Factors affecting the incidence of flystrike in sheep – a description and analysis of data from three separate areas in eastern Australia

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Summary

This paper presents a brief review of the factors affecting flystrike (cutaneous myiasis) as background to the on-going analysis of information on strike incidence, flock management, weather conditions and fly abundance in three discrete sheep grazing areas in eastern Australia (Flinders Island, Gunning and Inverell). These data were assembled in the late 1980s - early 1990s as part of a program aimed at the development of a strike management model. Information on weather, fly abundance and flock management was provided weekly by 30-40 graziers in each area over 3-4 years. Sheep data were collected using a questionnaire survey providing information on flock size, drenching practice, crutching, shearing, dagging, number of animals checked for strike, number struck in each age class and the type and method of insecticide usage.

Previous studies have assessed strike incidence on the basis of the number of animals struck relative to the number of animals in the survey. The latter figure invariably includes sheep that, by reason of recent management (e.g., shearing, crutching or jetting), are not liable to infection. The extent to which such a procedure imparts an overall bias in regional estimates of strike is unknown, but its effect between weeks at the individual flock level is often quite marked (e.g., strike incidence after jetting may decrease to 0% even though prevailing fly and weather conditions would suggest that a high proportion of sheep were still technically susceptible). Hence in order to properly assess the inherent effects of weather and fly abundance, confounding influences associated with flock management need to be removed or minimised prior to data analysis. This paper describes the methods that have been adopted to transform weekly flock numbers into estimates of the number of sheep that are susceptible to fly attack as a first stage in the process of developing a strike management model.

Keywords

Lucilia cuprina, sheep susceptibility, myiasis, strike model

Introduction

Flystrike was first recognised as an emerging problem for the Australian sheep industry in the late 1890s (Froggatt 1904). At the time the problem was thought to be related partly to a change in the behaviour of native blowflies and partly to the widespread adoption of new Vermont blood lines, which were rapidly transforming the short-wooled, plain-bodied Merino into a breed characterised by long, dense wool and extensive skin-folds, i.e. into sheep that were potentially more susceptible to fly attack (Froggatt 1915). There was also a continuing trend towards less intensive flock management, especially as sheep grazing spread into the drier pastoral areas (Graham 1979). Accordingly, it was not until the late 1920s that the real cause of the escalating problem of flystrike was identified, namely the presence and spread of a new species of blowfly, *Lucilia cuprina* (Mackerras 1930). *L. cuprina* has now reached New Zealand and, although the interval between arrival and detection was much shorter (5-10 years), the circumstances leading to its discovery were similar, i.e. a sudden upsurge in strike incidence (Heath and Bishop 1995; Bishop and Heath 1996).

L. cuprina has been implicated in the development of myiases in cattle (Wilkinson 1961) and humans (Lukins 1989), but over much of its range the species functions effectively as an obligatory parasite of sheep (e.g., Waterhouse 1947; Barton 1982; Anderson *et al*. 1984; Anderson *et al*. 1988). However, the fact that the known distribution of *L. cuprina* is more extensive than the area devoted to sheep grazing (Norris 1990) clearly indicates the species' capacity to persist in the absence of its primary host. It follows therefore that management programs that rely on minimising sheep susceptibility rather than targeting the fly are less likely to provide a lasting solution.

Strike location

Strikes can develop on most parts of the body, the key requirement being the presence of sufficient moisture to protect eggs and young larvae from desiccation (Sandeman *et al*. 1987). A number of early monographs (e.g., Seddon *et al.* 1931; Holdaway 1932; Tillyard and Seddon 1933; Belschner 1937; Mackerras and Mackerras 1944) have detailed the factors that predispose sheep to fly attack (conformation, fleece characteristics, age, etc.,) and the requirements for strike initiation (e.g., weather, moisture, fly abundance). Breech strike, associated with urine stain or faecal scouring, was recognised as the most common form of myiasis, being especially prevalent in unmulesed sheep, where dermatitis was usually an additional pre-disposing factor. Although breech strike might occur at any time during the fly season, its incidence was observed to increase during wet weather (Belchner 1937).

