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GRAZING PREFERENCES OF SHEEP AND NUTRITIVE VALUE OF PLANT COMPONENTS IN A MITCHELL GRASS ASSOCIATION IN NORTH-WESTERN QUEENSLAND

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SUMMARY

Merino ewes grazed over a large area of a Mitchell grass pasture even though there was abundant forage available near their water supply. They grazed only those portions of plants or whole plants attractive at the time and showed an obvious sequence of progression from one species to another. After break-of-season rains they progressed from eating herbage and annual grasses almost exclusively, and after herbage was eaten out, to seed-heads of curly Mitchell grass (*Astrebla lappacea*) with some leaf of bull Mitchell grass (*Astrebla squarrosa*), Flinders grasses (species of *Iseilema*) and other remaining or late-germinating annuals. After these portions of plants or species were eaten out, they ate the leaves of curly Mitchell grass with some leaves, and pods of mimosa bush (*Acacia farnesiana*) and then took the stem of curly Mitchell gass.

The quality and quantity of feed taken were adequate for body-weight gains until the seed-heads of curly Mitchell grass were largely eaten out. Body-weight losses which occurred after this were due to a decline in the quality of the diet eaten.

I. INTRODUCTION

There are 24 million sheep in Queensland and of these 3·5 million are located in the North Western Statistical Division. Average annual wool production in this Division in 1964-65 was 3·29 kg greasy wool, while in the Far Western and South Western Divisions, wool production was 3·65 and 3·67 kg greasy wool per sheep, respectively (Queensland Year Book 1966).

The region is semi-arid. Average annual rainfall ranges between 380 and 500 mm but the area receives effective rainfall in only two summer months in 75% of years. In five consecutive months the mean maximum temperature exceeds 35°C (Farmer, Everist, and Moule 1947).

Although a combination of high ambient temperatures and inadequate nutrition is generally held to be responsible for the lower wool production in north-western Queensland, little as yet can be done economically to ensure an

adequate plane of nutrition for grazing sheep at all times where pasture yields vary widely. The main objective of this investigation was to observe the manner in which sheep grazed plants on a Mitchell grass pasture with a view to obtaining basic data which might be used in formulating general principles for preserving these pastures at their present level of productivity. Other objectives were to observe the growing habits of some pasture species and to determine the extent and severity of seasonal nutritional deficiencies.

II. MATERIALS AND METHODS

Experimental area.—The investigation was made at Toorak Sheep Field Research Station (21°S., 141°45'E.) located near Julia Creek in north-western Queensland. The soil type and vegetation on this property are typical of the Mitchell grass downs which form the largest part of the 5 million hectares of the Julia Land System (Perry 1964). The area consists of undulating treeless plains with heavy cracking soils carrying Mitchell grass (species of *Astrebla*) pasture. A few other perennial tussocks occur and a number of annual grasses and forbs occupy the interspaces. Flinders grasses (species of *Iseilema*) are the most common annuals.

TABLE 1

SPECIES RECORDED IN OBSERVATION AREA

Botanical Name	Common Name
Grasses	
Astrebla elymoides	hoop Mitchell grass
lappacea	curly Mitchell grass
pectinata	barley Mitchell grass
squarrosa	bull Mitchell grass
Aristida latifolia	feather-top wire grass
Bothriochloa ewartiana	desert blue grass
Brachiaria miliiformis	green summer grass
Brachyachne convergens	spider grass and native couch
Chloris pectinata	windmill grass
Cynodon dactylon	couch grass
Dactyloctenium radulans	button grass
Dichanthium annulatum	Sheda grass
fecundum	Gulf blue grass
sericeum	Queensland blue grass
superciliatum	tassel blue grass
Digitaria ctenantha	—
Eriochloa sp.	early spring grass
Eulalia fulva	brown top
Iseilema membranaceum	small Flinders grass
vaginiflorum	red Flinders grass
Panicum decompositum	native millet
whitei	pepper grass
Pennisetum basedowii	Paddy's grass
Sporobolus australasicus	northern fairy grass
benthamii	rat-tail couch

