

**BRACHIARIA DECUMBENS (SIGNAL GRASS)—A REVIEW
WITH PARTICULAR REFERENCE TO AUSTRALIA**

D. S. LOCH*

ABSTRACT

Brachiaria decumbens (signal grass) is a high-yielding stoloniferous grass adapted to a wide range of well-drained soils in humid tropical areas. It has no major pest and disease problems, and is generally better suited to such areas than *Digitaria decumbens* (pangola grass)—the main sward-forming alternative—except where flooding or poorly drained conditions are encountered.

In north Queensland, pure signal grass pastures receiving fertilizer nitrogen are recommended for strategic use as "buffer" pastures in predominantly grass/legume systems. The species is well adapted to such intensive utilization because it makes very efficient use of fertilizer nitrogen and withstands heavy stocking. However, it is an aggressive grass, and *Desmodium heterophyllum* is the only legume recorded as forming a stable, productive association with *B. decumbens* in the long term.

The taxonomic situation is one of confusion. Distinctions between the various *Brachiaria* species commonly used in pastures are unclear, and detailed studies of morphological and agronomic variations are desirable.

INTRODUCTION

The genus *Brachiaria* includes a number of species utilized by pastoralists in the tropics. In addition to several annual species widely distributed in tropical Africa, six perennial species—*B. brizantha*, *B. decumbens*, *B. dictyoneura*, *B. humidicola*, *B. mutica*, and *B. ruziziensis*—have been used in tropical pastures with varying degrees of success (114). *B. decumbens* is one of the more widely used and, of recent years, increasing interest has been shown in a number of countries. It is therefore timely to review available information and to assess its potential in tropical pastures.

ORIGIN AND GEOGRAPHICAL DISTRIBUTION

B. decumbens is widespread in both open grasslands and partial shade on the Great Lakes Plateau in Uganda and adjoining countries of east and central Africa (21, 28, 40, 55, 90, 101, 111). It is regarded as a desirable native species, providing good grazing for both cattle and wildlife (41, 42, 44, 45, 57, 90).

In Uganda, it occurs in a variety of climax and derived plant communities—thicket, woodland, tree savannah, savannah woodland and grassland, and montane grassland (70, 71, 72, 73, 74, 75). These are found over a wide range of environmental conditions: altitude varies from about 650 to 2300 m; average annual rainfall ranges from approximately 700 to 1600 mm with dry seasons of 1–5½ months duration; soils on well-drained hillsides include skeletal soils and sands through to clays, while, in seasonally waterlogged valleys, they include sandy soils, clays, and undifferentiated alluvium. Most communities are burnt annually or regularly.

The species has also shown promise in a number of other tropical countries in Africa, Central and South America, southern Asia, and the Pacific region. These include Malawi (5, 9), Jamaica (2, 92), Trinidad (46, 65), Guyana (4), French Guiana (22), Surinam (3, 16, 35, 36, 37, 66), Venezuela (84, 119), Colombia (19), Peru (96), Brazil, India (69), Sarawak (12, 13, 43), Sabah (10, 11), Papua and New Guinea (7, 62), Fiji (93), and northern Australia (18, 78, 102, 115).

* Department of Primary Industries, P.O. Box 33, Gympie, Qld. 4570.

HISTORY IN AUSTRALIA

Seed was introduced to Queensland from the Department of Agriculture, Kampala, Uganda in 1930 (C.P.I.* 1694) and 1937 (C.P.I. 6798) (18). The latter introduction was multiplied and later tested under grazing at Fitzroyvale in central coastal Queensland by C.S.I.R.† (83).

The earlier introduction was multiplied by C.S.I.R. at Gatton in southern Queensland and later at Fitzroyvale (18). During the 1930s, it was sown around Brisbane by the Queensland Department of Agriculture and Stock‡ at Lawnton, St. Lucia, and Moggill, and remains naturalized in parts of Brisbane. On the basis of good results in coastal southern and central Queensland, C.P.I. 1694 was listed as "useful" (79).

From 1936, C.P.I. 1694 was sown by the Department of Agriculture and Stock at South Johnstone on the wet tropical coast of north Queensland (52). Although it produced relatively high dry matter yields in early cutting experiments (97), its widespread commercial utilization was not feasible at this stage: seed germination was invariably poor; management problems were foreseen; and there was no suitable companion legume for such an aggressive grass (T. G. Graham, personal communication).

