Incidence and severity of ryegrass staggers and liveweight gain in lambs grazing different mixtures of ryegrass-cocksfoot pastures

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Abstract

Livestock grazing ryegrass infected with endophytic fungi are susceptible to staggers, a neurological disorder characterised by uncoordinated movement and loss of appetite. A possible strategy to minimise staggers is to dilute the toxic effects of ryegrass by providing other non-toxic pasture species in the diet. Therefore, the incidence and severity of ryegrass staggers, and liveweight gain, was monitored in lambs grazing varying mixtures of ryegrass-cocksfoot pastures during four six-week periods throughout summer and autumn over two years. There was a significant effect of pasture type on staggers. On a scale of 0 (no staggers) to 5 (severe muscular tremors invariably resulting in collapse and tetanic spasm), pure ryegrass resulted in a mean of 3.1, S.E.M. $\pm$ 1.6 compared with 0.3, S.E.M. $\pm$ 0.9 with pure cocksfoot. Ryegrass/cocksfoot mixtures were slightly less toxic than pure ryegrass with means ($\pm$ S.E.M.) ranging from 2.2, S.E.M. $\pm$ 1.6 to 2.9, S.E.M. $\pm$ 1.8. Mean liveweight gains ranged from 62 g/d on both pure ryegrass and 80:20 ryegrass:cocksfoot mix, to 83 g/d on pure cocksfoot, with no significant effect of pasture type. In those periods when ryegrass staggers was significant, the percentage of ryegrass in the sward was positively related to the severity of staggers and negatively correlated with liveweight gain. The inclusion of cocksfoot in ryegrass-dominant pastures is thus able to reduce to some extent the adverse neurological effects of endophyte on lambs.

Keywords: cocksfoot, endophyte, lambs, liveweight gain, ryegrass, ryegrass staggers

Introduction

Most, though not all, perennial ryegrass pastures are naturally infected with the endophytic fungus *Neotyphodium lolii*, imparting a degree of insect resistance to the plant, especially giving protection against Argentine stem weevil (*Listronotus bonariensis*) and discouraging overgrazing by stock (Prestidge 1993; Easton 1999). The endophyte produces a number of alkaloids, one of which, *Lolitre* B, is the major cause of ryegrass staggers (Gallagher *et al.* 1981). This neurological disorder is

characterised by uncoordinated movement and loss of appetite (Keogh 1973), and is often seen in stock grazing perennial ryegrass dominant pastures. Cattle, sheep, deer and horses are susceptible, with affected sheep having significantly reduced liveweight gains (Fletcher 1983; Fletcher & Borrell 1984; Fletcher *et al.* 1999). Furthermore, these animals are difficult to move, and may become immobile and occasionally die of starvation, dehydration or misadventure. Management routines can be disrupted, often at mating time, and occasionally severe outbreaks may result in significant stock deaths (Milne *et al.* 1999).

Several strategies have been investigated to avoid the deleterious effects of ryegrass staggers. These include feeding animals non-toxic forage, either low or toxin-free endophyte ryegrass, or other grass species to either reduce the incidence of staggers, or allow animals to detoxify after infection (Bluett *et al.* 1997; Milne *et al.* 1997; Popay *et al.* 1999). Similarly, rotational grazing routines may enable herbage regrowth of reduced endophyte content (Keogh 1983; Keogh & Clements 1993). Other strategies have included prophylactic treatment of animals with liquid seaweed (McKenzie 1982; McKenzie & Everest 1985) and selecting animals for resistance to staggers (Morris *et al.* 1995, 1998).

A further possibility is that of diluting the toxic effects of ryegrass, by offering significant amounts of other, non-toxic, species in the pasture of grazing stock. A survey of pastoral farmers (Korte & Smith 1993) reported that the risk of ryegrass staggers may be lower in mixed ryegrass/cocksfoot pastures than in those containing ryegrass alone. The objective of the current experiment was to determine whether increasing levels of cocksfoot herbage in ryegrass pastures would affect the incidence and severity of ryegrass staggers in growing ewe lambs. The pastures were established specifically for the experiment and grazed over a three-year period.

