# Threshold tolerances for sorghum ergot in cattle feedlot rations

## Project: FLOT.114

## FINAL REPORT

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# FLOT.114

# THRESHOLD TOLERANCES FOR SORGHUM ERGOT IN CATTLE FEEDLOT RATIONS

# FLOT.114: Threshold tolerances for sorghum ergot in cattle feedlot rations

## Milestone 3 – Final report


## SUMMARY

Sorghum ergot is a fungal disease of sorghum which has been shown to depress performance of cattle fed contaminated grain in feedlots. Earlier studies by the current research team have shown marked reductions in intake and growth rate of cattle consuming sorghum grain containing as low as 1.5 mg/kg (parts per million; ppm) dry matter (DM) of dihydroergosine (DHES), an alkaloid compound which is the toxic component of the ergot sclerotes in grain. The effects of the ergot appeared most severe when fed during the hotter months of the year, due to an apparent impairment of heat dissipation mechanisms in the animals. Nevertheless, even in winter contamination at 3 ppm alkaloid impaired animal performance. The present experiment was designed to (i) measure the effect on cattle performance of various concentrations of sorghum ergot alkaloid, at or below the industry standard for ergot contamination, in feedlot rations fed during the cooler months of the year; and (ii) determine the threshold level for ergot alkaloid concentration below which there is no effect on cattle growth rates.

At the DPI's Animal Husbandry Research Farm (AHRF), Rocklea, Hereford steers (307.8 ± 12.04 (± s.d.) kg liveweight) were fed concentrate / hay (90:10) rations based on sorghum grain with various concentrations of ergot alkaloid, as achieved by mixing clean and ergot-contaminated grain in varying proportions. The infected grain used in this experiment contained approximately 8% ergot and 23.5 ppm alkaloid (DHES), so that the current industry standard of 0.3% ergot by weight was exceeded in this study when the alkaloid concentration exceeded 0.9 ppm. The DHES (alkaloid) concentrations in the grain component of the rations were initially 0 (control; clean grain only), 0.3, 0.6 and 1.2 ppm. Several weeks into the experiment, the concentrations of alkaloid in two treatments were increased from 0.3 to 2.3 (week 7) and 0.6 to 4.6 (week 8) ppm. Thus treatment alkaloid concentrations overall were: 0 ppm throughout (Control); 0.3 then 2.3 ppm after week 7 (E 0.3/2.3); 0.6 then 4.6 ppm after week 8 (E 0.6/4.6); and 1.2 ppm throughout (E 1.2). The experiment continued for 18 weeks between May 8 and September 11, 2000. The steers were weighed and rectal temperatures taken once weekly, prior to feeding in the morning.

Conditions remained relatively cool throughout the experiment and the temperature-humidity index (THI) was at all times below 70, the point above which *Bos taurus* cattle are likely to show signs of heat stress in the presence of ergot. Rectal temperature of the steers was not affected by ergot inclusion in the diet at any level. Control steers had an intake equivalent to 2.8% liveweight (LW; DM basis) and grew at 1.25 kg/day over the total feeding period. The ergot appeared to have little effect on animal performance until the concentrations of alkaloid were increased in weeks 7 and 8. After this change, the trend was for intake to decline with ergot inclusion, especially for the E 0.6/4.6 group relative to the control group (2.27 vs. 2.75% liveweight; $P<0.05$). In addition, growth rate was 28% lower for the E 0.6/4.6 group than the control, but the effect was not statistically significant. Inclusion of ergot alkaloid at 1.2 or 2.3 ppm had no significant effect on animal performance.

An analysis of the growth depression in cattle at different concentrations of alkaloid in the grain, for the three experiments conducted to date, suggests that cattle can tolerate concentrations of up to 2 ppm when fed during the cooler months of the year, but a lower

tolerance of 1 ppm applies when feeding occurs under conditions of high temperature and humidity. As it impractical to have different standards for different feeding conditions, the lower value of 1 ppm should be adopted as the industry standard for cattle feedlot rations. With the grain used in the current study this was equivalent to about 0.3% ergot, the current industry standard, but the relationship between ergot percentage and alkaloid concentration has been shown to vary over a wide range in practice. It is therefore proposed that the standards be set on an alkaloid concentration which can be determined more precisely and repeatably than can ergot percentage. The need for a rapid, simple, accurate, low cost method of determining alkaloid concentration in grain shipments is highlighted.