Its high productivity was further demonstrated by cutting and grazing experiments in the early 1960s (51, 54). However, it was not until *B. decumbens* was shown to be functionally a fertile grass (50) that the Queensland Herbage Plant Liaison Committee released C.P.I. 1694 for commercial use in 1966 (18). The common name, signal grass, was approved by the Herbage Plant Registration Authority, but cultivar status (as Basilisk) was withheld until December 1973 (78).

The name "signal grass" refers to the arrangement of the racemes like a railway signal, but its choice as the official common name for *B. decumbens* in Australia could lead to confusion because it is used by some overseas workers (e.g. 66, 114) in reference to the closely-related *B. brizantha*. Different common names have also been applied to *B. decumbens* in other countries: e.g., sheepgrass in Surinam (16, 35, 66), Kenya sheepgrass in Trinidad (27, 49), and Surinam grass in Jamaica (86, 92).

TAXONOMY

Distinction between the various *Brachiaria* species used in pastures is unclear and confusion is common. There is no simple solution, however, as many species intergrade.

The description of *B. eminii* (as *Panicum Emini*) (81) precedes Stapf's (101) description of *B. decumbens* by 15 years. Robyns, who subsequently transferred the former species to *B. Emini* (94), regarded the two species as identical and, therefore, treated *B. decumbens* as its synonym (94, 95). His view has since influenced other authors (e.g. 87, 114), but current opinion at Kew is that *B. decumbens* and *B. eminii* are separate species, the former being a decumbent perennial with 2-4 racemes and spikelets 4-5 mm long, and the latter being a slender, erect annual with 7-12 (-20) racemes and spikelets 3-4 mm long (S. A. Renvoize, personal communication).

B. brizantha and *B. decumbens* intergrade completely on all their morphological features, and the descriptions of the two species represent nothing more than the two extremities of the range of variation (S. A. Renvoize, personal communication). However, since these two extremes are so very different, it seems worthwhile maintaining them as separate species which may be recognized as follows:—

B. decumbens: Decumbent perennial, culms up to about 1.5 m long; leaf-blades lanceolate, 10-15 mm wide and less than 20 cm long; 2-4 racemes up

* Commonwealth Plant Introduction.

† Council for Scientific and Industrial Research.

‡ Now Department of Primary Industries.

to 6 cm long, rarely more; rhachis flat, sometimes ribbon-like, ciliate along the angles, cilia not tubercle based; spikelets closely contiguous and generally in two ranks; upper glume seven-nerved, silkily hairy.

B. brizantha: Tufted perennial with stout culms up to about 2 m high; leaf-blades linear, (6-) 8-14 mm wide and over 20 cm long; 2-8 racemes 6-20 cm long; rhachis with tubercle based cilia along the margins; spikelets more widely spaced so that they appear to be in a single rank on the rhachis which is villosulous at the base; upper glume with 7-11 nerves, usually glabrous.

Specimens of *B. decumbens* collected from commercial pastures and naturalized stands in Queensland differ from the typical form in their longer culms and longer, more numerous (2-7) racemes; they are at the end of the range of variation in *B. decumbens* and within the range of introgression with *B. brizantha* (S. A. Renvoize, personal communication). In view of this, it is not surprising that material naturalized around Brisbane and now accepted as *B. decumbens* was, until quite recently, confused with *B. brizantha*.

MORPHOLOGICAL DESCRIPTION

Stapf (101) has provided a detailed description of *B. decumbens* and this has been largely reproduced by Barnard (18) and Mackay (78).

Briefly, *B. decumbens* is a vigorous, trailing perennial grass with short, dark green leaves, rooting from the lower nodes of erect culms. These arise from a long, prostrate, stoloniferous base to 30-45 cm high when vegetative and up to 1 m high when in flower. The inflorescence is a secund panicle of 2-4, more or less curved, racemes attached at right angles to the rhachis of the panicle and spreading horizontally. Spikelets have a male lower floret and a fertile hermaphrodite upper floret, and are closely contiguous and generally arranged in two ranks.

