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FUNGAL DISTRIBUTION AND LIVESTOCK DEFOLIATION PATTERNS IN PASTURE ECOSYSTEMS, AND THE DEVELOPMENT AND CONTROL OF DIETARY-DEPENDENT DISORDERS

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ABSTRACT

The fungal saprophytes, *Pithomyces chartarum* and *Fusarium culmorum,* have similar distrubtion patterns in grazed-pasture ecosystems. Spore loads (and toxin levels) of each are highest at the base of pastures and rapidly decline up the profile. But variation is considerable from site to site within a pasture, with the highest levels associated with high N (viz: urine-patch) sites.

In vegetative tillers of ryegrass the fungal endophyte, *Acremonium loliae*, has a similar vertical distribution pattern to the above-mentioned saprophytes, the greatest concentration being in the leaf sheath component in the pasture base. It also develops better within ryegrass at high N sites.

Grazed-pastures are not uniformly defoliated by livestock during summer and autumn — urine-patch sites are grazed more frequently and intensively and dung-patch sites less frequently and intensively than the remainder of a pasture, especially when set-stocked. The close grazing which occurs at urine-patch sites, especially in grass-dominant pastures can, therefore, contribute disproportionately to the acquisition of fungal toxins by livestock.

Observations of field outbreaks and results of grazing experiments show that the risk of outbreaks of ryegrass staggers in sheep is greater under set-stocking and during the latter stages of defoliation of a pasture in a rotational system. When necessary defoliation, especially at urine-patch sites, and hence acquisition of fungal contaminants (and toxins), can be controlled adequately by a rapid rotation in which stock are moved daily. Moving stock less frequently does not control defoliation or the development of dietary-dependent disorders.

Keywords: Pasture fungi, saprophytes, ryegrass endophyte, distribution patterns, feeding behaviour, toxin acquisition, dietary-dependent disorders, facial eczema, ryegrass staggers, ill-thrift, infertility, grazing management and control.

INTRODUCTION

Facial eczema (FE), ryegrass staggers (RGS), ill-thrift, bloat, and some infertility problems are examples of dietary-dependent disorders affecting grazing animals. The risks and severity of outbreaks of each of these disorders, except for bloat and infertility problems associated with phyto-estrogen are greater on high fertility, rye-grass-dominant pastures than on grass-legume or legume-dominant pastures (Levy and Smallfield 1942, Keogh 1973b, 1978). Grazed-pasture ecosystems of these types have been studied to gain a better understanding of the factors — soil, plant, animal, microbiological, environmental, and management — andinteractions associatedwith the aetiology and control of these disorders (Lancashire and Keogh 1964, 1966a, 1966b, 1968, Keogh 1973a, 1973b, 1973c, 1973d, 1974, 1975, 1978, 1983, 1984).

The aim of this paper is to present a perspective based on the information obtained from these studies which were mainly made in the Manawatu environment. Such information provides a rational basis for management decisions designed to minimise the risks of dietary-dependent disorders developing in livestock.

SOME CHARACTERISTICS OF GRAZED-PASTURE ECOSYSTEMS

A. Pasture growth and structure

As most of the available soil N is take up by pasture plants during spring growth, further growth largely depends, in the absence of legumes on N recycling via the animal. As the season progresses ryegrass-dominant pastures become heterogeneous, consisting of a mosaic of excreta and inter-excreta type sites: urine-patch sites support densely tillered, rapidly growing ryegrass; herbage at dung patch sites is generally unacceptable to stock and can remain ungrazed throughout summer and autumn; inter-excreta sites become N-deficient and contain relatively sparse, slower growing tiller populations (Keogh 1973a, 1983, 1984).

With the onset of dry conditions urine-patch herbage becomes conspicuous through its more rapid growth and, depending on fertility, type of stock, management, and growth conditions, may occupy up to 40% of the pasture area.

As growth rates decrease because of reduced soil-N availability, the grass at inter-excreta sites matures and becomes less acceptable to stock than faster growing grass. Unless defoliated the inter-excreta and dung patch herbage becomes progressively more mature, is susceptible to rust *(Puccinia coronata)* infection, and eventually forms part of the standing litter. Crown rust infections can greatly increase dead ryegrass leaf (Lancashire and Latch 1966).

