An Evaluation of Barrel Medic (*Medicago truncatula*) as an Introduced Pasture Legume for Marginal Cropping Areas of South-eastern Australia

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Highlight: *The potential of barrel medic (*Medicago truncatula*) as a possible improved pasture legume for introduction to marginal cropping areas was examined with breeding Merino ewes at four stocking rates. Although the dry matter production was similar to that of natural pasture, the proportion of barrel medic, ranging from 5 to 30%, was higher than that of naturalized medics in adjacent natural pasture areas. However, although barrel medic persisted in the pasture under all stocking treatments, it was unable to compete with barley grass (*Hordeum leporinum*), which invaded the pasture soon after establishment. While the pasture could support 5 ewes per hectare under favourable seasonal conditions with only moderate supplementary feeding in winter, it could not adequately support any stocking rate under drought conditions without considerable supplementary feeding.*

Annual wool production per head declined significantly with increased stocking rate and adverse seasonal conditions. Stocking rate did not affect lamb growth rates, but drought caused a high lamb mortality rate. The usefulness of barrel medic at Trangie is questionable, since it did not significantly improve either carrying capacity or lamb growth rates above that of natural pasture. At the same time, lucerne pastures under rotational management were able to support higher stocking rates and improve lamb growth above those of either barrel medic or natural pasture.

In areas of low rainfall throughout the world, new plants are usually introduced into existing pasture because they are expected to increase total production, or because they are considered "more desirable" species. A number of grasses and legumes have been recommended for improving "Mediterranean type climate" rangelands in California (Miller et al., 1957; Williams, 1963) and southern Australia (Trumble, 1949; Morley, 1961; Andrew, 1962). The term "rangeland" in the Australian context is used to designate arid and semiarid areas unsuitable for cropping activities because of inadequate rainfall (Perry, 1966). However, the definition does not make for a static boundary between arid and nonarid country, since the economics of crop production alter with changes in technology, cultivars, costs of production, or the value of the product (Box and Perry, 1971). Thus, the boundary between arid and nonarid land fluctuates in response to such changes.

The 300-to 480-mm rainfall zone of central western New South Wales (Fig. 1) is one such marginal cropping area, where farmers have endeavoured to grow grain as far as possible into the semiarid pastoral areas. This has been accomplished by the integration of cereal grain cropping (mainly wheat) and animal production activities as suggested by Rossiter (1966) for Mediterranean-type environments.

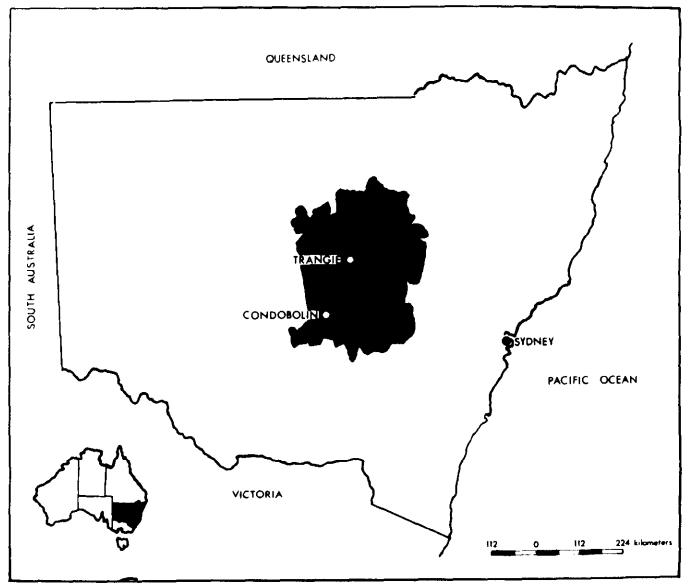

Fig. 1. *Map of southeastern Australia showing the location of central western New South Wales and the Trangie Experimental Site.*

The expansion in wheat acreages in this low rainfall belt has encouraged a similar expansion in pasture improvement.