GENETIC VARIATION

B. decumbens is a tetraploid with 36 chromosomes (89, 118) and, at least in the case of Basilisk, an aposporous apomict (89). There is no available evidence to suggest that Basilisk (C.P.I. 1694) and C.P.I. 6798 have any distinctive characteristics, but this is not surprising because C.P.I. 6798 may be no more than a re-introduction of C.P.I. 1694 from Kampala.

Although there is no published information concerning variability within the species, this should be forthcoming in the future. There have been many introductions of *Brachiaria* material into Australia (see Commonwealth Plant Introduction Lists), particularly in recent years. From lines labelled *B. decumbens* and *B. eminii*, and perhaps *B. brizantha* and *Bracharia* sp., it should now be possible to select an adequate range of material with greater or lesser affinity to *B. decumbens* for a study of morphological and agronomic variation.

ENVIRONMENTAL ADAPTATION

Signal grass is best suited to a humid tropical environment (e.g. the wet tropical coast of north Queensland, Surinam) where the dry season is not longer than 4-5 months (114). In such cases, it is usually described as drought resistant (16, 32, 66) or having the capacity to remain green under adverse weather conditions (48); under an average annual rainfall of about 1400 mm and a four month dry season at Serere in Uganda (63), however, it was not regarded as sufficiently tolerant of dry season conditions (64). Signal grass is considered more drought resistant than *Digitaria decumbens* (pangola grass) (104, 108) and *B. mutica* (para grass), growing well on steep hillsides and quick-drying shallow soils where the last species would not succeed (B. Grof, personal communication).

B. decumbens is readily frosted. In the absence of frost, however, its winter production is regarded as superior to that of pangola grass (104, 108) although the latter is to be preferred in flooded or waterlogged situations which signal grass does not tolerate (52, 66, 104, 108). In Surinam, *B. decumbens* grew in pots where the water table was maintained at 25 cm below the soil surface for four weeks, but died within three weeks in a saturated soil (112).

In cultivation, signal grass has grown successfully on a wide range of well-drained soils (16, 52, 66, 108). These include sandy soils (35), infertile podsollic soils (38, 112), and topsoil (15–60 cm depth) spread for reclaiming land after bauxite mining (86).

ROLE IN PASTURES

In north Queensland, pure grass pastures receiving fertilizer nitrogen and covering up to about 25% of the farm are recommended for strategic use to relieve stocking pressure on more vulnerable grass-legume mixtures during their period of slow growth in the cool dry season (105, 107). Signal grass makes very efficient use of fertilizer nitrogen and withstands heavy grazing, so that it is well suited to such a system. On well-drained soils, it is the preferred species for this role, because the stoloniferous alternative, pangola grass, is less drought tolerant and less productive during winter (104).

Aggression, however, is less desirable in mixed pastures. In the long term, the dense vigorous growth of signal grass suppresses most associated legumes. The only legume capable of forming a stable productive association with this grass over a long period is the stoloniferous *Desmodium heterophyllum* (hetero) cv. Johnstone (53, 77, 104).

Associations with other legumes have been less successful. In early experiments at South Johnstone, signal grass proved an unsatisfactory companion for *Stylosanthes guianensis* (stylo) cv. Schofield under intermittent grazing; the dense, stemmy grass growth was never well grazed and shaded the associated stylo so that, two years after establishment, very few stylo plants remained (99). The recently released stylo cultivars, Cook and Endeavour, are more competitive than Schofield and have combined reasonably with signal grass in the short term (53, 116, 117). *Centrosema pubescens* (centro) has also formed a satisfactory short-term association with signal grass in north Queensland (113). In Sarawak, mixtures of signal grass with either stylo or centro gave the best short term herbage and crude protein production; both were far superior to a mixture with *Pueraria phaseoloides* (puero) (14, 15).

ESTABLISHMENT

Grof (50) showed *B. decumbens* to be functionally a fertile grass, germination of otherwise sound caryopses being impeded by an impermeable seed coat. Acid-scarification of freshly harvested seed with concentrated sulphuric acid for 10–15 minutes both hastened and significantly increased germination (Table 1). All three periods of acid treatment resulted in the complete dehulling of seeds, but the longer periods (i.e. 10 or 15 minutes), which severely mutilated the seed coat, were necessary to improve germination shortly after harvest. Storage of untreated seed at room temperature for 10 months also improved germination, but further improvement was still possible with acid scarification (though a shorter period was necessary than for fresh seed). Seed stored for at least 10 months usually germinates reasonably well (52). However, some samples will germinate in laboratory tests much earlier than this.