Other common sites for myiasis initiation are the poll and pizzle in male sheep and the udder in ewes. Foot-rot lesions and wounds associated with shearing, crutching or mulesing are also favoured sites for attack. However, it is body strike (*i.e.*, strikes to the back, withers or shoulder) that is the form of myiasis that is of most concern to graziers. Body strike is usually triggered by above average rainfall (Holdaway and Mulhearn 1934; Belchner 1937; Hayman 1953; Hayman 1955) and is commonly associated with the development of fleece-rot and/or dermatitis. Unlike other forms of strike, most of which can be minimised by judicious management (e.g., mulesing, dagging, crutching, ringing, pizzle dropping, foot paring – see Graham 1979), graziers have little opportunity to prevent body strike other than by shearing, or by the prophylactic use of insecticides. From experience, most graziers are broadly familiar with the weather conditions that are the precursor of an outbreak of body strike (fly wave). However, because a precise understanding of the mechanisms involved is lacking, few graziers are prepared to commit to the preventative treatment of their sheep. Since most strikes are covert in their earliest stage of development (Wardhaugh and Dallwitz 1984; Anderson *et al.* 1988), it is probable that by the time insecticides are applied during a fly wave, numbers of fully-fed larvae will have left the sheep and entered the soil (i.e. the ensuing generation of flies is already assured).

Effects of weather

Belchner (1937) observed that at least 100 mm of rain over a period of 4-6 weeks was required for the development of fleece-rot. However, Hayman (1953 and 1955) was the first to attempt to quantify this relationship. A systematic 5-year evaluation of weather conditions in eastern Australia, indicated that the probability of fleece-rot was high (0.89) in months in which the total rainfall exceeded 100 mm over 8 or more wet days per month. Moreover, months with a sequence of wet days seemed to be more conducive to the development of the disease than months in which daily falls were discrete. In months in which there were fewer than 8 wet days, or less than 100 mm of rain, the probability of fleece-rot fell sharply (0.21), and where neither of these conditions was fulfilled, fleece-rot did not occur. Unfortunately, comparable information is lacking about the role of rainfall in the development of dermatitis, which is also an important pre-disposing cause of strike (Gherardi *et al*. 1983).

Wardhaugh and Morton (1990) have attempted to use Hayman's fleece-rot analysis to examine the occurrence of flystrike in the Shoalhaven Valley, near Braidwood. They concluded that there was a positive relationship between strike incidence and fly abundance and that body strike was more predictable than crutch strike. Overall levels of strike increased as monthly rainfall increased, and frequent small falls of rain were found to be more conducive to strike initiation than occasional heavy falls. Other factors, including pasture growth and cloud cover, were also implicated in promoting strike. There was also evidence of strong auto-correlation, with strike in week (n-1) being a good estimator of strike in week n. The combination of weather, fly abundance and pasture growth accounted for 76% of the observed variance in body strike and 58% of that for crutch strike. The latter replaced body strike under dry conditions and also when fly densities were low (<0.5 gravid females h^{-1} $trap^{-1}$) regardless of past weather conditions. This latter finding was interpreted as signifying the existence of a threshold fly population for strike initiation, *i.e.*, when low fly numbers coincided with large numbers of susceptible sheep (e.g., during periods of wet weather), the chances of multiple oviposition (and hence strike initiation) were likely to be diminished as compared with occasions when fly numbers and the number of susceptible sheep were both low. In these circumstances, the few gravid flies that were present would be induced to aggregate because of the small number of susceptible animals.