Another major source of litter production under dry summer and autumn conditions is urine-scorched herbage. In a ryegrass-dominant pasture fresh urine scorch was recorded on more than 15% of the area after a single grazing by sheep. Mature leaf and leaf sheath not removed at previous grazings is also a major potential source of litter.

In ryegrass-dominant pastures much of the litter consists of leaf sheath material which is at the base of the pasture (Keogh 1973a, 1975).

B. Defoliation patterns

Livestock select urine-patch in preference to inter-excreta and dung patch herbage. Under continuous grazing ("set-stocking") this is expressed as a higher frequency and greater intensity of defoliation of herbage at urine-patch sites (Keogh 1973a). Under rotational forms of grazing management livestock remove a greater proportion of the material present at urine-patch than at inter-excreta sites (Keogh 1975, 1984).

The presence of white clover also has a major influence on feeding behaviour. Inter-excreta areas containing white clover are grazed in preference to similar ryegrass-dominant areas devoid of white clover (Keogh 1975).

The ryegrass present at sites containing white clover is also grazed much closer than is ryegrass at either urine-patch or inter-excreta sites. This closer grazing owing to the presence of white clover coupled with a lower ryegrass content can greatly reduce the amount of ryegrass litter produced (Keogh 1975).

C. Fungal distribution patterns

The fungal saprophtes Pithomyces chartorum (Berk. and Curt.) M. B. Ellis and Fusarium culmorum (W. G. sm.) Sacc. have similar patterns of distribution within pastures (Keogh 1973c, 1973d). Spore loads (spores present per unit dry weight of herbage) are greatest in the base of pastures on dead ryegrass leaf sheath and decrease rapidly as distance from this component increases.

The *Lolium* endophyte, Acremonium *loliae,* is generally present in higher concentration in the leaf sheath than in the leaf blade components of vegetative tillers of ryegrass (Musgrave 1984, Musgrave and Fletcher 1984, Keogh 1984). It is found throughout the reproductive tiller, albeit in concentrations lower than in the live sheath component of vegetative tillers (Musgrave and Fletcher 1984).

Marked variation exists from micro-site to micro-site in the development of both *P. chartrum* and F. *culmorum* in grazed-pastures (Keogh 1973c, 1973d). P. chartarum spore loads are generally much higher within urine-patch than other types of site throughout the summer and autumn (Keogh 1975, and Table 1). *F. culmorum* develop ment is highly stimulated by N application (urine or artifical N) and many dead ryegrass tillers at high N sites are virtually pure cultures.

TABLE 1: Mean *P. chartarum* and *F. culmorum* spore loads (spores × 10^3/g) on dead ryegrass leaf sheath from urine-patch (UP) and inter-excreta (IE) sites.

Season	Sampling duration (weeks)	Spore loads *P. chartarum* UP	IE	*F. culmorum* UP	IE
Summer	9	100	Nil	2740	5
Late summer	3	470	20	2230	85
Early autumn	3	630	110	730	20
Autumn	6	1380	a5	8220	135
Autumn	1	1000	160	3280	135

TABLE 2: Relative yields of *A.* loliae mycelium in live ryegrass leaf and leaf sheath per unit area.

SITE		
Inter-Excreta	Urine-Patch	Urea*
2.6	10.2	9.7

* Urea equivalent to 640 kg N/ha

Development of A. loliae is also stimulated by N (Table 2), comparative yields of mycelium of the endophyte being increased 4-fold within urine-patch sites and on ryegrass to which urea was applied. Higher plant component yields as well as higher A. *loliae* concentrations contributed to these results.

Development of both *P. chartarum* and F. *culmorum* is much lower on ryegrass litter present beneath a canopy of white clover than on similar substrate in a ryegrass-dominant pasture (Keogh 1974).

INVOLVEMENT OF FUNGI IN DIETARY-DPEENDENT DISORDERS

The involvement of *P.* chartarum and A. loliae in the aetiology of FE and of RGS respectively is well established and documented. To the extent that these disorders affect the health and performance (productive and reproductive) of livestock, the casual organisms will each also be associated with unthriftiness and with reproductive problems.

Ill-thrift may also result from inadequate intake. Any factor that lowers feed acceptability or utilisation, such as fungal contamination (Table 3, Davis and Norton 1978) or faecal presence (Keogh 1984), will also contribute to unthriftiness.