With the exception of Hosking and Stephens (64), signal grass had previously been regarded as setting very little viable seed. In many parts of the world (e.g. Uganda, Venezuela, Surinam, Papua and New Guinea, Australia), the recommended method of establishment was therefore by means of cuttings from stems or stolons (6, 16, 23, 31, 33, 34, 35, 37, 66, 113, 114, 119). Vegetative establishment is still used in the absence of seed supplies (30, 112) and is rapid. In Surinam, pastures planted from cut-

tings can be grazed within 4–5 months (34) and sometimes within 10 weeks (66). Successful vegetative establishment, however, is dependent on rainfall (33) and on the material used. Some failures are experienced with unrooted cuttings which do not root freely from the nodes (6, 62, 112), and occasional failures even occur with rooted cuttings (112).

TABLE 1

Effects of three periods of acid-scarification on germinations of freshly harvested (left) and stored (right) seed of B. decumbens (50).

		Mean percentage of emerged seedlings						
Weeks After Sowing	Untreated Control	Period of acid- scarification (minutes)			Untreated Control	Period of acid- scarification (minutes)		
		5	10	15		5	10	15
1	0	0	2.8	3.4	0.04	7.1	9.5	16.5
2	0	1	17.2	21.0	14.2	51.2	51.4	54.1
3	1	2.8	30.0	33.2	21.7	51.4	52.6	54.1

Acid-scarification >> untreated; 10 and 15 minutes acid-scarification >> 5 minutes acid-scarification. 5–15 minutes acid-scarification >> control.

The need for vegetative establishment severely restricted the use of signal grass in pastures, and it is only in the last decade that seeding rates of about 2 kg ha⁻¹ (103) and 4.5 kg ha⁻¹ (104) have been recommended in north Queensland. There are approximately 220,000 seeds per kilogram (R. L. Harty, personal communication). The relatively large seed enables establishment in rough seedbeds, although better results can be expected from well-prepared seed-beds. Seedling growth is rapid and, under good growing conditions, a high initial plant population can provide a complete ground cover in three months.

On the Atherton Tableland of north Queensland, signal grass has shown a high degree of tolerance to pre-emergence applications of atrazine which, even at relatively low rates, gives very good control of a wide range of annual weeds (61). Atrazine has since been used successfully in the establishment of commercial seed crops.

DRY MATTER PRODUCTION

Dry matter production can vary greatly, depending on rainfall and fertility conditions. In particular, the dry matter yield of signal grass can be increased markedly by fertilizer nitrogen (54, 88). Consequently, comparative production figures are more important than actual dry matter yields.

In early cutting experiments at South Johnstone, signal grass performed well compared with 18 other perennial grasses (97). It has continued to perform well under cutting there, and has consistently outyielded pangola grass (51, 82). Higher dry matter yields are obtained as the cutting interval is lengthened (82, 97). In a comparison of 12 grasses in northern Cape York Peninsula, Basilisk was consistently the highest producing grass, mainly as a result of its high production in the second half of the wet season (115).

High dry matter yields have also been recorded from cutting experiments in Colombia (30), Sarawak (88), and Fiji (93). In the last experiment, signal grass outyielded the seven other grasses studied.

CHEMICAL COMPOSITION AND FEEDING VALUE

Data on crude protein and crude fibre contents and digestibility coefficients of dry matter and crude protein are available from a number of sources (Table 2). From this, it is evident that crude protein content, in particular, can vary considerably.

TABLE 2
Contents of crude protein and crude fibre and digestibility coefficients of dry matter and crude protein for Brachiaria decumbens from various sources.