## BACKGROUND

Sorghum ergot is a fungal disease new to Australia (first identified in 1996) but it is now evident that it has the potential to affect a large proportion of Queensland's sorghum crop. Late-planted crops are particularly vulnerable to ergot infestations. At first sorghum ergot was thought to be relatively harmless to livestock compared to rye ergot, because no cases of poisoning had been reported in Africa or elsewhere. However, this situation changed when cases of reduced milk production in sows and dairy cows were reported in central Queensland and shown to be caused by sorghum ergot (Blaney *et al.* 1998).

A feedlot study completed in May 1998 indicated that sorghum ergot also adversely affects beef cattle in feedlots (Blaney, McLennan *et al.*, unpublished data). In this study, Hereford steers (initial liveweight 295 kg) were fed a ration based on dry-rolled sorghum (90:10, concentrate: hay) over a 119 day feeding period during summer/autumn. Growth rate was reduced from 1.37 kg/day for steers given clean (no ergot) grain to 1.01, 0.92 and 0.77 kg/day for those receiving grain (sorghum) mixes containing ergot alkaloid (DHES) concentrations of 1.5, 3 and 6 ppm, respectively. The current Queensland stockfeed standard is 0.3% ergot in sorghum, which for the above experiment was equivalent to about 1 ppm ergot alkaloid although this appears to be highly variable in practice. These reduced growth rates reflected depressed feed intakes. The effects of the ergot seemed to be most pronounced during hot, humid weather when affected animals were apparently unable to dissipate heat and showed signs of severe heat stress. Our preliminary examination of the results indicated that the temperature-humidity index (THI) threshold above which *Bos taurus* steers suffered heat stress was reduced from 79 without ergot to 70 for those consuming ergot-contaminated grain.

A subsequent study carried out in the winter/spring of 1999 examined the effects of sorghum ergot on cattle performance in the feedlot when ambient temperatures were lower. The hypothesis was that cattle could tolerate higher concentrations of ergot alkaloid in the cooler months. Ergot was included to provide alkaloid concentrations of 0, 3, 6, 9 and 12 ppm in the grain. The results indicated that at all levels of ergot inclusion intakes were significantly reduced and growth rates depressed by 33% on average, with only minor differences between the various levels of ergot inclusion.

The current study was set up to determine whether even lower concentrations of ergot alkaloid than those used previously would impair liveweight performance, whether the current industry standard was appropriate and, if not, what lower threshold for ergot contamination should be set. This information is required in order for the feedlot industry to assess the likely economic costs of ergot inclusion in grain.

## OBJECTIVES

1. To measure the effect on cattle performance of various concentrations of sorghum ergot alkaloid, at or below the industry standard for ergot contamination, in feedlot rations fed during the cooler months of the year.
2. To determine the threshold level for ergot alkaloid concentration below which there is no effect on cattle growth rates.
3. Based on 1 and 2 above, to make recommendations to the feedlot industry on the practical utilisation and commercial value of ergot-infected sorghum.

# FEEDLOT EXPERIMENT

## Methodology

### Formulation of rations

Feedlot rations based on a combination of grain concentrate and Rhodes grass hay (90:10; as fed) were prepared and fed to cattle. The grain concentrate composition was (g/kg, as fed): dry rolled sorghum grain, 866; urea, 10; limestone, 12; cottonseed meal, 30; molasses, 56; bentonite, 20; ammonium sulphate, 2; and pre-mix, 4. The pre-mix included trace minerals, vitamins and Rumensin©. Treatment ergot alkaloid concentrations in the grain component of the ration were achieved by mixing different proportions of ergot-infected and non-infected (clean) sorghum. The ergot-infected sorghum used contained 23.5 mg/kg (ppm) dihydroergosine (DHES), the alkaloid which is the main toxic component of ergot sclerotes and which constitutes about 85% of the total alkaloids present. Rations were formulated initially so that the sorghum component of the ration had concentrations of 0 (Control), 0.3, 0.6 and 1.2 ppm DHES. These treatments levels were later changed in weeks 7 and 8 so that the concentrations (ppm) were: 0 (Control); 0.3 up to, 2.3 after, week 7 (E 0.3/2.3); 0.6 up to, 4.6 after, week 8 (E 0.6/4.6); 1.2, unchanged throughout (E 1.2). As the infected sorghum was determined to have approximately 8% ergot content by weight, the industry standard of 0.3% ergot equated to approximately 0.9 ppm alkaloid in the grain used.