In most areas legumes are desirable for introduction to natural pastures because they produce high quality feed, are readily acceptable to grazing animals, and increase soil nitrogen. Although the naturalized medic *Medicago minima* is widespread in the central west of New South Wales (Andrew and Hely, 1960), an improved legume is desirable because *M. minima* is not highly productive and does not contribute significantly to soil nitrogen (Purchase, et al., 1949). Furthermore, *M. minima* pods become entangled in wool because of

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their spiny nature. Therefore the replacement of the species could boost the quality of the wool produced in this region.

In higher rainfall areas of southern Australia, subterranean clover (*Trifolium subterraneum*) has been a successful legume introduction, but it is not suited to the alkaline soils and low, erratic rainfall of the central western region. To date the only improved species which is widely sown in the area is lucerne (*Medicago sativa*). However for maximum productivity and persistence, lucerne must be carefully, rotationally grazed in this environment (Peart, 1968). Prior to this experiment it appeared that the only possible alternative was barrel medic (*Medicago truncatula*) as it has been recommended for dry areas with short growing seasons (Amor, 1965; Scott and Brownlee, 1970) and has performed well under grazing at Condobolin (Brownlee, 1973) and in Western Australia (Halpin and Nelson, 1965; Parkin, 1966).

This paper reports the results of an experiment conducted at Trangie between 1970 and 1972 to determine the effect of stocking rate on animal and plant production from a Jemalong barrel medic pasture. Optimum stocking rate and lamb production are compared with results from other types of natural and improved pastures in central western New South Wales.

Environment

Trangie Agricultural Research Station is situated on the riverine plain of the Macquarie River in central western New South Wales (31° 59′ S, 147° 57′ E) (Fig. 1).

The region has a mean annual rainfall of 480 mm which, although fairly evenly distributed throughout the year (Table 1), has a tendency to be higher in the late summer months of January and February. However, variability between and within seasons is high. For example the rainfall for February, March, and April recorded over 89 years has an average coefficient of variation of 118%. The lowest variability occurs in winter with an average coefficient for June, July, and August of 77%.

Table 1. Monthly rainfall (mm), effective rainfall (mm), and temperature (°C) at the Agricultural Research Station, Trangie, N.S.W.

Month	Temperature Min.	Temperature Max.	Effective rainfall*	89 year average rainfall +	Rainfall during experiment + 1970	1971	1972
January	17.8	32.5	69	49	**81**	**112**	**110**
February	16.2	31.2	59	49	23	**66**	29
March	15.5	28.4	52	47	**57**	11	4
April	11.0	25.3	40	38	**43**	9	3
May	6.6	18.7	28	**36**	25	7	25
June	4.4	16.1	22	**40**	14	7	12
July	2.8	14.8	23	**35**	1	**50**	7
August	4.1	16.6	27	**36**	**36**	**68**	24
September	6.4	19.9	36	31	**81**	32	7
October	10.1	24.3	43	40	**74**	9	26
November	11.8	29.4	57	41	15	**80**	39
December	15.9	31.5	67	37	64	43	19
Total					514	494	305

*$P = 0.544\ E^{0.7}$ (calculated for evaporation in inches, then converted to metric).
+Months receiving effective rainfall or more, indicated in bold type.

Summer temperatures are high and relative humidity low, consequently evaporation rates counter the higher amount of summer rainfall. Conversely, effective rainfall (based on Prescott's ratio) occurs in the May–August period when evaporation is low.

Frosts are common during winter with minima below freezing regularly occurring in June, July, and August, and sometimes in September and early October. Thus although winter is the period of effective rainfall, low temperatures limit the growth of most pasture species.

The experimental site of 17 hectares was located on an alluvial red-brown earth (Downes and Sleeman, 1955) with surface pH of 6.0–6.5, increasing to 8.5 with depth. Soil fertility as indicated by available phosphate measurements was medium (24 ppm).