Reference	Fertilizer Nitrogen (kg N ha ⁻¹ year ⁻¹)	Other Remarks	Crude Protein* (%)	Crude Fibre (%)	Dry Matter Digestibility (%)	Crude Protein Digestibility (%)
27		Flowering	7.8	35.8	61.0	33.5
49	33 before trial work	3-week regrowth (immature)	8.2	33.4	62.5	46.9
		4-week regrowth (immature)	13.1		60.0	74.4
		5-week regrowth (flowering)	11.9		68.5	70.8
24	Range pasture	Undisturbed regrowth**	3.7 - 6.2 (4.8)	27.0 - 30.0 (28.8)		
25	"	Undisturbed regrowth**	5.2 - 7.5 (5.9)	31.0 - 34.0 (32.5)		
		Whole plant	5.4	36.1		70.5
76	"	Leaves	8.3	25.8		
80	"	208 survey samples**	2.8 - 13.8 (7.3)	21.8 - 39.5 (30.5)		
		10 randomly-selected survey samples	7.8		53.9	
119		Flowering	4.1	30.1		
19		6 months from sowing	12.4	41.1		
20		Commercial pasture sampled in December prior to wet season	6.0	37.1		
66		Aerial Parts, fresh				
		14 days growth	9.8		82	
		28 days growth	8.2		82	
		42 days growth	8.0		79	
		56 days growth	4.2		66	
		70 days growth	3.6		64	
		84 days growth	3.4		71	
		96 days growth	3.5		64	
		112 days growth	3.2		67	
		30-day regrowth: 1940/41	10.0			
		30-day regrowth: 1941/42	8.9			
		60-day regrowth: 1940/41	5.6			
		60-day regrowth: 1941/42	7.0			
90-day regrowth: 1940/41	4.2					
90-day cutting interval	4.9					
6- to 14-week regrowth (weighted means)	4.6					
54		1962/63	5.3			
		1963/64	5.9			
		1962/63	8.3			
		1963/64	7.7			
		1962/63	10.6			
		1963/64	10.8			
		1962/63	11.3	4 week regrowth		
1963/64	13.8					
1460	730		15.0			
1460	1460		17.5			
1460	1460		17.1			

*N% × 6.25.

**Mean shown in brackets.

Crude Protein

The critical level of crude protein required in a pasture before intake is reduced by nitrogen deficiency has been variously estimated at between 6.0 and 8.5 per cent (85), and a number of the crude protein determinations in Table 2 are either within this critical range or below it. However, whilst nutritive value is partly a function of the species involved, it is also the result of other factors such as soil nutrient levels (especially nitrogen), the time of year and growth rate when sampled, and the age of regrowth.

The protein content of signal grass responds markedly to nitrogen fertilization (29, 54, 88). Sources of data in Table 2, however, differed markedly in this respect; fertilizer rates ranged from zero (54, 88) to 1460 kg N ha⁻¹ year⁻¹ (54), and a number of measurements were made on range pastures (24, 25, 76, 80).

As with other tropical grasses, minimum crude protein values occur during the period of most rapid growth and maximum values during the period of slowest growth (54, 98). The most effective time to increase the protein content by applying fertilizer nitrogen is therefore when plants are not capable of rapid growth.

The crude protein level of signal grass falls as the age of regrowth increases (23, 24, 68, 98) and this is accompanied by increases in crude fibre (23, 24). The species is palatable during vegetative growth (16), but rank, coarse, stemmy growth is not well accepted by stock (113).

Digestibility

As would be expected, *in vitro* digestibility of signal grass falls over a long period with increasing maturity, but is at least comparable to that of other grasses suited to moist tropical areas (68, 91) (Tables 2 and 3). However, where three- to five-week old forages were tested in other experiments, dry matter digestibility of *B. decumbens* increased over the short two-week period (Table 2—49); but dry matter digestibility of most other species tested (e.g. pangola grass, *Digitaria pentzii*, *B. ruziziensis*) also increased, suggesting that factors other than species may have influenced the results of these experiments.

Intake

Experiments with pen-fed wethers in Trinidad showed the mean daily dry matter intake (g kg⁻¹ LW^{0.75}) of signal grass (68.2) to be significantly higher than intakes of *D. pentzii* (62.7) and pangola grass (55.6) (49).

Calcium and Phosphorus

Schofield (100) rated signal grass as having relatively low yields of calcium and phosphorus. However, since it was among the top group of grasses for the annual yield of both elements, this probably reflects its relatively high dry matter production and the low levels of fertilizer applied. More recent work (e.g. 49) has recorded calcium and phosphorus contents for signal grass which were adequate for most classes of ruminant livestock and comparable with those of pangola grass and material labelled *Setaria sphacelata*.