### Cattle, their husbandry and general procedures

The experiment was carried out at the Queensland DPI's Animal Husbandry Research Farm, Rocklea, commencing on 8 May 2000. Thirty-six Hereford steers of initial liveweight 307.8 ± 12.04 (± s.d.) kg were used in a random block experimental design involving 9 replicates of the 4 treatments. The steers were allocated to treatments and to blocks by stratified randomisation on the basis of fasted (24 h without food, 15 h without water) liveweight, and then randomly allocated to individual pens within these blocks. All steers were gradually adapted to a high-concentrate ration by incrementally increasing the ratio of grain concentrate (non-infected):hay from 1:9 to 9:1 over a 14 day period. Following this equilibration period, treatment concentrations of ergot alkaloid were included in the rations from day 15. The experiment was completed on 12 September 2000 after 127 days.

Rations were fed once daily in the morning. The amount fed to each steer was adjusted on a daily basis so that some residue (about 10% in excess of intake) remained in the trough the next morning, thereby ensuring *ad libitum* intake. Feed residues were removed once weekly and weighed. Sub-samples of feed and residue feed were dried in a fan-forced oven at 60°C for 48 h for DM determination, and proximate analysis was carried out on the hay and grain concentrates sub-sampled weekly and bulked over approximately 8 week periods. Grain samples were taken weekly, bulked over 2 weeks, and analysed for ergot alkaloid concentration.

The steers were weighed (unfasted) once weekly prior to the morning feeding. Fasted liveweights were also recorded on all steers at the end of the experiment. Rectal temperatures were also recorded once weekly at the time of weighing. Blood samples were taken from the tail prior to feeding on days 15 (just prior to feeding ergot), 36, 71 and 99 and analysed for plasma prolactin. Steers were observed closely at least twice daily for any possible effects of the ergot on behaviour.

Climate data from the Meteorological Bureau was used to define climatic conditions prevailing during the feeding period.

## Results and discussion

### Composition of feed ingredients and mixed rations

The chemical compositions of the hay and sorghum and of the mixed concentrate rations (excluding hay) fed to the various treatment groups, are shown in Table 1. Because the treatments were changed at weeks 7 and 8, separate analyses were also carried out on concentrate rations for the periods prior to and following the change for the 2 treatments involved (E 0.3/2.3 and E 0.6/4.6).

The ergot-infected grain was relatively uniform in composition for the two batches used (see Table 1). This infected grain tended to have higher protein but lower starch content than the clean grain. The fungal sclerotes of sorghum ergot are of relatively high protein, high fibre and low starch content and their replacement of grain kernels in infected crops would have contributed to this finding. However, estimated metabolisable energy density was similar for the 2 grain sources. There were only minor differences in composition of the mixed rations between treatments and also within treatments for different periods. The grain concentrate component of the rations tended to be slightly low in CP content for a finishing diet, at approximately 11% CP.

The concentration of DHES varied only slightly between fortnightly samplings, averaging 23.5 mg/kg for the whole feeding period.

***Table 1. Composition of the feed ingredients and mixed rations (DM basis)***

| | OM (%) | CP (%) | CF (%) | NDF (%) | ADF (%) | Starch (%) | Fat (%) | Ca (%) | P (%) | IVOMD (%) | ME (MJ/kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Hay** | 89.6 | 6.1 | - | 70.2 | 36.2 | - | - | 0.40 | 0.41 | 54.7 | 7.4 |
| **Clean sorghum (wk 1-18)** [A] | 98.6 | 10.3 | 2.5 | - | - | 70.6 | 3.9 | 0.03 | 0.29 | - | 14.0 |
| **Ergot-sorghum (wk 3-8)** [A] | 97.9 | 13.1 | 2.9 | - | - | 62.9 | 3.2 | 0.05 | 0.41 | - | 13.7 |
| **(wk 9-18)** [A] | 97.7 | 12.9 | 3.0 | - | - | 64.3 | 3.2 | 0.07 | 0.44 | - | 13.7 |
| **Grain concentrate mixes** | | | | | | | | | | | |
| **Control (wk 1-18)** [B] | 93.9 | 10.9 | 2.4 | - | - | 62.9 | 2.8 | 0.64 | 0.34 | - | 13.2 |
| **E 0.3/2.3 (wk 3-7)** [B] | 94.2 | 11.0 | 2.7 | - | - | 62.5 | 2.9 | 0.84 | 0.33 | - | 13.2 |
| **(wk 8-18)** [B] | 94.1 | 11.0 | 2.5 | - | - | 61.1 | 3.0 | 0.62 | 0.36 | - | 13.2 |
| **E 0.6/4.6 (wk 3-8)** [B] | 94.4 | 10.8 | 2.3 | - | - | 61.8 | 2.8 | 0.59 | 0.35 | - | 13.3 |
| **(wk 9-18)** [B] | 94.2 | 11.1 | 1.9 | - | - | 59.7 | 3.1 | 0.56 | 0.33 | - | 13.3 |
| **E 1.2 (wk 3-18)** [B] | 94.6 | 10.9 | 3.0 | - | - | 60.5 | 3.0 | 0.54 | 0.32 | - | 13.3 |