In more recent studies, McLeod (1997) applied time-series analysis to long-term records of flystrike in western New South Wales (see also McLeod and McLeod 2001) and showed that strike incidence was positively correlated with both fly abundance and rainfall during the preceding month. Ward (2000) also used time-series analysis to examine the occurrence of blowfly strike in 247 flocks in Queensland between 1993 and 1999. Variations in the proportion of animals struck were best explained by an auto-regressive model that included strike incidence during each of the preceding two months. The model was improved by including either radiation, or a lagged estimate of the Southern Oscillation Index (SOI) but, unlike the studies of McLeod (1997) and Wardhaugh and Morton (1990), there were no significant effects due to temperature or rainfall. However, if it is accepted that strike is an expression of the integrated effects of fly abundance, weather variables and sheep susceptibility, then the removal of effects due to strike in months n-1 and n-2, will also be effective in removing much of the effect normally attributable to weather, in particular rainfall.

In each of the above analyses of flystrike, strike incidence was calculated on the basis of the number of sheep reported struck compared with the total number of animals in the flock. However, in order to properly examine the inter-relationships of strike, weather and fly abundance, it is important to minimise the potentially confounding influences of management practices, such as shearing, crutching and jetting, all of which reduce the susceptibility of sheep to fly attack. For example, spring in the Southern Tablelands of New South Wales is normally a time when flies are present and weather conditions are favourable for a high incidence of strike (Wardhaugh and Morton 1990). However, the fact that most graziers shear their sheep at this time of the year means that many sheep are less liable to be struck than might otherwise be the case. When analysing the data for an individual flock, it is relatively easy to allow for the intervention of management effects by simply including a regressor variable such as ‘numbers with foot rot’ or ‘days since shearing or jetting’ (Wardhaugh *et al*. 1989). But in large-scale, regional studies of flystrike of the kind described below, management activities between farms are rarely synchronised and cannot be allowed for so easily.

Flystrike surveys in Shoalhaven, Gunning, Inverell and Flinders Island

In the late- 1980s and early- 1990s CSIRO Entomology conducted a series of studies on flystrike in several discrete geographical areas in south-eastern Australia. Some of these (e.g., the Flinders Island and Shoalhaven Valley projects, (Mahon 2001) were also designed to provide data on fly abundance and flystrike before and after the implementation of genetic control; the others (Gunning and Inverell) were a follow-on from the encouraging results obtained from an analysis of the Shoalhaven data (Wardhaugh and Morton 1990) and were intended to provide a basis for developing a strike management model. Unfortunately, analysis of these data was barely underway, when a lack of funds brought about the abrupt demise of Entomology’s blowfly program in 1994. Because of the growing costs of scientific research and the declining pool of research funding, it is vital that efforts be made to extract, analyse and synthesize the important information that these large data sets contain. This paper describes the type of data that are available and reports on the limited progress that has been made with its analysis. It also outlines what further analyses are required to ensure a useful return to the grazing industry.

Methods

Study areas

Shoalhaven Valley - Data on strike incidence and fly abundance for the Shoalhaven (149°50´E : 35°30´S) were assembled over a 4-year period (1981-84) on some 20-40 properties in the upper reaches of the valley. These data have been described and analysed elsewhere (Wardhaugh and Morton 1990), but attempts to allow for management effects were limited by the nature of the information collected. Nevertheless, these records would be useful for model evaluation.

Flinders Island - Data are available for 40-50 graziers on Flinders Island, Bass Strait (148°00´E : 40°00´S) from September 1987-May 1991.

Gunning and Inverell - Surveys were conducted from April 1991-May 1993 and involved 25-35 graziers in the Gunning area (149°15´E : 34°50´S) and 50-57 graziers around Inverell (151°10´E : 29°45´S).

Data collection

In each area, strike incidence was monitored via a weekly questionnaire and provided information under the following headings:

- Date, property name, grazier's name,
- Number of sheep on the property,
- Number of sheep checked during the past week in each age class (ewes, wethers, hoggets, lambs and rams),
- Number and types of strike (crutch, pizzle, back, flank, belly, head, foot, other) found in each age class,
- Flock management during the past week in each age class (crutching, shearing, mulesing, drenching, jetting, marking, foot-vax, or other),
- Chemicals used during flock management over the past week,
- Weekly rainfall and,
- Other information.