ANIMAL PRODUCTION AND GRAZING MANAGEMENT

Signal grass withstands heavy stocking and trampling (10, 11, 16, 107, 113). In a grazing experiment in northern Cape York Peninsula, Basilisk was more persistent than *Panicum maximum* (common guinea grass) when heavily stocked at low rates of phosphorus fertilizer (116). It is therefore amenable to the frequent heavy grazing or mowing necessary to maintain such pastures in a highly productive and acceptable state (113, 114).

Grazing experiments at South Johnstone have shown the beef production that is possible from intensively-used signal grass pastures receiving fertilizer nitrogen. With a constant heavy stocking rate of 4.55 beasts ha⁻¹ and 196 kg N ha⁻¹ year⁻¹, live-weight gains of 1030 and 869 kg ha⁻¹ were recorded in 1965/66 and 1967/68 respectively; these compared with 740 and 693 kg ha⁻¹ at 3.45 beasts ha⁻¹ and the same

TABLE 3
 In vitro dry matter digestibility (%) coefficients for six tropical grasses harvested at different stages of maturity (from 91)

Species	Weeks of Growth															
	1	2	3	4	5	6	7	8	9	10	11	12	14	16		
<i>Brachiaria decumbens</i>		78.2	72.8	73.0	71.9	71.0*	66.7	66.9	61.6	63.7	58.9	54.8		48.9		
<i>Brachiaria mutica</i>		75.6	78.9	76.4	71.2		59.5	61.1	53.8*	48.5		47.3		38.7		
<i>Brachiaria ruziziensis</i>	82.5	81.2	79.7	73.9*	72.1	72.1	69.2	66.2	68.6	64.0		54.8	54.5	49.8		
<i>Digitaria decumbens</i>		77.0	78.1	75.8*	75.0	70.4	66.0	59.5	62.4	59.8		56.3	55.2	56.3		
<i>Panicum maximum</i>		82.2	77.2	74.8	69.8*	70.6	61.2	59.6	55.8	54.6	53.8	48.6		38.4		
cv. Creeping Embu																
<i>Panicum maximum</i>	76.4	75.2		60.5*	52.4	46.1	52.5	49.6	53.8	47.1		49.8	41.6	42.0		
cv. Makueni																

*Stage of early heading.

fertilizer, and 592 and 553 kg ha⁻¹ at 3.45 beasts ha⁻¹ and no fertilizer nitrogen (54). By comparison, pure guinea grass pastures near South Johnstone (stocked at 3.2 beasts ha⁻¹) produced animal liveweight gains of 460 and 313 kg ha⁻¹ without fertilizer nitrogen in 1963/64 and 1964/65 respectively, and 596 and 725 kg ha⁻¹ with the addition of 168 kg N ha⁻¹ year⁻¹ (51).

In a recent experiment on a sandy yellow earth in northern Cape York Peninsula, mixed pastures (which remained remarkably stable between years and averaged 58% grass, 34% Endeavour stylo, and 8% *Macroptilium atropurpureum* cv. Siratro) were stocked at 0.7, 1.2, 1.7, and 2.2 (reduced after nine months to 1.9) beasts ha⁻¹ (116). The optimum stocking rate was between 1.7 and 1.9 beasts ha⁻¹, and *B. decumbens* compared favourably with common guinea grass, especially at high stocking rates and low rates of phosphorus fertilizer where guinea grass pastures became overgrazed and required destocking during the experiment (117). Liveweight gains (of up to 500–600 kg ha⁻¹ over approximately 34 months) were not as high as those in grazing experiments on grass-legume (51) or nitrogen-fertilized grass pastures (51, 54) near South Johnstone, because larger animals were used in this experiment, and because there is a longer period of 4–4.5 months at this site when animals lose weight or gain moderately (117).

High production has also been achieved in Colombia. In the Cauca Valley, irrigated signal grass (receiving 100 kg N ha⁻¹ initially and 50 kg N ha⁻¹ after each grazing period) in four 0.35 ha paddocks was grazed rotationally (10 days on, 30 days off) by about six two-year old crossbred Brahmans per hectare; a liveweight gain of 0.78 kg ha⁻¹ daily (or around 1700 kg ha⁻¹ annually) was recorded (30).

