data). Herbicidal eradication of *F. communis* was practised in the past, but it is now considered ecologically unsound. In regions where *F. communis* is widespread, shepherds will defer grazing and alternate grazing in infested and non-infested paddocks to prevent poisoning, which results in incomplete exploitation of pasture (Shlosberg and Egyed 1985). While *F. communis* is toxic when fed to lambs at 2.5 g/kg BW/day, it causes no disturbance in blood clotting at 1.0 g/kg BW/day (Shlosberg and Egyed 1985). Toxicity of *F. communis* decreases somewhat after the plant has flowered (Egyed et al. 1981). There is no quantitative information available on *F. communis* intake by weaned lambs grazed on infested range.

It appears that no post-ingestive discomfort is felt when sheep feed on *F. communis* (Shlosberg and Egyed 1985) and the plant is abundant and palatable. These are favorable conditions for the implementation of conditioned food aversion (CFA) against *F. communis*, e.g. artificial build-up of temporal contiguity between ingestion of the plant and artificially induced post-ingestive pain,

in order to elicit rejection by lambs at later encounters (Ralphs 1992). Lithium chloride (LiCl) has been used frequently as a malaise-inducing agent to establish a CFA procedure, due to its relative safety and taste analogy with sodium chloride (du Toit et al. 1991). The procedure has been shown to induce persistent CFA to *Cercocarpus montanus* and *Amelanchier alnifolia* in sheep by Burritt and Provenza (1989), to *Oxytropis sericea* (Ralphs et al. 1997) and *Delphinium barbeyi* (Ralphs 1997) in cattle, and to *Pinus brutia* in goat kids (Nolan and Nastis 1996). Procedures for conditioned food aversion (CFA) have been implemented in lambs accompanying their mothers (Provenza et al. 1993), in 3-month old weaned lambs (Burritt and Provenza 1990, du Toit et al. 1991) and in adult sheep (Provenza et al. 1993). We recently developed a procedure to establish CFA to *F. communis* in orphaned weaned lambs in individual cages. While testing the procedure in the field, we found that the efficacy of CFA to *F. communis* interacts with pasture availability (Egber et al., unpublished data). Others have shown that social facilitation causes sheep to extinguish aversions (Burritt and Provenza 1989, Provenza and Burritt 1991, Provenza et al. 1993). Therefore, the assessment of the efficacy of CFA and, in particular, the evaluation of its persistence, must be carried out under strictly controlled field conditions, where averted and non-averted lambs graze separately in similar plots, before any extrapolation to commercial range conditions.

This study was aimed at: (i) quantifying the intake of *F. communis* by weaned lambs at the onset of their first grazing season; and (ii) assessing the value of creating conditioned food aversion to *F. communis* as a potential aid to improve range utilization by sheep in infested regions under controlled field conditions.

## Materials and Methods

The experiments were carried out at Kibbutz Har'el in the Judean Hills of Israel (31.7°N, 35.0°E), where rangelands are heavily infested with *F. communis*. Twelve weaned "orphaned" German Landschaff Merino ewe-lambs, aged 80 days and weighing approximately 27.8 kg (SE=0.90), were housed

in individual cages (1.7 × 1.7 m) on a dirt floor in a roofed building. Six lambs served as averted group and 6 lambs served as controls. During the 2 weeks before attempting to establish aversions to *F. communis* was implemented, lambs were fed daily a basic diet comprising 300 g of a commercial starter concentrate (18% crude protein, Ambar, Hadera, Israel) and 300 g of chopped oat hay containing 8.1% crude protein (CP), 68.5% neutral detergent fiber (NDF) and 42.1% acid detergent fiber (ADF) on a dry matter (DM) basis. Fresh water was available ad lib. As lambs were reluctant to consume *F. communis* foliage when it was offered in the trough, the plant was tied in bunches of approximately 200 g which were positioned vertically to the cage frames with metal clamps, so as to simulate the natural position of plants, as described by Meuret (1988) and Provenza et al. (1993). On March 27, when the average daily intake of *F. communis* foliage reached approximately 40 g (SE=9 g) fresh, a conditioned food aversion (CFA) protocol was carried out by administering 4 g LiCl in aqueous solution, immediately after *F. communis* was provided, independent of *F. communis* intake, using a de-worming gun (day 0). Sodium chloride was administered to the control lambs. No *F. communis* was provided on March 28. On March 29, *F. communis* foliage was presented to lambs, followed by a second administration of 4 g LiCl. Following the second LiCl administration, individual cages were dismantled, lambs were managed as 1 flock and turned to a late vegetative Italian ryegrass (*Lolium multiflorum* Lam.) paddock of 0.30 ha which had been sown in November and grazed occasionally from the beginning of January. It was divided into 2 similar plots, each of 0.15 ha. Lambs were accustomed to grazing in both plots as 1 group from day 4 to day 7 after the first LiCl treatment. Provision of the basic diet of oat hay was discontinued in order to enhance intake at pasture. Standing biomass and pasture quality were estimated by clipping five, 0.25 × 0.25 m quadrats in each plot. Samples were dried in a forced air oven at 60°C for 48 hours and then weighed. Initial standing biomass averaged 4,740 (SE=320) and 6,040 (SE=350) kg/ha in plots A and B, respectively; CP, ADF, NDF and ash content were similar in both plots and

averaged 10.8%, 30.3%, 51.2% and 13.3%, respectively. The standing biomass throughout the experiment was similar in the two fields (Fig. 1).