[A] Grain sorghum only
[B] Total grain concentrate mix (excluding hay component)

## Climatic conditions

The experiment was conducted primarily during the winter months and climatic conditions were generally mild, even in early September. The temperature-humidity index did not exceed 70 at any time during the feeding period (see Figure 1), where the threshold THI for *Bos taurus* cattle above which heat stress is experienced is considered to be 79 generally but about 70 when ergot is present, the latter value based on the results of a previous experiment in this series.

## Animal health

In general, the steers showed few signs of ill-health during the experiment. However, several steers failed to adapt to the feeding situation and had to be removed from the experiment due to very low intakes, including during the equilibration period with clean grain, which did not appear to be treatment related. This included a steer from each of the Control, E 0.3/2.3 and E 0.6/4.6 treatment groups. Data for these steers were not included in the analysis. Another steer in the E 0.3/2.3 group developed a large abscess on its leg during the last 2 weeks of the experiment, and its intake declined markedly. Data for this steer is included except for the last 2 weeks of the experiment. The physical symptoms usually associated with ergot toxicity, viz. excess salivation, high respiration rates, open-mouthed breathing, were not as evident in this experiment conducted during the winter period as in previous trials carried out in warmer months. Most steers maintained a long coat throughout the trial, and this did not seem to be related to treatment.

## Liveweight changes

The changes in liveweight of the steers are illustrated in Figure 1 and average daily gains for various phases of the experiment are detailed in Table 2. The control steers gained weight at

***Table 2. Effect of level of ergot inclusion in sorghum on intake, liveweight, liveweight change (average daily gains; ADG) and feed conversion ratio (FCR) for Hereford steers receiving a sorghum-based feedlot ration***

| | Control | E 0.3/2.3 | E 0.6/4.6 | E 1.2 | s.e.m |
|---|---|---|---|---|---|
| Initial liveweight (8 May 2000) (kg) | 308.5 | 307.1 | 305.1 | 309.2 | |
| **Weeks 1-8** (8 May – 4 July) | | | | | |
| Intake (% LW) | 2.88 | 2.79 | 2.68 | 2.64 | 0.084 |
| ADG (kg) | 1.16 | 1.05 | 1.11 | 0.98 | 0.093 |
| FCR (kg food/ kg LW gain) | 8.9 | 9.3 | 8.3 | 9.2 | 0.52 |
| Liveweight – 4 July 2000 (kg) | 376.3 | 364.4 | 369.9 | 365.2 | |
| **Weeks 9-18** (4 July – 11 September) | | | | | |
| Intake (% LW) | 2.75 [a] | 2.64 [a] | 2.27 [b] | 2.64 [a] | 0.090 |
| ADG (kg) | 1.32 | 1.25 | 0.95 | 1.30 | 0.120 |
| FCR (kg food/ kg LW gain) | 9.1 | 9.4 | 10.5 | 9.1 | 0.79 |
| Liveweight – 11 September (kg) | 467.0 | 441.0 | 434.8 | 455.2 | |
| **Weeks 1-18** (8 May – 11 September) | | | | | |
| Intake (% LW) | 2.80 [a] | 2.70 [a] | 2.45 [b] | 2.64 [ab] | 0.079 |
| ADG (kg) | 1.25 | 1.16 | 1.02 | 1.16 | 0.089 |
| FCR (kg food/ kg LW gain) | 8.9 | 9.2 | 9.1 | 8.8 | 0.42 |

[a, b] Means with different superscripts are significantly different ($P<0.05$)

