EFFECT OF SHELTER ON PLANT AND ANIMAL PRODUCTION

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SUMMARY

Shelter may substantially increase the productivity of livestock by increasing the supply of pasture and/or by mitigation of environmental stress. Shelterbelts, individual and clumps of trees may also counter erosion and salting that are major hazards to agriculture. Fodder trees and timber producing species could provide other benefits in shelter systems.

Mortality of lambs can be reduced by 50% if effective shelter is provided; development of practical systems is required. Shelter for newly shorn sheep is essential in southern Australia and particularly where sheep are shorn in winter.

Exposure to cold increases maintenance energy costs. Conversely, exposure to heat may restrict feed intake and reduce productivity. There is a dearth of information on the effect and economic benefit, in Australia, of various types of shelter on the productivity of pasture, cattle and sheep.

SHELTER AND PLANT GROWTH

Overseas studies have demonstrated that pasture and crop yields in a zone extending at least 10 heights (H) to the lee of a windbreak are about 30% greater than in unsheltered areas of the field (Cabom 1957; Sturrock 1981; Radcliffe 1983). A negative effect occurs within c. 1 H of a living shelterbelt due to shading, interception of rain and competition for soil moisture. The beneficial effects of shelter occur mainly in drier climates and when the soil is below field capacity (Marshall 1967; Lynch et al. 1980a; Radcliffe 1983). Pasture growth may be prolonged after an early 'break' and at the end of spring. Without shelter high wind speeds increase the evaporative demands on the plant and water stress may occur, even when irrigation is used. Stomata1 closure then reduces transpiration, photosynthesis and plant yield (Sturrock 1982). Mechanical damage to tissues also occurs at higher wind speeds and causes production losses (Sturrock 1978).

The only Australian study on the effect of shelter on the growth and productivity of animals and pastures is that of Lynch and Donnelly (1980) at Armidale. At the highest stocking rate (SR) wool production was increased by a mean of 31% over 5 years. Responses at lower SR were less. Sheep live weights were also greater on sheltered plots, particularly at the highest SR (6 kg), and in years of poor pasture growth at the low SR. Intake of metabolisable energy from pasture at the highest SR was estimated to be 18% greater on sheltered plots, while the amount of feed available remained constant i.e. any extra pasture grown was consumed.

To increase pasture productivity windbreaks should be tall, moderately but uniformly permeable from base to top, width/H <5, length >12 H, and be placed transverse to prevailing winds at intervals c. 25 H (Caborn 1957). In New Zealand one farmer estimated that farm productivity increased by 20% when effective shelter occupied c. 5% of the farm (Radcliffe 1983).

SHELTER AND THE ALLEVIATION OF ENVIRONMENTAL STRESS

Cold stress in sheep Death of newborn lambs from exposure in southern Australia is commonplace; perhaps 15% of all lambs born (Arnold and Dudzinski 1978). The newborn animal has a large surface/mass ratio, poor insulation and small energy reserves. Alexander (1962) has indicated that a wet lamb exposed to windy conditions (20 kph) could become hypothermic at 13^{o}C ambient temp., but in still air only at –4^{o}C. On Kangaroo Island, Obst and Ellis (1977) found that mortality exceeded 70% when the wind run was >18 kph and rainfall >1.5 mm in the first 6 h, but

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losses were only 5-10% when no rain fell and the wind run was 0-8 kph. Alexander et al. (1980) have shown that protection from wind during periods of rain with temp. <5°C gave an increase of 27% in survival of single lambs but was of no advantage to twins. Donnelly (1984) has also shown that exposure during the first 3 days is the major cause of lamb losses. He has developed a model with a chill index (rainfall, mean temp. and wind speed) and other variables to predict lamb mortality, and this shows that, e.g. if wind speed is reduced (by dense shelter) from 10 to 2.5 m/s, lamb mortality in cold or wet weather is at least halved.

The amount of shelter needed will depend on the climate, topography and the lambing system. An intensive system (e.g. Egan et al 1976) may employ only 4 ha/ 1000 ewes during the critical period. An extensive system requires more shelter as ewes will not seek it unless recently shorn (Lynch and Alexander 1980) thus exposing their lambs unless shelter is nearby. Desertion of lambs up to 3 d old by ewes moving to distant shelter or the flock is a danger when the wind run is >18 kph together with >2 mm rain within the hour (Obst and Ellis 1977; Lynch unpubl.). Suitable dispersed shelter may be provided by retaining tall native Poa tussocks, or by planting rows of dense shelter (shrubs or grass) 10-15 H apart, transverse to the prevailing winds (Lynch et al. 1980b). The effect of topography, or clumps of trees, on wind velocity and sheep behaviour has not been defined. Published work indicates that effective shelter could reduce lamb mortality by 50% (Table 1).

TABLE 1 Per cent lamb mortality to 48 h in unsheltered versus sheltered areas

Reference	Shelter	Location	Duration (years)	Single born	Multiple births
Egan et al. (1972)	Cypress	Hamilton	1	19 vs. 6	27 vs. 13
Egan et al. (1976)	Phalaris	"	4	12 " 9	33 " 19
McLaughlin et al. (1970)	Cypress	"	2	13 " 7	25 " 12
Watson et al. (1968)	Shed	Caramut	1	21 " 8	60 " 24
Alexander et al. (1980)	Phalaris	Armidale	5	17 " 9	51 " 36
Lynch & Alexander (1977)	Sarlon mesh	"	1	11 " 5	68 " 31