Materials and methods

Pasture establishment and experimental design

Five ryegrass (*Grasslands Nui* containing a high proportion of seed infected with wild-type endophyte)

and cocksfoot (*Grasslands Wana*) pastures were established as 20 m x 80 m plots in the autumn of 1994 at Poukawa Research Station (39°45' S, 176°43' E), Hawkes Bay, following herbicide (glyphosate) application and conventional cultivation of an area of old, established, mixed-sward pasture. Pastures were sown in a randomised complete block

design with two replicate treatments of the following ratio of sowing rates of approximately (1) 100% ryegrass (20 kg/ha), (2) 80% ryegrass, 20% cocksfoot (16 kg/ha and 4 kg/ha, respectively), (3) 75% ryegrass, 25% cocksfoot (13 kg/ha and 4 kg/ha, respectively), (4) 60% ryegrass, 40% cocksfoot (10 kg/ha and 6 kg/ha, respectively), and (5) 100% cocksfoot (10 kg/ha) for each treatment respectively. The plots were maintained by light grazing and mowing (to 5–8cm) of seedheads to maintain pasture quality prior to the first period of experimental grazing 12 months after establishment. Depending on herbage mass (1057 - 3050 kg DM/ha) on offer, each plot was grazed by 6–8 ewe lambs (6–8 months of age) during each of two autumn and two summer periods, 1–3 years after pastures were established (Table 1). Between experimental grazings, phosphate and urea fertilisers were applied routinely, thistles removed by grubbing and pastures maintained by grazing with dry stock and mowing of seedheads.

Measurements

Pasture composition was recorded on two occasions. At three months (July 1994) after establishment, plants were identified and counted in 12, 15 x 30cm quadrants per plot. Two years later (July 1996), a point analysis was undertaken on fixed transects monitoring 200 points on each plot. Pasture samples were collected at the start and end of each grazing period for mass and morphological composition. In addition, during the final grazing period (summer 1997), pasture mass and morphological composition (grass leaf, stem, seedhead, pseudostem, white and subterranean clover, other legumes, weeds, grasses and dead material) were monitored at weekly intervals (Figure 2).

Lamb live weights were measured following an overnight fast immediately prior to, and at the completion of each grazing period. Ryegrass staggers were scored at the completion of each grazing period according to Keogh (1973). The lambs were briskly moved 320 m (4 plot lengths) and scored, where 0 = no symptoms and 5 = severe muscle tremors elicited

Table 1 Time periods when plots were grazed with young ewe lambs on pastures established in April–May 1994, and the pasture mass (kg DM/ha) at the start and end of each grazing.

Grazing period	Start of grazing	End of grazing	Days	Pasture mass start	Pasture mass end
1 (autumn)	11 Apr 1995	11 May 1995	29	1230	330
2 (summer)	21 Dec 1995	24 Jan 1996	33	2060	1290
3 (autumn)	5 Mar 1996	17 Apr 1996	42	2100	620
4 (summer)	23 Jan 1997	26 Feb 1997	33	2570	760

by slight disturbance or exercise invariably resulting in staggering and collapse in a severe tetanic spasm.

Statistical analyses

The incidence and severity of ryegrass staggers were analysed using a generalised linear model (McCullagh *et al.* 1983) after classing staggers as either absent (score 0), minimal (scores 1 and 2), moderate (scores 3 and 4) and severe (score 5). The model incorporated the following factors: class of staggers, plot, grazing period, and pasture treatment. Lamb liveweight gain was expressed as g/day and analysed by REML (Payne 1993). Results are expressed as the mean, plus or minus the standard error of the mean ($\pm$ SEM), or as a range.

Results

Pasture

Pasture composition between treatments measured three months after establishment, and two years later, ranged from ryegrass dominant with no cocksfoot, to mixtures of both species, to cocksfoot dominant with little ryegrass (Table 2). The pasture on offer at the beginning of grazing averaged 1990 kg/DM/ha (range 1060 - 3050), and the residual at the end of grazing was 750 (range 160 - 1720) kg/DM/ha (Table 3). Herbage available on each pasture treatment was similar (Table 3, $P > 0.05$), but varied between seasons.