TABLE 1—*continued*

SPECIES RECORDED IN OBSERVATION AREA—*continued*

Botanical Name	Common Name
Miscellaneous Herbage Species	
Acacia farnesiana	mimosa bush
Boerhavia diffusa	tar vine
Cassia planitiicola	cassia
Commelina lanceolata	wandering Jew
Corchorus pascuorum	—
Crotalaria dissitiflora	grey rattlepod
Cyperus bifax	inland nut grass
Desmodium muelleri	—
Glinus lotoides	—
Gomphrena conica	—
Glycine falcata	native glycine
Hibiscus ficulneus	wild rosella
Ipomoea lonchophylla	cow vine
polymorpha	—
sp.	—
Indigofera parviflora	small-flower indigo
trita	—
Justicia procumbens	—
Malvastrum spicatum	malvastrum
Operculina turpethum	onion vine
Pimelea decora	Flinders poppy
Polanisia viscosa	tick weed
Polymeria longifolia	Peak Downs curse
Portulaca oleracea	pigweed
Psoralea cinerea	emu foot
Pterigeron odorus	—
Ptilotus leucocoma	—
spicatus	—
Rhynchosia minima	—
Salsola kali	soft roly poly
Sesbania brachycarpa	sesbania pea
Sida fibulifera	silver sida
spinosa	spiny sida
Sphaeranthus indicus	—
Teucrium integrifolium	—

The area observed was a paddock of 1,200 ha grazed by 300 Merino ewes. Watering was by artesian bore and there was approximately 0·8 km of bore drain (channel) along the northern fence line.

Line transects through the area totalling 4·02 km in August 1962 showed that the average basal intercept of 2·84 % was made up of 2·60 for *Astrebla lappacea,* 0·18 for *A. elymoides,* 0·05 for *A. squarrosa* and 0·01 for *Aristida latifolia.*

Aristida latifolia (feather-top wire grass), a pest species on all *Astrebla* grasslands and causing "shive" in wool, was included to show its relative insignificance in these open, well-drained Mitchell grass downs. A small area

of barley Mitchell grass (*Astrebla pectinata*) was present in the area but was not intercepted by any of the transects. Green couch grass (*Cynodon dactylon*) was present along the bore drain.

No trees were present, but mimosa bush (*Acacia farnesiana*) and Parkinsonia (*Parkinsonia aculeata*) occurred at irregular intervals along the bore drain. Some isolated patches of mimosa also were present in depressions or on calcareous outcrops.

A full list of species recorded is given in Table 1.

Grazing and pasture observations.—Sheep were observed through field glasses for a period each day for three consecutive days. These observations were made at monthly intervals from December 1961 to December 1962. By carrying out observations of the pasture after it had been grazed and comparing the grazed species with ungrazed species, the parts of plants which had been eaten were estimated. Observations of growing habits of different species were made on these occasions. Less detailed observations were made of the grazing preferences of sheep in heavier stocked paddocks (1 sheep to 2 ha) adjacent to the experimental area.

Pasture sampling.—After estimating the parts of plants which had been eaten, samples corresponding to these parts were taken from adjacent ungrazed plants.

Whole plants of curly Mitchell grass (*Astrebla lappacea*) and bull Mitchell grass (*A. squarrosa*) were taken from areas on the highest and on the lowest regions of the Mitchell grass downs and also in areas adjacent to the bore drain.

Faecal sampling.—Samples were taken per rectum from 20 sheep and subsamples were bulked for analysis.

Body-weight.—This was determined at intervals on each of the 300 sheep, but statistical analysis was made only on body-weight data of 52 sheep which remained non-pregnant during 1962.

Chemical analysis.—Pasture and faecal samples were air-dried and after milling were oven-dried and analysed for crude protein, ash, phosphorus and calcium by methods described by Moir (1960*a, b*).

III. RESULTS

(a) Grazing and Pasture Observations

The major plants or parts of plants eaten by sheep from December 1961 to December 1962 are recorded in Table 2.