Some Fusarium saprophytes common in pasture ecosystems (Menna and Parle 1970, Keogh 1973c) are renowed for their capacity to produce secondary metabolites that can affect mammals (Lillehoj 1973). F. culmorum, which is very active under high N conditions in ryegrass-dominant pastures (Keogh 1973c) can produce not only trichothecenes (Ueno 1977) but also the oestrogenic compound zearalenone (or F-2 toxin) (Pathre and Mirocha 1976). Although trichothecenes produced by *F. culmorum* have not been detected in pastures, zearalenone in concentrations of up to 1.25 ug/g has been detected in samples taken from ryegrass-dominant pastures (Keogh — unpublished data). It does not follow, however, that livestock will necessarily ingest zearalenone from pasture. The evidence so far for acquisition is indirect and relates

TABLE 3: Effects of crown rust *(Puccinia coronata)* infection on acceptability of ryegrass at urine-patch sites (250 ewes/ha).

Days from start of grazing	Mean height (cm) of ryegrass	
	Rust-infected	Non-rusted
0	10.7	12.3
1	10.7	7.5
2	10.7	5.7
3	9.6	4.2
4	7.5	3.3
5	7.1	3.0
d 0.05	2.3	1.5

TABLE 4: Mean *F. culmorum* spore intakes' of sheep on ryegrass-dominant pastures.

Day	Spore Intakes*
1	110 ± 75
2	500 ± 325
3 & 4	880 ± 675

[1] spores × 10^3/g dry wgt. of ingesta.
*mean of 5 experiments + SE.

only to the intake of Fusarium-contaminated herbage (Table 4). The intake of even small amounts of zearalenone may, nevertheless, contribute to reproductive problems especially in animals that have impaired liver function (Kallela 1964) as occurs in FE. The significance of zearalenone intake on the fertility of sheep with impaired liver function needs to be determined.

TOXIN PRODUCTION AND ACQUISITION

There is a strong correlation between P. chartarum sporulation and sporidesmin production (Menna et al. 1970). Lolitrem B, a neurotoxin, implicated in the aetiology of RGS has been detected only in ryegrass containing the endophyte *A. loliae* (Gallagher et *al.* 1982a) and higher levels of lolitrem B, moreover were detected in ryegrass that had higher levels of A. *loliae* (Gallagher et. al. 1982b). If toxin production is a function of the development and activity of these fungi then toxin levels will be higher at sites where development and activity is greatest. For *P. chartarum,* F. *culmorum* and A. *loliae* in ryegrass-dominant pastures these sites are the sites of urine deposition.
assessed by spore intakes increases markedly during the second and subsequent days in the grazing off of pastures (Table 4, Lancashire and Keogh 1964, 1968). This reflects the increased consumption of basal material and espcially that from urine-patch sites.

As *A.* loliae yields are much higher at urine-patch sites (Table 2) and a much greater proportion of the ryegrass from such sites is ingested during grasing (Keogh 1975, 1984) it follows that ryegrass at urine-patch sites will also be the major source of acquisition of material contaminated with *A. loliae.*

The close grazing which occurs at urine-patch sites, especially in ryegrass-dominant pastures can, therefore, contribute disproportionately to the acquisition of toxins by livestock.

MANAGEMENT AND THE CONTROL OF DIETARY-DEPENDENT DISORDERS

The information in previous sections gives a perspective on some of the factors involved in the development of the disorders being considered. that the risks of outbreaks of the disorders occurring are higher on ryegrass-dominant pastures because the fungi involved develop better at high N sites which are also the preferred feeding sites of livestock. Two obvious aspects of control relate to manipulation of pasture composition and of feeding behaviour.

There should be no need to emphasise the importance of preventing pastures from becoming rye-grass dominant during summer and autumn. Grazing management should aim to maintain and encourage the growth of the legume components, and especially white clover, in grazed pastures. This will minimise the risks of disorders developing because fungal development (and toxin production) are reduced (Lancashire and Keogh 1968, Keogh 1974, 1975) and better control of defoliation patterns is possible where white clover is uniformly distributed throughout the pasture.