Before the establishment of barrel medic, the experimental site consisted of natural pasture dominated by cool-season annuals, particularly *Medicago* spp. (naturalized medics), barley grass (*Hordeum leporinum*), silver grass (*Vulpia myuros*), and blue crowfoot (*Erodium crinitum*). Warm-season annuals occur in summers of above-average rainfall, particularly Heliotrope (*Heliotropium europaeum*), dwarf amaranth (*Amaranthus macrocarpus*), and caltrop (*Tribulus terrestris*). Perennial grasses, particularly *Chloris acicularis* and *C. truncata*, are still a pasture component when spring and autumn rains promote growth.

Experimental Methods

The experiment was a completely randomized design with each of four treatments twice replicated. The treatments consisted of stocking rates of 3.1, 4.3, 5.6, and 6.8 ewes/ha. Each flock contained eight sheep, with the plot size varying with stocking rate.

The barrel medic pasture cv. Jemalong studied in this experiment was sown in May, 1968, at the rate of 2 kg/ha under a cereal cover crop. At the commencement of the experiment in 1970, the pasture consisted of barrel medic, naturalized medics, barley grass, and a variety of broadleaf species. Since it is not a common local practice to fertilize pasture, no fertilizer was applied to plots during the course of the experiment.

The amounts of total plant (including litter) and available green material, and botanical composition were estimated within each treatment at intervals of about 4 months. A visual estimation technique, similar to that outlined by Morley et al. (1964), was employed with five independent observers each estimating ten randomly thrown quadrats and two standard quadrats.

At the end of summer each year, a suction harvester was used to collect the ground surface material from ten randomly thrown quadrats (0.4 m x 0.4 m) per plot. Barrel medic pod was weighed after being separated from trash.

At the conclusion of the grazing experiment, the area was sown with wheat in order to assess the effective contribution of the pasture to the levels of total soil nitrogen and its possible effects on grain yield.

The experimental animals were selected from a flock of Merino ewes born in spring 1966. They were allocated to each paddock by stratified randomization based on hogget wool production and body-weight. A flock of spare animals was maintained on the same pasture type to replace animals that died during the experiment. The results from replacement animals were not included in the analyses.

The sheep were weighed at six weekly intervals, and at each weighing three sheep within each group were dye banded on the midside to allow wool production per six weekly period to be calculated. After annual shearing in October, clean wool production per sheep was calculated from greasy fleece weight and yield of a midside sample. Corrected liveweight was calculated by subtracting the accumulated greasy fleece weight from the recorded liveweight.

At the completion of lambing, ewes were re-randomized to equalize the number of lambs per paddock. Lambs were weighed at birth and at six weekly intervals until weaning. Routine management practices were employed: shearing in October, mating in March, crutching in May, lambing in July, weaning of lambs in November, and hoof-trimming, jetting, and treatment for fly-strike as required.

In order to avoid unrealistic stress on the ewes, hand-feeding commenced when mean liveweight of any ewes in a treatment plot fell below 45 kg. Feeding was continued on both replicates until pasture was sufficiently plentiful to sustain both ewes and lambs. The ration consisting of hay during 1971 and oats grain (with limestone) during 1972, was fed at 9 megajoules metabolisable (MJ ME) energy per day for pregnant ewes and 13 MJ ME per day for ewes with lambs. Records were kept of the amount of feed fed and the period over which feeding occurred on each treatment (Table 2).

The data were analysed by analysis of variance. The percentages of barrel medic and barley grass of the available green material at each date of measurement were transformed to arcsin for analysis.

Table 2. Amount (kg/head) of oats and hay fed to ewes grazing Jemalong barrel medic.

	Quantity fed at stocking rates of								
	3.1		4.3		5.6		6.8		Feeding
Year	Oats	Hay	Oats	Hay	Oats	Hay	Oats	Hay	period
1970	0	0	0	0	0	0	0	0	June-Aug.
1971	0	26.8	0	58.1	0	67.7	0	99.9	June -Aug.
1972	66.3	0	66.3	0	66.3	0	83.3	0	June-Oct.