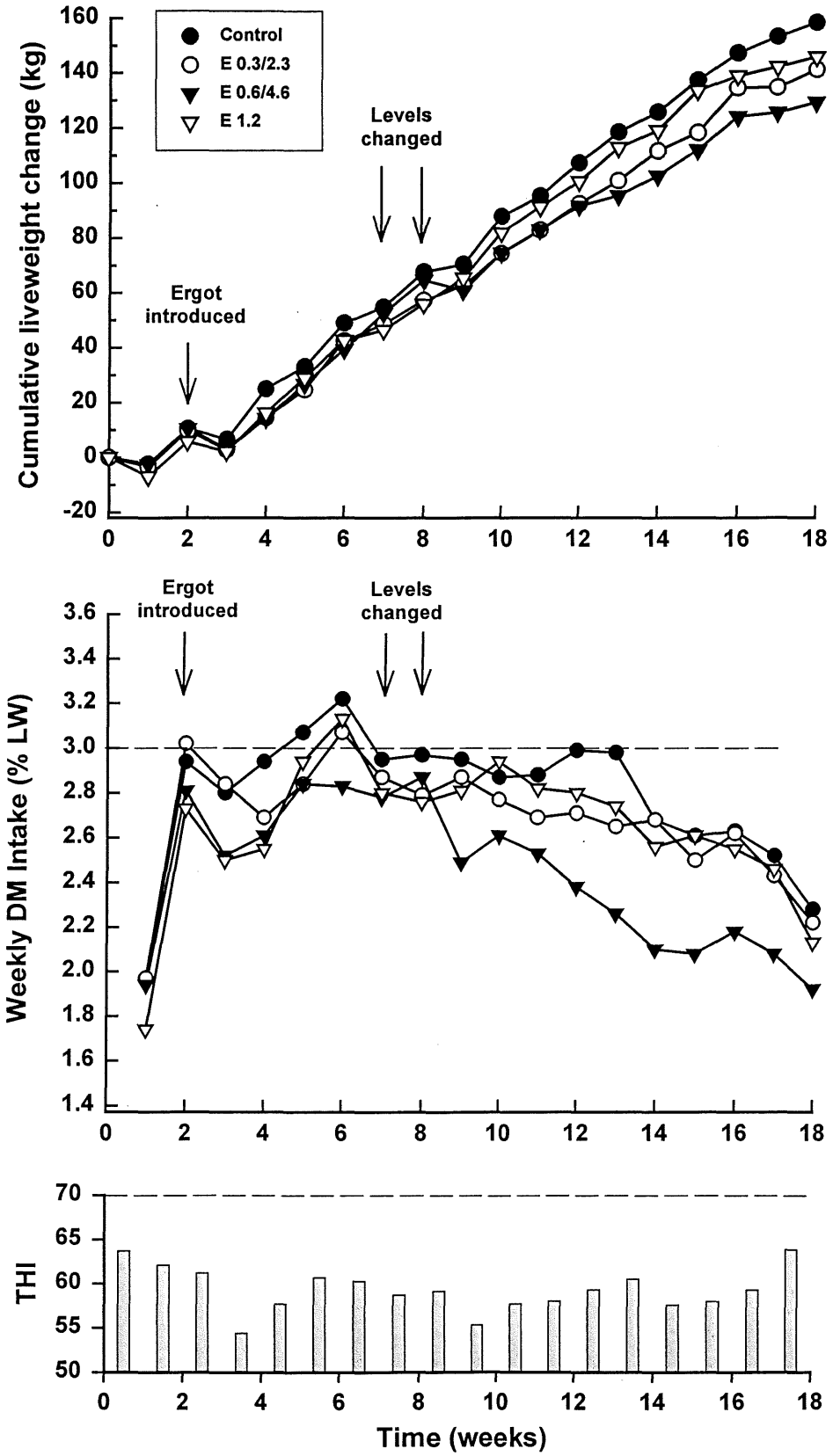


*Figure 1. Effect of concentration of ergot alkaloids in sorghum on the pattern of change in liveweight and intake for Hereford steers receiving a sorghum-based feedlot ration, and the weekly temperature-humidity index over the feeding period.*

a relatively constant rate, which averaged 1.2 kg/day, throughout the experiment. The reason for this low rate of gain is not clear but the protein level in the total ration, including hay (10.3%, calculated), was lower than planned and may have restricted growth. At the levels of ergot inclusion used in the first 8 weeks of the experiment, there was no effect of ergot alkaloid on growth rate of the steers. However, increasing the alkaloid concentration in the ration at weeks 7-8 appeared to depress liveweight performance for the E 0.6/4.6 group in particular (Figure 1), so that overall gain for this group in the second half of the experiment was 28% lower compared with the controls. Nevertheless, treatment differences were not significantly different (P=0.13) due apparently to the high between-animal variability. This variability seems to be a feature of animals receiving diets including ergot, with some animals apparently able to cope with the toxin better than others. Inclusion of alkaloid at the 1.2 ppm level had no apparent effect on liveweight gain in any period.