In December 1961, Mitchell grass responded to light storm rains by producing culm shoots. By January, it had produced some new tiller growth in response to storm rains and after general rain amounting to 175 mm in 24 hr in March,

TABLE 2

PLANTS OBERVED TO BE EATEN BY MERINO SHEEP ON A MITCHELL GRASS PASTURE IN NORTH–WESTERN QUEENSLAND

Month	Plants Eaten
Dec. 1961 ..	Green Mitchell grass shoots. Little alternative pasture
Jan. 1962 ..	Herbs and forbs, Flinders grass, button grass and other annual species; some Mitchell grass shoots
Feb. 1962 ..	Herbs and forbs; other annuals; small amounts of Mitchell grass
Mar. 1962 ..	General rains gave full pasture response. Sheep grazed herbs and forbs; other annuals
Apr. 1962 ..	All species developed rapidly to maturity. Sheep grazed a wide range of annual species and some seed-heads of curly Mitchell and hoop Mitchell grasses, and some leaf of bull Mitchell grass
May 1962 ..	The pasture has now matured to standing hay. Sheep grazed curly Mitchell grass seed-heads; some pig weed, tar vine, nut grass and some seed-heads of hoop Mitchell grass
June 1962 ..	Curly Mitchell grass seed-heads; Flinders grass; *Sida* spp; *Rhynchosia* sp. and *Glycine* sp.
July 1962 ..	Curly Mitchell grass seed-heads; Flinders grass; some *Pterigeron odorus;* small amounts of green couch
Aug. 1962 ..	Curly Mitchell grass seed-heads, scarce but still sought after; Flinders grass; some *P. odorus*, mimosa bush leaf and pod and small amounts of leaf of curly Mitchell and bull Mitchell grasses, and couch grass
Sept. 1962 ..	Curly Mitchell grass seed-heads and leaf; Flinders grass; *P. odorus;* mimosa bush leaf and pod
Oct. 1962 ..	Curly Mitchell grass leaf and leaves and pods of mimosa bush
Nov. 1962 ..	Curly Mitchell grass stem; leaves and pods of mimosa bush
Dec. 1962 ..	Green shoots of Mitchell grass

Mitchell grass resumed active growth and produced abundant tillers. In April all species developed rapidly to maturity and hoop Mitchell grass (*Astrebla elymoides*) was the first of this genus to seed.

When grazing curly Mitchell grass, sheep pulled at the seed-head, which separated at the leaf sheath, leaving no clear sign of tissue removal except for the absence of the seed-head. Following the removal of curly Mitchell grass seed-head by sheep, leaf was utilized and then stem, but only after all leaf had been eaten.

With an increase in temperature from 24·4°C in July to 27·6°C in August, bull Mitchell grass and other species growing in areas of moisture accumulation resumed slow growth for a short period.

During October and November, light storm rains caused the loss of the remaining loosely attached seed-heads and the leaf of the Mitchell grasses. After further light rain in December, Mitchell grasses produced new culm shoots before other species responded.

Other perennial grasses present on the experimental area were not seen to be grazed in significant amounts. In some quarters the opinion is held that green

couch (*Cynodon dactylon*), which grows along bore drains, provides a valuable part of the diet of sheep in areas served by artesian water. In the present series of observations only small amounts of this species were eaten.

Some germination of annual species occurred from light rains in January and February. General rains in early March caused extensive germination and rapid development of annual species.

Pure swards of button grass (*Dactyloctenium radulans*) developed in denuded areas where light erosion had taken place. This species generally was not found associated with taller perennial grass. By April, button grass had become dry and in this condition was not attractive to sheep at the grazing pressure observed.

The most prevalent annual grasses in the region are Flinders grasses (*Iseilema vaginiflorum* and *I. membranaceum*), but their distribution in north-western Queensland is restricted relative to the Mitchell grasses. They seeded well in April and by May had hayed off in a very attractive state. After rain in November they decomposed rapidly. When sheep attempted to graze Flinders grass as they did curly Mitchell grass, small, poorly developed plants were pulled up and eaten. Flinders grass occupied the major portion of the interspaces between Mitchell grass tussocks.

Species such as cow vine (*Ipomoea lonchophylla*), onion vine (*Operculina turpethum*) and *Ipomoea* sp., which had been selectively grazed when actively growing, were ignored by the sheep after maturity. Exceptions were pigweed (*Portulaca oleracea*), western nut grass (*Cyperus bifax*) and tar vine (*Boerhavia diffusa*), but these had been eaten out by June. Two autumn-growing species—emu foot (*Psoralea cinerea*) and *Pterigeron odorus*—became apparent in May, but the former was not seen to be eaten. *P. odorus* appeared to be most acceptable to sheep when the plants were flowering. It was selectively grazed and the fleshy root also was eaten.