Results and Discussion

Pasture Production

Pasture availability was reduced by stocking rate, with both total dry and green material lowest in the 6.8 ewes/ha treatment on most of the sampling occasions (Fig. 2). Season caused wide variation in available pasture, with production increases occurring in the autumn and spring periods. In the drought year (1972) pasture yields were small, with overall production being reduced to the 300-kg/ha levels that Williams (1960) indicated would result on marginal areas of improved pasture in seasons of poorly distributed or low rainfall. However, seed production, together with hard seed stored from the previous year, was sufficient to ensure persistence under the high stocking levels and adverse weather conditions (Table 3). Also, the amount of pod lying on the ground surface during late summer showed little dependency on stocking rate, but there was a marked decline in pod reserves with time from the average 799± 73 kg/ha at the commencement of the experiment. However, pods were probably a valuable source of feed, since protein levels of 18% or higher have been reported (Franklin and Downing, 1942; Vercoe and Pearce, 1960). This probably acted as a supplement to standing feed, although the expected increase in pod removal with increased stocking rate (Amor, 1965) may not have occurred because of a combination of increased pod consumption per head at the lower stocking rates and powdering of the soil surface at higher stocking rates, thus rendering soil covered pod unavailable to stock. This contributed to the persistence of barrel medic during the course of the experiment.

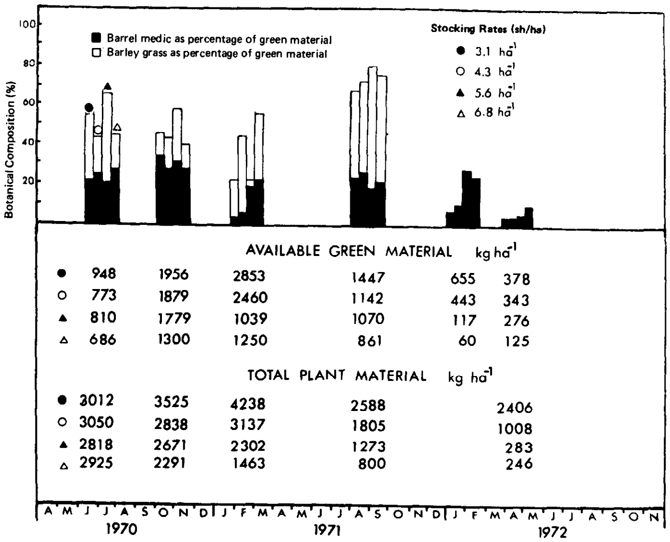

Fig. 2. *Botanical composition, available green material, and total dry material for each stocking treatment.*

Table 3. Barrel medic pod (kg/ha) lying on the surface during late summer and barrel medic plant density at the end of experiment, March 1973.

Stocking rate rate (sheep/ha)	Pod 1970	Pod 1971	Pod 1972	Plant density[1] (no./m²)
3.1	908	484	374	42.4 a
4.3	725	316	315	32.5 b
5.6	740	381	491	27.3 b
6.3	815	398	370	28.2 b
Significance of stocking rate effect[2]	NS	NS	NS	*

[1] Means followed by the same letter are not significantly different at $P < 0.05$.
[2] NS = not significantly different at $P < 0.05$, * = significantly different at $P < 0.05$.

Botanical Composition

The proportion of barrel medic in the pasture varied with season and year (Fig. 2). During the winter-spring of 1970, barrel medic accounted for 30% (by weight) of the green pasture while in adjacent plots of natural pasture only 6% of naturalized medics was measured. Similarly, in the dry winter-spring period of 1972 while the contribution of barrel medic fell to about 5%, the proportion of medic in natural pasture was less than 1%. Thus the sowing of barrel medic substantially increased the legume component of the pasture, confirming results reported by Brownlee (1973).