Animal performance

The variation in individual lamb growth rates over the experiment was immense, ranging from –82 to 238 g/day. Mean liveweight gains ranged from 62 g/day on pure ryegrass and 80:20 ryegrass:cocksfoot mix to 83 g/day on pure cocksfoot (Table 3), with no significant effect of pasture type. Clinical signs of ryegrass staggers were detected in more than three-quarters of lambs grazing pure ryegrass or ryegrass-cocksfoot mixtures, while few lambs (13%) grazing cocksfoot alone displayed symptoms. While the addition of cocksfoot to ryegrass pasture did not affect the number of lambs with staggers (Table 4), it

Figure 2 Morphological components of the swards and the ryegrass staggers score during the summer (1997) grazing period.

significantly reduced the severity of the symptoms. Moderate or severe symptoms were evident in 71% of lambs grazing pure ryegrass, only 57% were similarly affected when cocksfoot was included in the pasture (Table 4). Few lambs (<5%) showed moderate or severe symptoms when grazing pure cocksfoot. There were significant ($P<0.01$) effects of the grazing period, with few lambs displaying staggers in the first autumn (mean staggers score of 0.3 ± 0.10) compared with subsequent grazing periods (2.4 ± 0.16 for the following summer, 3.2 ± 0.20 autumn and 2.9 ± 0.19 , and summer periods, respectively). Limiting the analysis to the grazing periods where staggers was frequent revealed a significant positive relationship between the percentage of ryegrass in each plot at the beginning of grazing and the severity of staggers ($P<0.01$). As the proportion of ryegrass on offer increased, the mean staggers score tended to increase linearly (Figure 1). The relationship with liveweight gain was similarly linearly significant ($P<0.01$), average liveweight gain decreased as the amount of ryegrass in the sward increased (Figure 1).

Sward components and ryegrass staggers

The morphological components temporal effects (as sward components were removed by grazing) of the sward had a significant effect on staggers score during the final grazing period (summer). In all the forage treatment combinations (except pure cocksfoot), staggers score increased as the proportions of ryegrass green leaf decreased and percentage dead increased (Figure 2). However, there was no significant effect of the proportion of ryegrass stem on staggers score as these did not significantly change over the grazing

Table 2 Composition (%) of ryegrass, cocksfoot and ryegrass-cocksfoot pastures counted in 15 x 30cm quadrants on each plot three months after sowing and again by point analysis two years after sowing.

Time from establishment	Pure ryegrass	80:20 ryegrass-cocksfoot	75:25 ryegrass-cocksfoot	60:40 ryegrass-cocksfoot	Pure cocksfoot
3 months					
Ryegrass	80	65	49	32	<1
Cocksfoot	<1	10	25	39	72
Legume	20	25	26	29	28
2 years*					
Ryegrass	74	70	53	54	1
Cocksfoot	0	6	11	16	72
Legumes	7	5	9	7	4

* The proportions of other grasses (4-8%), weeds and litter (3-6%) and bare ground (11-16%) were similar across treatments.

Table 3 Mean and range of liveweight gains (g/day) of ewe lambs grazing different mixtures of ryegrass/cocksfoot pastures over one-month periods during autumn and summer, and pasture mass before and after grazing.

Pasture mix	Liveweight gain (g/day)		Pasture mass (kg/DM/h)	
	Mean	Range	start	end
Pure ryegrass	62	-39.4 to 157.6	2030	350
80:20 ryegrass:cocksfoot	61	-81.8 to 178.8	2090	1000
75:25 ryegrass:cocksfoot	71	-30.3 to 184.9	1950	990
60:40 ryegrass:cocksfoot	78	-18.2 to 162.1	1950	650
Pure cocksfoot	83	-33.3 to 237.9	1930	770

Table 4 Mean ($\pm$ S.E.M.) staggers score and number of lambs without staggers or displaying minimal, moderate or severe symptoms of staggers whilst grazing different mixtures of ryegrass/cocksfoot pastures over approximately one-month periods during autumn and summer.

Pasture mix	Staggers score	n	Lambs with staggers classed as			
			absent	minimal	moderate	severe
Pure ryegrass	3.1 ± 0.24	58	12	5	21	20
80:20 ryegrass:cocksfoot	2.9 ± 0.24	60	14	6	26	14
75:25 ryegrass:cocksfoot	2.2 ± 0.20	60	14	17	24	5
60:40 ryegrass:cocksfoot	2.4 ± 0.20	60	13	13	26	8
Pure cocksfoot	0.3 ± 0.12	61	53	3	3	0

period within any treatment. Over time, as staggers score increased, so did the removal by grazing of live cocksfoot sward components relative to the rate of removal of ryegrass green leaf and stem (Figure 2), and this was increasingly evident in swards containing lower percentages of cocksfoot.