In Gunning and Inverell, a data logger was used to provide hourly weather data at a meteorological station located centrally in each survey area. Grids of wind-oriented fly traps were used to monitor fly populations and, depending on the number of flies caught, a sample of 50 females was dissected each week to provide information on population age structure. Similar procedures were used to monitor weekly fly populations on Flinders Island, except that sampling was done with West Australian fly traps. Weather data were collected from two sites, one in the north of the island, the other in the south.

Data processing

All data relating to weather, fly abundance and sheep husbandry in each study area are now available in electronic format, but detailed analysis of the data is still at a preliminary stage (see below). Sheep data from each week and property have been processed to allow strike incidence to be calculated as a proportion of the number of sheep considered potentially susceptible as distinct from the total number of sheep on the property. The functions used to make these adjustments were as follows:

- Sheep that had been recently shorn or crutched were assumed to be non-susceptible for the first 30 days post-shearing or crutching, increasing linearly to 100% susceptible over the ensuing 30 days.
- A similar procedure was used in respect of insecticide treatment, but only when this involved the treatment of entire mobs. The form of the function varied according to the insecticide applied and, when this was not reported, it was classified in the 'All others' category (Table 1).

Table 1. Protocols for estimating the proportion of sheep that was potentially susceptible to flystrike following jetting with various insecticides.

Product	Period of full protection	Day on which zero protection is reached
Vetrazin	84	112
Sectar	56	84
Ectomort and Seraphos	28	56
All others	21	42

Flock data from Gunning, Inverell and Flinders Island have all been processed to remove effects due to shearing, crutching and jetting, but the output has yet to be verified. The Shoalhaven data are considered to have too many gaps to warrant such treatment.

Sample results

Female age structure

Data on female age structure for Gunning during the year 1992-1993 are presented in Figure 1. Depending on the number of females caught, a weekly sample of up to 50 females was dissected. Most of the females examined on the first few trapping occasions contained pupal fat and thus were newly emerged. The proportion of females with yellow bodies (parous females) increased sharply during late October and continued at a high level throughout the season. In contrast, the proportion of gravid females rarely exceeded 10%.

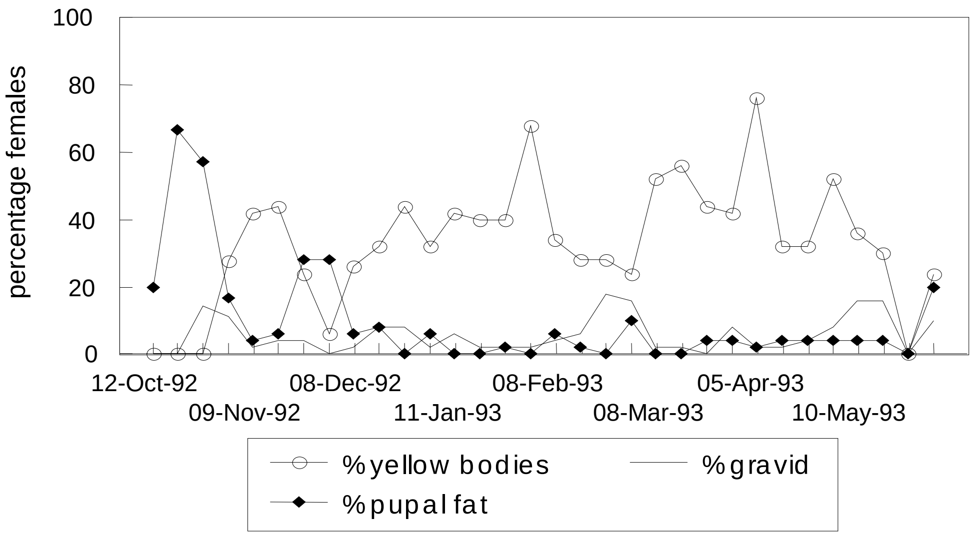

Figure 1. Percentage of newly emerged females (solid diamonds), parous females (open circles) and gravid females (solid line) of *L. cuprina* in the Gunning area during the period October 1992 – May 1993.