Annual winter species made a major contribution to the pasture, particularly during 1970 and 1971 when the barley grass component ranged from 20 to 80%. Although barley grass is highly acceptable to sheep when young and vegetative (Leigh and Mulham, 1966), at flowering the nutritive value declines rapidly and the long barbed awns of the inflorescence can cause substantial losses in sheep productivity. Barrel medic was not aggressive enough to successfully compete with barley grass under favourable seasonal conditions. In 1972 the barley grass component was small, but broadleaf species (mainly Paterson's Curse–*Echium plantagineum*) was high. The change in botanical composition may have been due to the low litter component, which is important in creating favourable micro-environmental conditions for the germination and establishment of barley grass (Campbell and Beale, 1973). In contrast, broadleaf species are relatively independent of surface mulch for germination and establishment (Evans and Young, 1970).

Soil Nitrogen

By the end of the experiment in November 1972, an increase in total soil nitrogen caused by fixation by legumes was noted in the upper 0- to 30-cm layer of the soil. At lower stocking rates, however, the increases were greater than those at the highest stocking level (190 and 90 ppm, respectively). All plots were cultivated at the conclusion of the stocking rate experiment and sown to wheat, but there was no statistical difference in yield as a result of the different soil nitrogen levels.

Animal Production

The key to economic pasture utilization lies in the proper assessment of an optimum stocking rate (Chisholm, 1965), hence the aim of the experiment was to arrive at an approximate carrying capacity for barrel medic for the Trangie environment. Under favourable conditions (1970) the pasture was productive enough to support breeding ewes at all the stocking rates examined. However, when drought (1972), or periods of unevenly distributed rainfall (1971) were encountered, pasture growth was inadequate to support ewes even at the low stocking rate without supplementary feeding (Table 2). As a result of decreases in available pasture with increased stocking rate and adverse seasonal conditions (Fig. 2), corresponding declines in annual clean wool production per head were observed (Table 4). Furthermore, Figure 3 shows that daily wool growth rate was most affected in the winter period when ewes were pregnant and green pasture scarce. While the highest stocking rate of 6.8 ewes/ha produced the greatest wool per hectare, the results were countered in "bad" seasons by the large amount of supplementary feeding required.

Table 4. Clean wool production (kg) of ewes grazing Jemalong barrel medic.

Stocking rate (sheep/ha)	Wool production per head[1]		
	1970	1971	1972
3.1	3.63 a	3.48 a	3.51 a
4.3	3.61 a	3.26 ab	3.28 ab
5.6	3.67 a	3.09 b	3.01 bc
6.8	3.48 a	2.73 c	2.78 c

[1]Means followed by the same letter and not significantly different at $P < 0.05$.