(b) Grazing Behaviour

The 300 sheep grazed together in a fairly compact group over an extensive area each day. The distance from water to the furthermost corner of the paddock was 4 km and the sheep often grazed over this distance in a day. They grazed more on ridges, even though in the depressions pasture remained greener for longer periods.

(c) Chemical Composition

In samples of plants representative of those selectively grazed (Table 3), crude protein and calcium concentrations generally were highest in the herbs and forbs. As would be expected, these nutrients also were high in samples from leguminous species. Nut grass and green couch contained the lowest phosphorus concentrations, although low concentrations were found in some samples of other grasses in some months. In annual grasses there was a decline from initial high concentrations of crude protein and phosphorus, but these nutrients did not decline subsequently to very low concentrations.

TABLE 3

CRUDE PROTEIN, PHOSPHORUS AND CALCIUM CONCENTRATIONS IN PLANTS AND PARTS OF PLANTS REPRESENTATIVE OF THOSE SELECTIVELY GRAZED BY MERINO SHEEP ON A MITCHELL GRASS PASTURE IN NORTH-WESTERN QUEENSLAND

Sampling Date (1962)	Plant	Crude Protein (%)	P (%)	Ca (%)
Feb. 1	Curly Mitchell, shoot	10·8	0·20	0·62
	Flinders grass	10·8	0·32	0·36
	Button grass	14·5	0·23	0·66
	Early spring grass	15·8	0·26	0·50
	Native millet	16·5	0·32	0·42
	Brown top	9·0	0·44	0·49
	Green couch	7·0	0·18	0·54
	Nut grass	8·6	0·19	2·25
	Pig weed	18·2	0·38	1·18
	Tar vine	19·1	0·16	2·66
	Sesbania pea	31·0	0·36	1·53
	Miscellaneous herbage	21·6	0·46	1·50
Feb. 25	Curly Mitchell, shoot	9·5	0·14	0·33
	Bull Mitchell, shoot	10·8	0·13	0·62
	Flinders grass	7·4	0·27	0·38
	Nut grass	9·5	0·13	0·75
	Sesbania pea	30·5	0·37	1·96
Mar. 25	Curly Mitchell, leaf	13·3	0·24	0·52
	Nut grass	14·4	0·13	0·34
	Pig weed	19·1	0·15	1·14
Apr. 24	Curly Mitchell, seed-head	9·6	0·27	0·29
	Bull Mitchell, leaf	9·4	0·27	0·98
	Hoop Mitchell, leaf	8·1	0·27	0·37
	Flinders grass	9·8	0·33	0·46
	Nut grass	14·4	0·08	0·71
	Pig weed	12·9	0·27	1·51
May 22	Curly Mitchell, seed-head	9·6	0·27	0·29
	Bull Mitchell, leaf	4·4	0·09	0·19
	Hoop Mitchell, seed-head	7·5	0·23	0·26
	Flinders grass	7·4	0·29	0·34
June 19	Curly Mitchell, seed-head	9·7	0·26	0·16
	Flinders grass	9·2	0·31	0·46
July 17	Curly Mitchell, seed-head	8·2	0·17	0·21
	Flinders grass	7·4	0·19	0·25
	Green couch	4·8	0·08	0·58
	Pterigeron odorus	10·2	0·22	1·07
Aug. 14	Curly Mitchell, seed-head	8·5	0·18	0·31
	Flinders grass	9·3	0·23	0·56
	Green couch	10·3	0·18	0·80
	Pterigeron odorus	10·2	0·18	1·22
	Mimosa, leaf and pod	23·4	0·15	1·30
Sept. 14	Curly Mitchell, seed-head	8·1	0·18	0·23
	Flinders grass	8·5	0·19	0·17
	Pterigeron odorus	8·4	0·17	1·04
Oct. 5	Curly Mitchell, leaf	7·9	0·14	0·22
	Flinders grass	6·8	0·15	0·27
	Green couch	5·5	0·15	0·27
	Pterigeron odorus	12·3	0·26	1·19
	Mimosa	25·3	0·28	1·95

The results of chemical analysis of selected samples of curly and bull Mitchell grasses were treated together with data obtained on whole plants of these species in an analysis of variance (Table 4). Significantly higher crude protein, phosphorus and calcium concentrations occurred in selected samples than in whole plants. Higher phosphorus concentrations were found in whole plants from gullies and higher protein and phosphorus, but lower calcium, concentrations were evident in curly and bull Mitchell grasses. There also was a significant decline with time in crude protein, phosphorus and calcium in whole plants and selected samples of curly and bull Mitchell grasses.