### Intakes

Changes in the weekly DM intakes (calculated on a liveweight basis) are also shown in Figure 1 and average intakes over various phases of the experiment are summarised in Table 2. Control steers maintained a relatively constant intake until about week 13 after which intake decreased substantially. This period of reduced intake coincided with the period of advanced fat deposition by the steers. Nevertheless, the average intake for this group was 2.8% of liveweight over the total feeding period. Consistent with the trend for liveweight changes, intakes were similar for all groups prior to the change in alkaloid concentrations in the rations at weeks 7-8 but declined after that point, most markedly for the E 0.6/4.6 steers. Average intake for this group was 17.5% lower for the second half of the experiment ($P<0.05$) and 12.5% lower overall ($P<0.05$), compared with the control group. Ergot included at other concentrations did not significantly reduce intake relative to the control group ($P>0.05$).

These results indicate that the threshold for ergot alkaloid effects on animal performance during the cooler months of the year lies somewhere between 2 and 4 ppm DHES concentration. Based on the results of a previous experiment carried out in the hotter months of the year, the tolerance for ergot may be as low as 1 ppm DHES.

Food conversion ratios were quite high throughout the experiment (see Table 2) and were not affected by treatment in any period ($P>0.05$).

### Rectal temperatures

Changes in rectal temperatures of the steers are illustrated in Figure 2. Rectal temperatures were maintained at about 39.5°C throughout the experiment and there was no significant effect ($P>0.05$) of alkaloid concentration on this parameter at any sampling time. Based on the results of earlier experiments, the effects of alkaloid concentration on rectal temperatures are usually only expressed when the temperature-humidity index is high, i.e., above about 70-75. These conditions were not experienced in the current study.

## Conclusions

Under the climatic conditions prevailing during this study, i.e., moderate to low temperatures and humidities as experienced in the winter months, steers were able to tolerate low concentrations of ergot alkaloid of about 2 ppm or less without obvious impairment of performance. By contrast, at the higher concentrations of 4.6 ppm, it appeared that both intake and growth rate were reduced although the depression in performance was not as marked as in a previous experiment carried out in the summer. These results suggest that the threshold for alkaloid concentration, or the concentration below which there is negligible effect, is considerably lower than for cattle fed in the hotter months of the year.

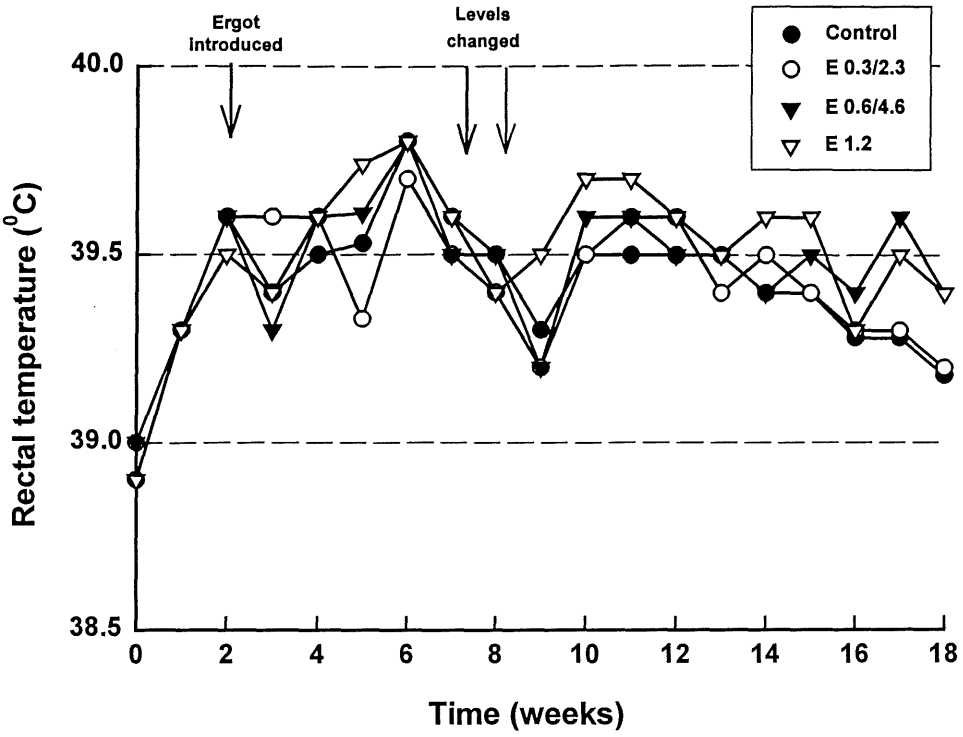


*Figure 2. Effect of concentration of ergot alkaloids in sorghum on the pattern of change in rectal temperatures for Hereford steers receiving a sorghum-based feedlot ration*