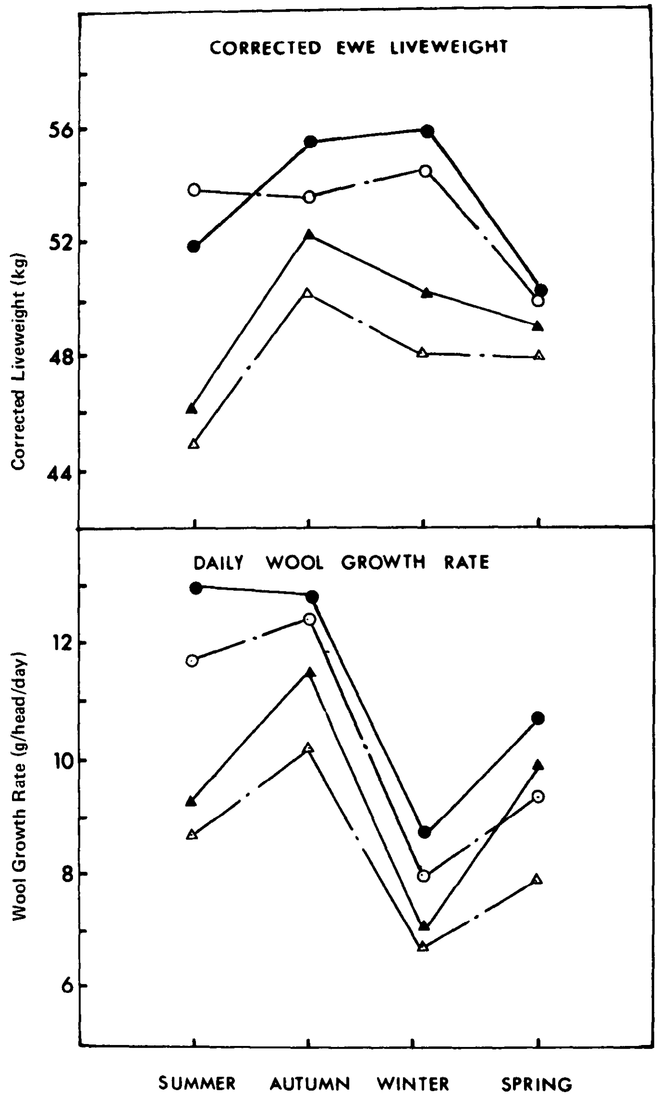

Fig. 3. *Average seasonal corrected ewe liveweight and daily wool growth rate at the four stocking rates. Stocking rates are: solid circle = 3.1; open circle = 4.3; solid triangle = 5.6; and open triangle = 6.8 sheep per hectare.*

Hence, in economic terms, the stocking rate of 5.6 ewes/ha was the most successful during the experiment.

In general corrected ewe liveweight was highest at the low stocking rate with seasonal fluctuations occurring at all stocking rates (Fig. 3). During 1972 lambing rates were low, particularly in the 6.8 ewes/ha treatment, which was probably due to low ewe liveweights at joining. Similar results have been reported by Tadmor et al. (1974) and Eyal et al. (1975). So few lambs were available that growth rate data have not been presented for 1972. In the other 2 years, stocking rate did not significantly affect the rates of growth, and the overall means were similar to growth rates for lambs on unimproved natural pasture (Robards, unpublished data).

Discussion

This experiment indicates that the optimum stocking rate for barrel medic at Trangie is five ewes per hectare. At this level wool growth rate per head was maintained and ewe liveweight was satisfactory except in poor seasons, when moderate levels of supplementary feeding had to be implemented to maintain pasture production. However, the real value of barrel medic has to be assessed by comparing it with the two pasture types (lucerne and natural pasture) on which sheep normally depend and for which productivity data have been obtained.

At Trangie, Campbell et al. (1973) reported that a stocking rate of 4.9 wethers/ha was optimum for natural pasture. Furthermore, Robards (unpublished data) suggests that the optimum stocking rate for ewes grazing the same pasture is between 4 and 5 per ha. From the results of this experiment, the optimum stocking rate on barrel medic pastures is 5.0 ewes/ha, which is not outstandingly better than natural pasture. Further increases in carrying capacity can be expected at Trangie by introducing lucerne as an improved species and utilizing a rotational management strategy (Robards, 1967; Peart, 1968).

At Condobolin (Fig. 1), Brownlee (1973b,c) showed that without supplementary feeding the optimum stocking rate for wethers grazing natural pasture and barrel medic pastures were 1.36/ha and 3.1/ha, respectively, an increase in stocking rate of 130%. Brownlee (1973a) also reported that rotationally managed lucerne, under high stocking rates (10 sheep/ha), could not persist through the high frequency of poor years and was destroyed within 18 months.