An artificial simulation of a pasture infested with *F. communis* was constructed as follows: Nine, 1-m-high iron stakes were sunk 30 cm into the ground and their position was defined using a letter and a number. The distance between stakes was approximately 10 m, which is approximately the distance between *F. communis* plants in infested range. The lambs were grazed alternately on the 2 plots; averted and non-averted lambs grazed separately, and allocation of plots was switched every day. Grazing behavior on the *F. communis*-infested paddock was observed on 7 occasions from 4 April to 22 April. On these days, freshly cut bunches of *F. communis* weighing approximately 350 g fresh were tied tightly to the base of each stake, to mimic the natural appearance of the plant. Three bunches were weighed and laid out of lambs' reach for evaluation of water loss. Grazing bouts lasted 180 min., apart from 1 bout of 120 min. on 1 very hot day. At the end of each grazing bout the *F. communis* bunches were gathered, weighed and weight change was corrected for water loss. If uneaten residues of *F. communis* were found on the ground near stakes, their weight was subtracted from the initial weight of a bunch before disappearance of *F. communis* was calculated. Lambs were identified by numbers painted on both sides of the body. Two observers were allocated to each plot, and observations were made from a distance of 2 to 5 m. The presence of observers had no detectable effect on the grazing activity and social relationships of these "orphaned" lambs, because they were accustomed to being handled from birth. Every encounter of a lamb with *F. communis* was documented. When an animal started to forage on *F. communis* (an event we term a "grazing encounter"), the observer recorded the lamb number and the exact time. At the end of an encounter, the time was recorded again. Persistence of conditioned food aversion (CFA) was tested until day 25 after establishment of the CFA. On that date *F. communis* began to flower, and *F. communis* is attractive and toxic mainly before flowering (Egyed et al. 1981).

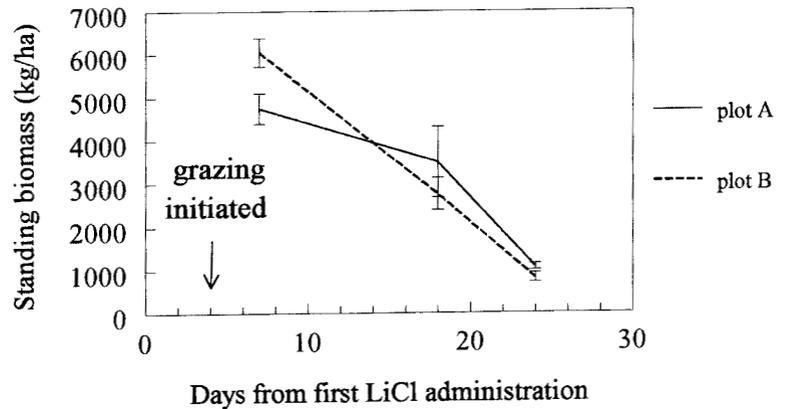


Fig. 1. Standing biomass (kg/ha) of plots A and B throughout the experiment.

The effects of the aversion procedure on the intake of *F. communis* were evaluated by analyses of variance using a repeated measures procedure with lamb-within-treatment as the error term (SAS 1985). The weight change of *F. communis* bunches was analyzed using a bi-factorial procedure with CFA (yes/no) and plot (A/B) as main effects and their interaction. The effect of the position of the bunch on the number of encounters and the intake of *F. communis* was analyzed separately for each plot, using a bi-factorial procedure with CFA (yes/no) and position of bunch as main effects and their interaction.

## Results and Discussion

No difference ( $P=0.15$ , Fig. 2a) was noted in the frequency of grazing encounters to *F. communis* in lambs averted or not averted to the plant but significant "plot" ( $P=0.01$ ) and "lamb" ( $P=0.03$ ) effects were noted for the frequency of grazing encounters ( $P=0.01$ ): some lambs grazed *F. communis* more frequently than others and plot B had 50% more grazing encounters to *F. communis* than plot A. The average time spent by a lamb foraging on *F. communis* ranged from 0 to 0.015 min/hour (not significantly different from nil) in averted, and 0.15–0.24 min/hour in unaverted lambs, more than 10-fold higher in the latter ( $P=0.002$ , Fig. 2b). A strong ( $P=0.008$ ) "lamb" effect on time spent foraging on *F. communis* was found, implying that some lambs consumed much more *F. communis* than others. This finding is in agreement with the description by Shlosberg and Egyed (1985) of lambs that "were assertively

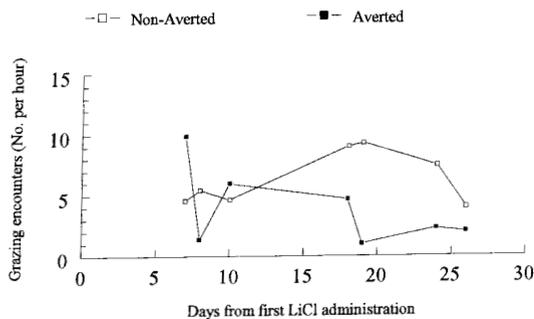
aggressive in their desire to receive their daily portion".