TABLE 4

PERCENTAGES OF CRUDE PROTEIN, PHOSPHORUS AND CALCIUM IN SELECTED SAMPLES AND IN WHOLE PLANTS OF CURLY AND BULL MITCHELL GRASSES FROM DIFFERENT SITES AT DIFFERENT TIMES IN A MITCHELL GRASS PASTURE IN NORTH-WESTERN QUEENSLAND

Source	Mean Protein (%)	Mean P (%)	Mean Ca (%)
Samples: Selected	9·13	0·176	0·438
Whole plants, ridge ..	6·50	0·124	0·299
Whole plants, gully ..	6·94	0·151	0·360
Whole plants, bore ..	7·07	0·144	0·300
Necessary differences for significance 5%	0·99	0·027	0·085
Necessary differences for significance 1%	1·36	0·037	0·117
Species: Curly Mitchell grass ..	8·02	0·172	0·315
Bull Mitchell grass ..	6·70	0·126	0·384
Necessary differences for significance 5%	0·71	0·019	0·060
Necessary differences for significance 1%	0·97	0·026	0·083
Times (1962): Feb. 1	9·42	0·187	0·604
Feb. 25	8·73	0·193	0·323
Mar. 25	10·56	0·193	0·447
Apr. 24	7·79	0·183	0·495
May 22	6·81	0·160	0·253
June 19	6·12	0·124	0·242
July 17	5·66	0·095	0·171
Aug. 14	5·36	0·086	0·338
Oct. 5	6·23	0·119	0·271
Necessary differences for significance 5%	1·28	0·035	0·109
Necessary differences for significance 1%	1·75	0·048	0·150

The chemical composition of faeces of the grazing sheep (Table 5) exhibited a similar trend. Associated with a decline in the quality of the diet eaten there was a decline in the amount of forage, but by the end of 1962 the pasture was far from having been completely eaten.

TABLE 5

ASH, PROTEIN, PHOSPHORUS AND CALCIUM CONCENTRATIONS IN THE DRY-MATTER FAECES OF GRAZING MERINO SHEEP ON A MITCHELL GRASS PASTURE IN NORTH-WESTERN QUEENSLAND

Date (1962)	Ash (%)	Protein (%)	P (%)	Ca (%)
Feb. 1 ..	52·4	8·5	0·56	3·68
Feb. 25 ..	49·9	9·5	0·42	4·41
Apr. 24 ..	23·1	10·9	0·78	4·83
May 22 ..	20·1	12·0	0·59	4·10
June 19 ..	23·2	9·8	0·49	3·17
July 17 ..	21·1	10·3	0·37	2·95
Aug. 14 ..	22·6	9·3	0·34	1·89
Sept. 14 ..	28·7	7·9	0·31	1·42
Oct. 5 ..	22·6	8·1	0·31	1·07
Nov. 7 ..	24·7	8·4	0·35	1·31
Dec. 12 ..	43·6	7·4	0·45	1·55

(d) Growth Rate

The growth rates were the combined effects of wool growth and body-weight gain or loss. As shearing took place in June, growth rates were not calculated for the period between weighings on June 19 and July 12. The analysis of variance of growth rates (Table 6) shows that the non-pregnant sheep gained weight from February 2 to August 15, 1962, and lost weight from August 15 to January 31, 1963.

TABLE 6

DAILY GROWTH RATES OF 52 NON-PREGNANT MERINO SHEEP ON A MITCHELL GRASS PASTURE IN NORTH-WESTERN QUEENSLAND

Period (1962–63)		Growth Rate g/day
Jan. 1–Feb. 25		62·2
Feb. 25–Apr. 24		40·0
Apr. 24–June 19		26·8
July 12–Aug. 15*		41·3
Aug. 15–Oct. 9		−13·8
Oct. 9–Dec. 4		−24·4
Dec. 4–Jan. 31		−8·6
Necessary differences for significance	5%	15·0
	1%	19·8

* First period after shearing.