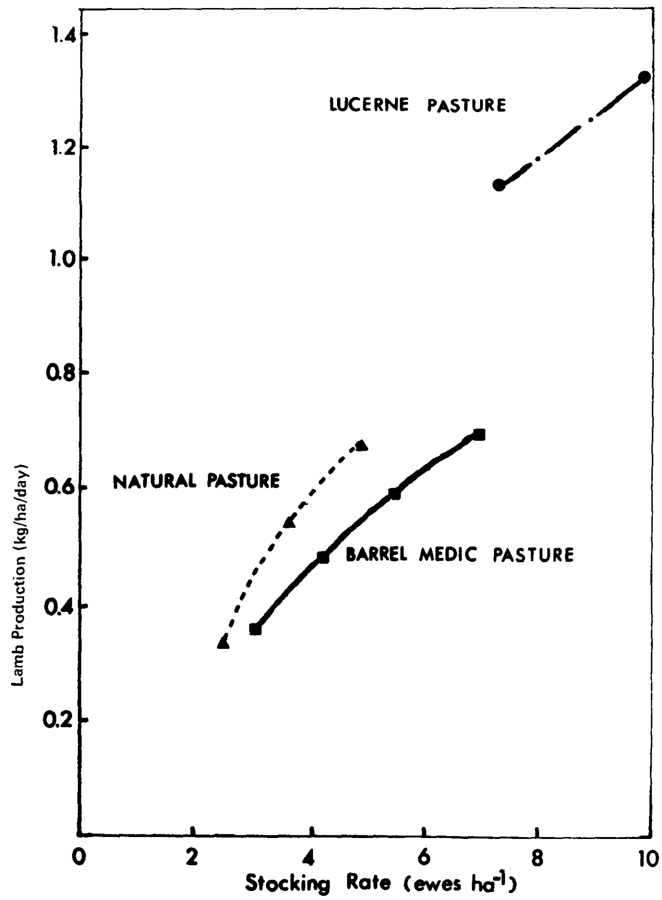

Fig. 4. *Lamb production (kg/ha/day) on natural pasture, barrel medic, and lucerne at Trangie.*

The large differences in optimum stocking rates on the different pasture types at the two sites can be attributed to differences in climatic and edaphic conditions. On average, Trangie receives 18% more rainfall than Condobolin. The additional rainfall gives Trangie the advantage of a more reliable autumn break, which promotes the growth of winter annuals before the onset of winter. Soil phosphate levels differ between sites: Condobolin soils are low in phosphorus (7–8 ppm Bray No. 1) (Scott, 1973), whereas Trangie soils have medium phosphorus status (15–24 ppm Bray No. 1). The interaction of these factors has resulted in the differing productivity of natural and improved pastures at the two sites.

Since, at Trangie, barrel medic does not significantly increase ewe carrying capacity over that of natural pasture, the only benefit in sowing the species may be to improve pasture quality and hence lamb growth rates. Figure 4 compares lamb production per hectare per day for natural pasture, barrel medic, and lucerne (Robards, unpublished data) measured over the same year. A figure for lamb production per hectare per day was calculated by the product of mean lamb growth rate per day and the expected number of lambs at each stocking rate, assuming a 70% weaning rate. On natural pasture and barrel medic, lamb production is similar but is much higher for lucerne pastures. Since the growing season of natural annual species and barrel medic is very similar at Trangie, there was little difference in lamb growth between birth and weaning. Lucerne, on the other hand, gave higher lamb production per hectare because feed quality is maintained throughout the whole year, whereas the quality of natural pastures and barrel medic declines as maturity is approached in the October–November period.

In conclusion, barrel medic has proved a valuable pasture species in the drier Condobolin environment by substantially increasing carrying capacity. In contrast to this, at Trangie barrel medic did not significantly improve either carrying capacity or lamb growth rates above that of natural pasture. Neither did barrel medic prove competitive enough to reduce the proportion of barley grass in the pasture, even under careful seedbed preparation at the commencement of the experiment. Thus, the usefulness of barrel medic as an improved species in marginal cropping lands at Trangie is questionable, particularly since lucerne pastures under rotational management support higher stocking rates and increase lamb growth above those of natural pasture or barrel medic.

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