Losses of sheep from exposure can occur up to 14 d after shearing, particularly with sheep that lost weight rapidly before shearing (Hutchinson and McRae 1969). The national loss is c. 0.7% p.a. (Hutchinson 1968). Severe losses can occur, as on 21 Mar. 1983 in S.W. Victoria when c. 30,000 sheep died in wind of 32 kph, mean temp. 16°C and rainfall 42 mm. A third of the losses were associated with the export of live shorn sheep. On 7 Dec. 1982 c. 50,000 sheep also died when the mean wind run was 32 kph, mean temp. 11°C and rainfall 21 mm. In one case sheep shorn 8-11 days earlier and protected by shelterbelts survived but losses of unsheltered shorn sheep averaged 11%. Deaths in a group of 104 large-frame Comeback ewes were 35% for those in poor condition (score 1-2 , 80% weighing <50 kg), and 13% for those in good condition (score 3-4 , weight >50 kg). A simulation model (Graham et al. 1976) predicts that the critical temp. for a 17.5 kg lamb exposed to the above conditions is 25°C and the rate of metabolism required for homeothermy is c. five times maintenance, with a fat loss of 115 g/d. Some sheep, and others that are acclimatised, can maintain a summit metabolism (>6 times basal) for long periods, at least while body fat reserves exceed c. 3% of body weight (J. Black pers. comm.). Acute cold stress may cause death from adrenal depletion (Panaretto 1967), and it can depress feed intake after shearing (Donnelly et al. 1974) so that prolonged exposure is likely to cause many more deaths.

Cold stress affects growth and wool production. Elvidge and Coop (1974) estimated that energy requirements in winter (mean temp. 7-10°C) increased by c. 46% for housed sheep and c. 78% for unsheltered sheep subjected to 81-128 mm rain and mean daily 7-10 kph wind run. To maintain energy balance feed intake would need to double when wind speed increased from 0-30 kph (Black and Bottomley 1980). Wool production is often increased by mild cold stress, probably in response to increased intake (Bottomley 1979). Severe cold stress may depress wool growth (Hopkins and Richards 1979). Grazing sheep seek shelter when cold and need to adjust grazing behaviour. Grazing time is reduced but they may eat faster to compensate. On cold wet days shorn sheep in poor condition (or at high SR) graze little. However shelter. provided by long dry grass to sheep at low SR enabled almost uninterrupted grazing (Arnold and Dudzinski 1978). The model of Graham et al. (1976) enables a prediction of the effect of cold stress on grazing sheep, e.g. at 5-15^{o} C the predicted growth rate of a freshly shorn 17.5 kg lamb given 1 kg/d of white clover is 260 g/d in still air but only140 g/d in wind of 10 m/sec.

Cold stress in cattle Cows graze less on very cold days than on warm days (>5^{o} C) but may compensate later by eating more rapidly, unless pasture quantity or quality is limiting (Arnold and Dudzinski 1978). Provision of shelter on treeless veld in South Africa increased cattle productivity (Arnold and Dudzinski 1978), but McCarrick and Drennan (1972) in Ireland found no effect of shelter on gains of Friesian steers in pens. In New Zealand Holmes et al. (1978) found that heat production in dairy cattle was increased only in wet windy conditions when the insulation of the coat was reduced. The liveweight gain of sheltered heifers was 3.6-7.2 kg (mean 31%) greater during the 44-54 day period. Possibly the muddy conditions contributed to the result since cattle kept in muddy pens during winter in California grew at 1.0 vs. 1.3 kg/d for cattle kept on concrete floors (Morrison et al. 1970). The effect of shelter on milk production of dairy cattle in cold, wet, windy weather is well established (Ames and Ray 1983).

Heat stress in sheep Excessive heat reduces wool growth by reducing feed intake. Shorn sheep without shade are more affected by radiation and high temps. than are fleeced sheep with at least 40 mm staple (Bottomley 1979). It is unlikely that significant effects of heat loads on grazing fleeced sheep occur in temperate areas or among acclimatised sheep in the tropics. Heat stress may affect the embryo, the foetus in late pregnancy and the development and maturation of secondary follicles (Hopkins and Richards 1979). Heat also affects ram fertility (Smith 1971), ovulation rate, oestrous duration and conception in females (Ames and Ray 1983), and the provision of shade is desirable. Newborn lambs deprived of shade in the sub-tropical summer are prone to heat stress. When shade is available the behaviour of the ewe assists the survival of the lamb (Arnold and Dudzinski 1978). Sheep may die if left in unshaded yards or trucks on very hot days when there is little air movement.

Well developed shelterbelts can reduce wind velocity to c. 25% of open values and in Victoria have shielded livestock from rapidly advancing grass fires (Bird 1981). This effect of windbreaks on stock survival is not widely appreciated.

Heat stress in cattle Milk production in unshaded dairy cattle is depressed by high temp. and radiant heat loads, particularly when there is little wind to dissipate body heat (Johnson 1965). Heat stress reduces feed intake, nitrogen retention and liveweight gain more in European than in Brahman cattle (Kellaway and Colditz 1975). Heat affects gains of feedlot cattle in Arizona (Ames and Ray 1983) and in Louisiana differences in the daily gains of cows and calves grazing with or without shade were 0.6 and 0.3 kg respectively (McDaniel and Roark 1956). Effects of shade were also recorded in California by Garrett et al. (1960) and in Kansas by McIlvain and Shoop (1971). The distribution of shade is important as cattle can continue grazing whilst shaded; artificial shade is not always effective (Arnold and Dudzinski 1978) especially when it restricts air flow and radiant heat loss.

CONCLUSION

Energy expenditure increases with extremes of heat or cold (Ames and Ray 1983). Shelter can improve animal productivity by reducing this energy loss, increasing plant growth, and reducing sheep mortality. For example, lamb weaning % may be increased by 10 units, a gain of c. $2000 from 1000 ewes, sufficient in 2 years to recover the cost of the shelter. Farmers and scientists in Australia are generally ignorant of, the effects, uses and benefits of trees in agriculture.

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