In the Ankole district of Uganda, *B. decumbens* occurs in savannah grassland communities with unpalatable *Cymbopogon afronardus*. The latter species limits animal productivity (110), but can be controlled by management. When burning is desirable, a late burn will do a minimum of damage to desirable sward characteristics (56). Signal grass is relatively favoured by heavy grazing and fertilizer nitrogen (60). After clearing, *C. afronardus* re-establishes more rapidly under rotational grazing which is therefore less productive than continuous grazing (58). Grazing pressures of 0.8 and 0.6 ha head⁻¹ (300 kg LW) encourage signal grass (59), but 0.8 ha head⁻¹ seems optimal for long term production from such pastures when cleared of *C. afronardus* (58).

ANIMAL DISORDERS

Continuous grazing of pure swards of signal grass in Jamaica has caused a form of scouring, resulting in poor animal performance (92). This has not been experienced in north Queensland on pure signal grass pastures fertilized with nitrogen (107). The only deleterious report concerning *Brachiaria* species under grazing in Australia is the photosensitisation of sheep at Lawes in southern Queensland when grazing pure stands of material classed as *B. brizantha* (26).

Analyses of four *Brachiaria* species in Brazil showed that, whilst *B. radicans* (Tanner grass) had high levels of nitrate (0.550–0.900% of KNO₃ equivalent), *B. decumbens* was quite safe and had only 0.025%, slightly below *B. ruziziensis* (0.037%) and *B. brizantha* (0.058%) (1).

WEEDS AND WEED POTENTIAL

The marked response of signal grass to fertilizer nitrogen, its rapid recovery following heavy stocking, and its inherent aggressiveness make it valuable in weedy situations. It is an ideal grass for smothering weeds (3, 16, 50, 66, 113), and pure signal grass pastures receiving fertilizer nitrogen have been recommended for areas severely infested with *Hyptis capitata* (knobweed) on the wet tropical coast of Queensland (17).

The inherent aggressiveness of signal grass, however, is undesirable when it becomes "a plant out of place". In Surinam, it invaded a coffee plantation and proved

difficult to eradicate (8). It can also invade existing stands of pasture and smother them out (113). This has occurred at Cootharaba (average annual rainfall approximately 1700 mm) in southern Queensland where signal grass has spread rapidly from small commercial sowings in the last decade, and has even colonized paddocks carrying mixed pastures to the virtual exclusion of the original species.

PESTS AND DISEASES

Although sporadic attacks by spittle bug have been recorded in several South American countries (B. Grof, personal communication), signal grass is relatively free of pest and disease problems, particularly by comparison with pangola grass. A stunt disease of viral origin in pangola grass (in addition to numerous pests and diseases) in Jamaica and Surinam led to increasing interest in signal grass which appears resistant (39, 66, 67, 92). Since 1971, pangola grass growing in the Ingham-Cooktown area of north Queensland has suffered from severe local attacks by a range of pests and diseases (47, 105, 106, 109), with the result that interest in signal grass has increased.

SEED PRODUCTION

In recent years, seed production in north Queensland (from the Atherton Tableland, East Palmerston, and Tully areas) has increased rapidly in response to the growing demand for seed both locally and overseas. Small quantities of seed have been harvested in southern Queensland, and seed production is also being undertaken in Brazil. In the early years, demand far exceeded supply. Since 1974, however, the situation has become more balanced, with Australian production geared to satisfy internal demand and also to supply a far larger export market.

Seed crops may be obtained at any time during the warmer months in north Queensland, depending on rainfall and management practice. In years with an early start to the wet season, two crops are possible, the first (and major) one harvested early in the calendar year, and the second ripening after the end of the wet season in about May. However, when the wet season is relatively short, one seed crop per year is more usual. Harvesting is by "all-crop" headers, and average commercial yields are of the order of 100–200 kg ha⁻¹ crop⁻¹. The time to harvest is a difficult decision because of (a) a progressive production of inflorescences as well as some spread of ripening within individual inflorescences, and (b) the absence of a distinctive colour change with ripeness of seed. However, the quality of a harvested sample can be gauged roughly with the teeth, the presence of a caryopsis being immediately apparent by the resistance of the seed.