Sheep susceptibility

Data on the numbers of sheep surveyed at Inverell during 1990-91 are shown in Figure 2, together with the estimated number of animals that were considered liable to body strike after allowances were made for sheep that had been recently shorn or jetted. By week 28 (mid-October), the number of animals considered susceptible to fly attack was roughly half the total sheep in the survey. In that week some 437 sheep were reported struck, which equates to a strike rate of 0.34% when related to the total number of sheep in the survey, but 0.59% when measured against the number of sheep that were considered susceptible to attack. The potential to underestimate the incidence of strike is clear.

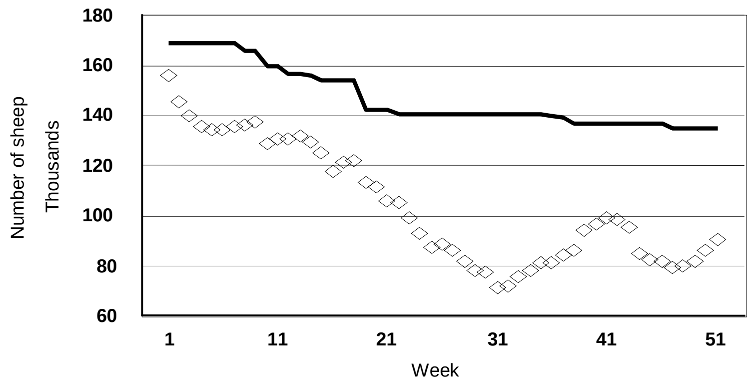

Figure 2. Total numbers of sheep (solid line) and estimated number of animals potentially susceptible to body strike after allowing for jetting and shearing (open symbol).

Strike incidence versus proportion of graziers reporting strike

Figure 3 shows the relationship between the mean weekly strike and the weekly proportion of graziers reporting strike in each of the four study areas and periods. The relationship appears to be very consistent between areas and years and suggests that surveys of the weekly proportion of graziers experiencing strike will provide a reasonable estimate of strike severity. The form of the response is suggestive of density dependence.

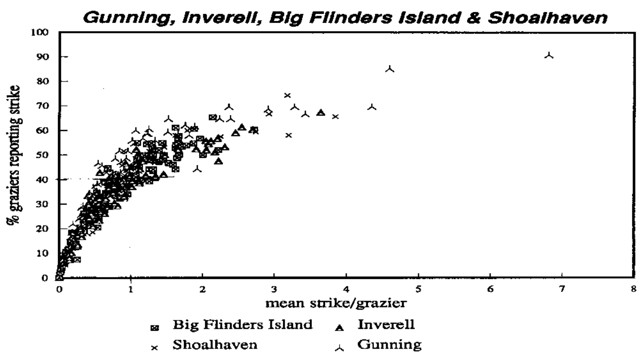

Figure 3. Relationship between mean number of strikes per week and proportion of graziers reporting strike.

Conclusions

The data sets available for the Shoalhaven valley, Flinders Island, Gunning and Inverell are a veritable mine of information on the biology and ecology of *L. cuprina.* They also contain important information about strike incidence and sheep husbandry in areas of disparate climate, vegetation and flock management. Although much of the assembled husbandry information may now be dated, it is certain to be useful to those interested in tracking historical changes in management practice. However, by far the most important aspect of the data is its potential to elucidate the causal relationships between weather, fly abundance and strike incidence and to provide a sound basis for the development of a strike management model.

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