The aim of control measures using grazing management is to minimise ingestion of toxins. The basis of such control is the ability to mainpulate feeding behaviour, so that close grazing of the most dangerous sites is prevented. Because these sites are common for the disorders in question, the control measures advocated for one also apply to the others. All results of field experiments indicate that the only successful system is a form of rotational managment in which stock are moved on a daily basis (Keogh 1973b, 1978, 1983; Keogh and Clements — unpublished). No other management, least of all set-stocking, will prevent stock from regrazing (and close grazing) at urine-patch sites. This management, and other precautions, such as feeding supplements or safe crops, are necessary, especially during the most dangerous periods in summer and autumn, to ensure that dangers to stock health and performance are minimised, if not prevented.

Where RGS is a problem consideration should be given to including other grasses such as 'Grasslands Wana'cocksfoot, 'Grasslands Maru' phalaris, or 'Grasslands Roa' tall fescue in any pasture renovation programme. These cultivars perform at least as well as perennial ryegrasses under dry conditions (Lancashire and Brock 1983) and their inclusion will lessen the risks associated with pastures dominated by perennial ryegrass.

REFERENCES

Davis, F. E.; Norton, B. W. 1978. *Proc. Aust. Soc. Anim.* Prod. 12: 283

Gallagher, R. T.; Campbell, A. G.; Hawkes, A. D.; Holland, P. T.; McGaveston, D.A.; Pansier, E. A.; Harvey, 1. C. 1982a. N.Z. *vet.* J. 30: 183-184.

Gallagher, R. T.; Smith, G. S.; Menna, M. E. di.; Young, P. W. 1982b. Ibid 30: 203.204.

Kallela, K. 1964. *Nord.* Vet. Med. 16: 723.730.

Keogh, R. G. 1973a. *N.Z.* J. *exp.* Agric. *1:* 51-54.

Keogh, R. G. 1973b. Ibid. I: 55-57.

Keogh, R. G. 1973c. *N.Z.* J. agric. Res. 16: 329-332.

Keogh, R. G. 1973d. Ibid. 16: 353-355.

Keogh, R. G. 1974. Dairyfarming *Annual* pp. 59-63.

Keogh, R. G. 1975. Proc. N.Z. Soc. Anim. Prod. 35: 198-203.

Keogh, R. G. 1978. *Ibid. 38:* 47-52.

Keogh, R. G. 1983. *Proc. N.Z. Grassld. Ass. 44:* 237-240.

Keogh, R. G. 1984. *Proc.* N.Z. *Soc. Anim. Prod.* 44: 189-191.

Lancashire, J. A.; Brock, J. L. 1983. *Proc. N.Z. Gross/d. Ass 44: 61-73.*

Lancashire, J. A.; Keogh, R. G. 1964. *Ibid. 26:* 153-163.

Lancashire, J. A.; Keogh, R. G. 1966a. *Proc. N.Z. Soc. Anim. Prod. 26: 22.35.*

Lancashire, J. A.; Keogh, R. G. 1966b. *N.Z. J. agric. Res. 9:* 916-924.

Lancashire, J. A.; Keogh, R. G. 1968. *Sheepfarming Annual 14: 29.35.*

Lancashire, J. A.; Latch, G. C. M. 1966. N.Z. *J. agric. Res. 9: 628.640.*

Levy, E. B.; Smallfield, P. W. 1942. N.Z. *Jl.* Sci. *Tech. A24:* 198-214.

Lillehoj, E. B. 1973. *J. Am. vet. med. Assn. 163:* 1281-1284.
Menna, M. E. di.; Campbell, J.; Mortimer, P. H. 1970. J. gen. *Microbiol.* 61: 87-96.
Menna, M. E. di.; Parle, J. N. 1970. N.Z. J. *agric. Res. 13:* 51-68.
Musgrave, D. R. 1984. Ibid. 27: 283-288.
Musgrave, D. R.; Fletcher, L. R. 1984. *Proc.* N.Z. *Soc.* Anim. *Prod. 44:* 185-187.
Pathre, S. V.; Mirocha, C. J. 1976. *Adu. Chem. Series 149:* 178-
Ueno, Y. 1977. in "Mycotoxins in Human and Animal Health" (Eds. J. V. Rodricks, C. W. Hesseltine and M. A. Mehlman). 189-207. Pathotox Publishers Inc., Illinois, U.S.A.