Discussion

Although providing perennial ryegrass with natural protection against insects, endophytic fungi are very toxic to grazing animals. This was evident in the

Figure 1 Relationship between the amount of ryegrass present in the pasture sward at the beginning of grazing and the severity of staggers (upper graph) and liveweight gain (lower graph) in lambs 33-42 days later. Note that the data has been limited to those treatments and seasons where significant staggers was recorded.

present study with 75% of lambs grazing ryegrass or ryegrass-dominant pastures exhibiting clinical signs of neurological disorder. These animals were significantly affected with symptoms ranging from slight trembling of the neck, shoulders, and flank muscles after exercise to severe muscle tremors elicited by disturbance or exercise invariably resulting in staggering and collapse in a tetanic spasm. The endophyte toxin is reasonably toxic, since even some animals grazing the pure cocksfoot treatment containing little ryegrass, exhibiting clinical symptoms, albeit minimal. While ryegrass staggers can result in significant mortality on farms (e.g. Milne *et al.* 1999) no deaths were associated with the present experiment.

The inclusion of cocksfoot in the ryegrass pasture did not affect the incidence of staggers (80% of lambs grazing ryegrass-dominant pastures exhibited clinical signs) but, cocksfoot significantly reduced the severity of the disorder. While lambs were either severely or moderately affected when grazing 80 or 100% ryegrass treatments, they were only moderately or minimally affected when the proportion of ryegrass was 60 or 70%. This experiment indicates that the

inclusion of other grasses with perennial ryegrass in the pasture sward would be able to reduce the toxic effects of the ryegrass. Whether this reflects physiological or metabolic dilution of toxins after ingestion or animal grazing preference for selecting non-toxic forage is unclear. Some evidence for the latter mechanism was seen in the increased grazing of cocksfoot sward components rather than ryegrass as the staggers score increased over time (Figure 2). The lambs may select different pasture species in response to the level of toxicity experienced. For instance stock will selectively graze swards uninfected by endophyte more severely than infected swards (Edwards *et al.* 1993). Preferential grazing for cocksfoot may also have been associated with the loss of the preferred parts of the ryegrass sward making the cocksfoot relatively more attractive. While cocksfoot reduced or diluted the toxic effects of ryegrass in the present experiment, others species could also be effective (Keogh 1986). The ability of some pasture species to counter the adverse effects of toxic species, or even enhance the beneficial effects of others, is therefore open to much investigation. Not only which species, but in what proportions are they

required in order to be most effective and how could they be offered in the grazing system, presents many options.

Lamb liveweight gain has been reported (Fletcher *et al.* 1999) to have been reduced by up to 10 g/d in summer and autumn, for every 10% increase in endophyte infection, though there was variation between years and localities. The range in individual liveweight gains in the present study was large (-82 to 238 g/d), possibly precluding detection of any overall relationship between pasture mix (and thus endophyte) and liveweight gain. When the incidence of staggers was significant though (removing the first grazing run from the analysis), as ryegrass content increased, so did ryegrass staggers, while liveweight gain decreased (Figure 1). This highlights the difficulty of separating the effects of ryegrass availability on either ryegrass staggers or liveweight gain. The reason for the low incidence of staggers in the first grazing period compared with the later periods is unknown, though environmental factors such as water availability are thought to affect the expression of endophyte toxins (Lane *et al.* 1997).

Essentially monocultural or bicultural pastures are a feature of many modern pastoral farming systems. While they may present opportunities for enhanced livestock production, they also reduce selective grazing opportunities for animals. Farm animal species have evolved in the presence of many forage species, providing a varied diet not often seen on most modern farms (Fisher & Bryant 1993). Access to varied forage species may be important to the animal for several reasons, one being self-medication (Clayton & Wolfe 1993). This aspect of animal husbandry requires more serious consideration as modern systems reflect our expectations of increased productivity rather than acknowledging the sometimes subtle, needs of animals. The establishment of pastures containing a diversity of forage species might favour animal health.

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