# GENERAL CONCLUSIONS

### Tolerance for ergot in sorghum

Data from the 3 experiments conducted to date have been plotted in Figure 3 in an attempt to establish tolerance levels for ergot inclusion in sorghum. It is apparent from this figure that cattle are able to tolerate slightly higher concentrations of ergot alkaloids during the cooler months of the year, as opposed to months of high temperature and humidity (high THI), and separate relationships between alkaloid concentration in sorghum and growth depression in cattle have been presented for the different seasonal conditions. This lower tolerance for ergot in summer is obviously related to the fact that the alkaloids apparently reduce the animal's capacity to dissipate heat so that heat stress is exacerbated in time of high THI. This was obvious in the first (summer) experiment when cattle receiving ergot had elevated rectal temperatures and had a higher incidence of heat stress, as demonstrated by increased panting and salivation, higher respiration rate and open-mouth breathing. The mechanism for this reduced heat dissipation seems to be a reduced peripheral blood supply through vasoconstriction, related to reduced concentration of plasma prolactin.

Nevertheless, performance of cattle receiving ergot in winter has also been depressed, albeit that this has generally occurred at higher alkaloid concentrations. In the most recent experiment there appeared to be little effect on animal performance when the alkaloid concentration was only 1.2 ppm whereas in the summer experiment growth rate was reduced by 26% with just 1.5 ppm alkaloid, a level of depression approximating that incurred with 4.6 ppm in the recent winter study.

From Figure 3, 1 ppm alkaloid is likely to have negligible effect in winter but reduce liveweight gain by 10% in summer. For winter feeding a similar depression of growth rate requires an alkaloid concentration of about 2 ppm (Figure 3). From these studies it could be deduced that the lower tolerance for alkaloid (DHES) concentration in sorghum should be 1 ppm in summer and about 2 ppm in winter. As it is impractical to have different industry tolerances for different feeding conditions, we propose that the lower figure of 1 ppm should be adopted for cattle diets.

At this point in time there is no rapid test for alkaloid concentration in sorghum and even under controlled laboratory conditions using high pressure liquid chromatography (HPLC) the analysis for this compound presently lacks high precision and repeatability. This is largely related to the difficulty experienced in achieving a representative sample of the grain as ergot sclerotes can be variably distributed through the grain and large sub-samples are required. These need to be finely ground for accurate results. A rapid test is needed at the depot site to decide on the acceptance or rejection of grain prior to mixing with other batches of grain. Traditional HPLC methods are unlikely to provide this rapid test. Previously a simple ergot assay has been used, involving the counting of ergot sclerotes in a standard weight of grain after flotation in saline water. However, it has been recently demonstrated that the relationship between ergot content (weight of sclerotes) and alkaloid concentration is highly variable (see Appendix 1) and this method can not be used with high precision. As the alkaloids are the toxic components of the ergot, it is logical to base an assay, and an industry tolerance level, on the concentration of alkaloid in the grain. A simple, inexpensive, rapid means of analysis is urgently required and with this in mind, other analytical methods such as near infra-red reflectance spectroscopy (NIRS) and immuno-assays are being investigated.