IV. DISCUSSION

In the colder semi-arid regions in Australia, the dominant constituents of the pastures are sparingly grazed, whereas many of the associated species which often constitute only a minor portion of the total available forage are heavily grazed (Leigh and Mulham 1966*a, b,* 1967; Robards, Leigh, and Mulham 1967). Conversely, in the present investigation, where sheep grazed over a large area, some minor species provided dry matter of high quality, while the dominant perennial grass, curly Mitchell grass, provided the major dry-matter contribution for the grazing animal for a large part of the year.

In the year of observation, a wide range of herbage and forbs was available. The development of these components of the pasture varies between years, depending upon climatic conditions, of which rainfall distribution, intensity and total are of major importance. The observations on the grazing preferences of sheep in adjacent paddocks more heavily grazed indicated that the order of preference for individual species was similar, but the speed of progression from one species to another was greater than in the lighter stocked experimental area. It therefore could be expected that the nutritive value of the diets selected by sheep grazing a Mitchell grass pasture would be partly governed by the rate of this progression from one species to another.

Body-weight gains in the period from February to August indicated that the grazing sheep were in positive nitrogen balance. From a consideration of the relative amounts and the chemical composition of the different plants grazed during this period, the nitrogen content of the diet should have been above the value of 1·25% quoted by Ferguson (1959) and Milford and Haydock (1965) as the minimum level necessary for positive nitrogen balance. Phosphorus and calcium concentrations in the diet also should have been above the minimum requirements recommended by the National Research Council, U.S.A. (1956) for growth and wool production.

There was a significant trend for the quality of pasture, as assessed by the protein concentration, to fall during the year. In the period from August 1962 to January 1963, when there were body-weight losses, there was a decrease in pasture quality as expressed through dietary crude protein, phosphorus and calcium. The chemical composition of the faeces of the grazing sheep reflected this trend for a fall in the quality of the grazed diet, but even so, on the basis of regressions relating feed and faecal composition derived by Moir (1960*a,b*) dietary crude protein, phosphorus and calcium concentrations should have been adequate for body-weight gains. Even though the total dry matter on offer to sheep appeared to be adequate, body-weight losses in the later part of the year may have been due to a number of undetermined factors.

High faecal calcium concentrations in the diet in the first half of the year were consistent with the grazing of herbage of high calcium content. High faecal ash concentrations at three sampling dates were associated with the grazing

of short succulent pasture, and although ingested soil may have contributed to faecal ash, it is submitted that these high values were due primarily to a high digestibility of the organic matter in the diet.

A high degree of selective grazing was evident. This observation was supported by the higher quality of selected diets compared with whole plants of curly and bull Mitchell grasses, which were present in the pasture in by far the greatest amounts. When conditions are such that a similar degree of selectivity is possible, the feeding of supplements in practical amounts probably would not be beneficial. These conditions would apply while there are seed-heads of curly Mitchell grass, some Flinders grass and leaves and pods of mimosa bush available for grazing or browsing. When there is less opportunity for sheep to select, both protein and energy supplements probably would be required to prevent body-weight losses, but this type of supplementary feeding if dependent upon fodder purchased and freighted from distant centres is unlikely to be economical in this region. However, small amounts of protein or non-protein nitrogen supplements stimulate the appetite of sheep grazing or subsisting on low quality roughage (Reid 1953) and this form of supplementation warrants economic evaluation.

The preference of sheep for curly Mitchell grass compared with bull Mitchell grass and the higher quality of the former were clearly demonstrated. Although the leaf of bull Mitchell grass was utilized, the stem apparently was too coarse for sheep. In this regard, the tendency for sheep to graze more on ridges than in depressions probably was because coarser species tend to inhabit the latter areas. Hoop Mitchell grass was the least palatable of the four Mitchell grass species, but subsequent observations have shown that this species is utilized during periods of prolonged feed shortage. Barley Mitchell grass was only poorly represented in this area, but it is reported to be quite palatable (Everist 1935).

Curly Mitchell grass is the most important species in this region from a management viewpoint. Although more palatable and nutritious species are available at different times of the year, curly Mitchell grass must be relied upon to support stock when alternative grazing is not available.

The progressive grazing of firstly seed-heads, then leaf, followed by stem, or "hedge grazing" in which sheep defoliated curly Mitchell grass, could be a valuable characteristic. If there is a critical relationship between the proportion of the plant removed and its survival, protection of the species either by deferment or by low grazing pressures beyond a given level of tissue removal becomes necessary.

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