Overall, no plot effect were observed for time spent foraging on *F. communis* ( $P=0.32$ ), but a stake  $\times$  aversion treatment interaction tended to be significant in plot B ( $P=0.06$ ).

The aversion to *F. communis*, when assessed according to time spent foraging on *F. communis*, seemed to persist throughout the experiment (Fig. 2b). The location of *F. communis* bunches did not affect the frequency of visits and time spent foraging on them in plot A.

The rate of disappearance of *F. communis* was 0.218 g fresh/min/lamb. It was approximately double when grazed by non-averted, compared with averted, lambs (0.29 and 0.15 g/min,  $P=0.01$ ). When disappearance was analyzed in a model which included aversion, plot, plot  $\times$  aversion and date, the effect of aversion was significant ( $P=0.008$ ) and aversion  $\times$  plot tended to be significant ( $P=0.10$ ). Rate of disappearance tended to be affected by stake position in plot B: 0.19 g/min for stakes A1-A2-A3, located along the fence between the 2 plots, compared with 0.13 g/min from other stakes ( $P=0.07$ ); a similar trend was found in plot A: 0.17 g/min for stakes C1-C2-C3, also located along the fence between the 2 plots, compared with 0.12 g/min for other stakes ( $P=0.19$ ). This finding can be interpreted as an outcome of lambs in the experimental groups to grazing as close as possible to mates of the other group. This strengthens our assumption that conditioned food aversion (CFA) had to be evaluated first with groups which were separated while grazing, because of the negative anticipated effects of unaverted controls on averted lambs

a



b

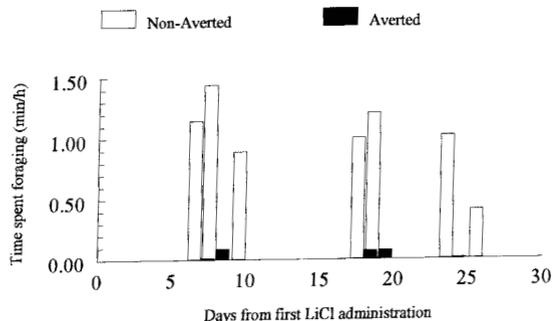


Fig. 2. The frequency of grazing encounters (a, lines) and time spent foraging (b, bars) on *F. communis* by lambs averted or non-averted to *F. communis*.

(Burrirt and Provenza 1989; Provenza and Burrirt 1991).

The rate of *F. communis* disappearance (0.218 g/min/lamb) was comparable to the 1.0 g/min found with 6 lambs in a previous trial (Egber et al., unpublished data). Assuming that most of the *F. communis* which disappeared was eventually eaten, it can be calculated that unaverted lambs consumed 17 g/hour, or approximately 70 g during a 4 hour grazing day. Although lambs spent only about 1 min/hour foraging on *F. communis*, the amount of *F. communis* presumably eaten was close to 2.5 g/kg BW/day. Supposing lambs were continuously grazing the infested paddock, which was not the case in the present study, this amount would be enough to impair prothrombin time in lambs within 9 days, and to be lethal within 11 days (Shlosberg and Eged 1985). In contrast, the amount of *F. communis* consumed by the averted lambs (35

g/day) was approximately 1g/kg BW/day, an amount which did not produce noticeable toxic effects within 21 days, according to Shlosberg and Eged (1985). Therefore, implementation of conditioned food aversion (CFA) to *F. communis* can be a viable management technique for ewe-lamb survival in *F. communis*-infested rangelands.

In addition, CFA to *F. communis* persisted for at least 25 days, which is approximately the period by which *F. communis* precedes the growth of most annual herbaceous plants. Therefore, CFA established in this critical period could alleviate the problem of *F. communis* poisoning in ewe-lambs. Poisoning in adult sheep is rare, however, visits to *F. communis* are common, which may negatively affect the grazing behavior of newly averted lambs. There-

fore, the potential social influence must be studied before the procedure can be used on a wide scale, to determine whether only young ewe-lambs, or the whole flock, should be subjected to the CFA procedure and whether the CFA procedure should be repeated every year. The number of animals to be averted and the necessary frequency of the procedure for each animal are issues that will strongly affect the economic viability of this management option impact because the CFA procedure is difficult and time-consuming.

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