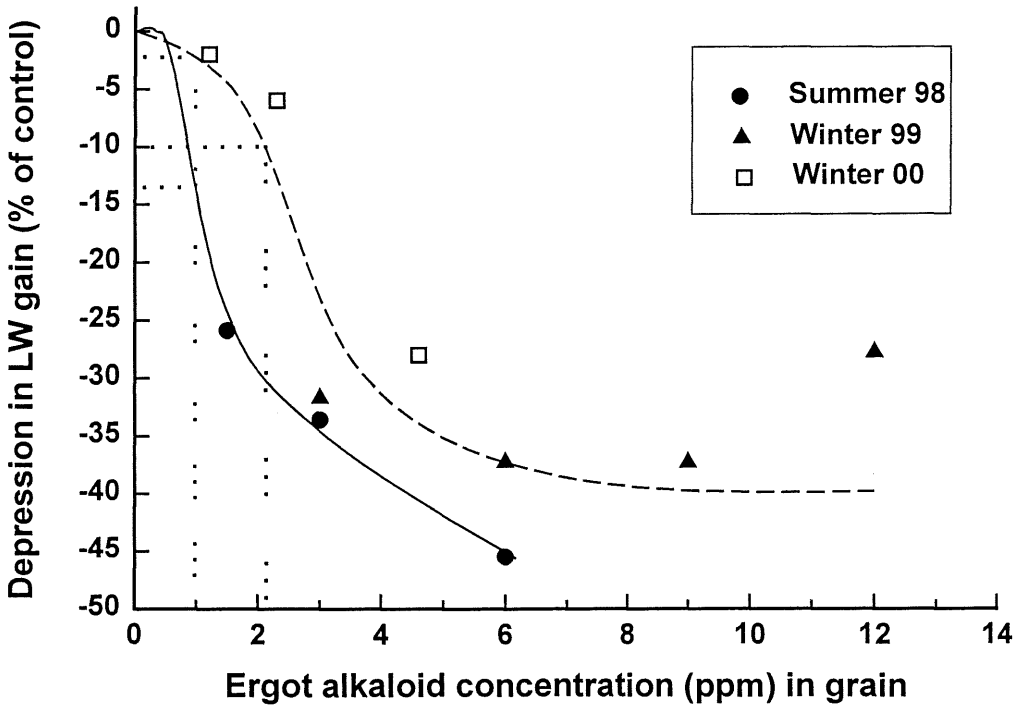


***Figure 3. Theoretical relationship between the concentration of ergot alkaloids in sorghum grain and the depression in liveweight performance of Hereford cattle receiving a sorghum-based feedlot ration.*** **Separate relationships are shown for cattle fed in summer (solid line), using data from the 1998 summer experiment, and winter (dashed line), using data from the 1999 and 2000 winter experiments.**

# APPENDIX 1

## Alkaloids of sorghum ergot (*Claviceps africana*)

The main alkaloid produced by this fungus is dihydroergosine (DHES). In all samples assayed so far in Queensland, DHES has comprised about >85% of the total alkaloid content (estimated by specific assay for DHES by chromatography compared to total alkaloids in the same extract determined by colorimetry after react with Van Urk's reagent. At least two minor alkaloid components have also be detected by chromatography in most of the samples assayed. These minor alkaloids present are probably dihydroelymoclavine (DHEL) and festuclavine (FECL), which are known to occur in the same biosynthetic pathway. Using standard material provided from collaborators in Croatia and Czechoslovakia, we have shown our minor alkaloids to be practically identical to DHEL and FECL, but very minor discrepancies in retention times require that we seek final confirmation by mass spectrometry by our collaborators.

In feeding studies, we have consistently used DHES concentrations to define our feeding levels, since the precision of the DHES chromatographic method is much better than the method for total alkaloids. However, it must be remembered that the total alkaloid contents will usually be about 15% greater than the DHES content alone. It is hoped that the minor components will be confirmed before submission of this material for journal publication. It must be admitted that the relative toxicity of DHES versus DHEL and FECL has not been tested, and a sceptic might suggest the possibility that all of the toxic effects might be due to the minor alkaloids. Against this argument is the finding that the toxicity of samples containing given DHES concentrations appears to be similar to the toxicity of samples of rye ergot containing similar total alkaloid contents composed of ergotamine and ergocryptine.

Before all toxic effects were investigated, a limit of 0.3% sorghum ergot was placed in stockfood regulations. Rye ergot is variously regulated at 0.05 to 0.2% in different countries, and it was thought that sorghum ergot would be less toxic. As investigations proceeded, it became clear that this was not necessarily the case. To further complicate the issue, it was found that ergot and alkaloid contents are not well correlated, and also that estimates of sorghum ergot are very imprecise and subjective when applied to bulk grain.

Surveys of ergot samples from various regions showed that the alkaloid content of individual mature ergot sclerotes could vary from 0.01% to almost 1%. However, when ergot was separated in bulk in a few naturally infected crops in 1996-7, either by salt flotation or density segregation, the most common average alkaloid concentration was 50 to 150 mg/kg. This means that a sample containing the regulated limit of 0.3% ergot most commonly would contain about 1 mg/kg, but in principal might contain anything from 0.3 to 24 mg alkaloids/ kg. In fact, DPI has already detected 6 mg/kg alkaloids in one sample of sorghum with only 0.3% ergot that was suspected of affecting pigs in NSW. Looked at in reverse, 1 mg alkaloid/kg might conceivably be present in samples containing as little as 0.01% ergot!

It should not been assumed that these problems are unique to sorghum ergot. Anyone reading the extensive literature on rye ergot, will see that the same problems have arisen, although rye ergot has been investigated for centuries.