PROSPECTS

In the last decade, signal grass has become increasingly important in the humid tropics, particularly where pure grass pastures receiving fertilizer nitrogen are used strategically as "buffer" pastures in predominantly grass/legume systems. It is better adapted to such areas than pangola grass, except where flooding or poorly drained conditions are encountered. Its high productivity, tolerance of low fertility conditions, and relative freedom from pests and diseases account for much of the current interest.

Although signal grass has become naturalized in coastal southern and central Queensland (notably around Brisbane and Cootharaba), it has not been planted commercially to any large extent in sub-tropical areas, even in high rainfall, frost-free situations. By comparison, pangola-grass—the main sward-forming alternative in the tropics—has received far more attention both experimentally and commercially. Possible reasons include the superiority of pangola grass in poorly-drained situations (e.g. the coastal lowlands of southern Queensland) and the availability of a range of satisfactory alternative species, particularly before seed of signal grass became readily available.

Grazing experiments in north Queensland and Colombia have shown signal grass pastures to be highly productive in terms of beef, but, so far, the only work with dairy cattle has been the recording of milk production from four pasture systems (including *B. decumbens* pastures receiving fertilizer nitrogen) (96). Grazing experiments to measure milk production would be valuable, as Basilisk has been sown on dairy farms on the Atherton Tableland and East Palmerston areas.

Unfortunately, our present knowledge (and, particularly, our published knowledge) of many aspects of *B. decumbens* is far from being detailed and comprehensive. Even the taxonomic situation is confused; the use of the same name in two places does not guarantee similarity; nor does the use of different names guarantee difference; and the application of any name by anyone but a trained botanist specialising in the flora of tropical east Africa must be treated with caution, at least until the final review of *Brachiaria* for the *Flora of Tropical East Africa* becomes available.

ACKNOWLEDGEMENTS

I am grateful to the many people who so freely gave advice and information; to Mrs D. M. Loch, Mr L. E. Brands, and Mr G. J. Cassidy for assistance with translations; and to the Australian Meat Research Committee for financial support.

REFERENCES

1. ANDRADE, S. O., RETZ, L., and MARMO, O. (1971)—Estudos sôbre *Brachiaria* sp. (Tanner Grass). III—Ocorrências de intoxicações de bovinos durante um ano (1970-1971) e níveis de nitrato em amostras da gramínea. *Arquivos do Instituto Biológico, São Paulo* 38: 239-252.
2. ANON. (1951)—Jamaica, Annual Report of the Department of Agriculture for the Year ended 31st March, 1951.
3. ANON. (1957)—Department van Landbouw, Veeteelf, en Visserij, Suriname, Jaarverslag over 1954.
4. ANON. (1958)—British Guiana, Annual Report of the Director of Agriculture for the Year 1955.
5. ANON. (1967)—Malawi Government, Annual Report of the Department of Agriculture (Part II) for the Year 1963/64.
6. ANON. (1968)—Territory of Papua and New Guinea Department of Agriculture, Stock and Fisheries, Annual Report 1965-66.
7. ANON. (1969)—Territory of Papua and New Guinea Department of Agriculture, Stock and Fisheries, Annual Report 1966-67.
8. ANON. (1970a)—Tien jaar proeftuin Brokobaka (1959-1969). *De Surinaamse Landbouw* 18: 5-43.
9. ANON. (1970b)—Malawi Government, Annual Report of the Department of Agriculture (Part II) for the year 1965/66.
10. ANON. (1971)—State of Sabah, Annual Report of the Department of Agriculture for the Year 1969.
11. ANON. (1972)—State of Sabah, Annual Report of the Department of Agriculture for the Year 1970.
12. ANON. (Undated a)—Sarawak Ministry of Agriculture & Forestry, Annual Report of the Research Branch Department of Agriculture for the Year 1968.
13. ANON. (Undated b)—Sarawak Ministry of Agriculture & Forestry Annual Report of the Research Branch Department of Agriculture for the Year 1969.
14. ANON. (Undated c)—Sarawak Ministry of Agriculture & Drainage and Irrigation, Annual Report of the Research Branch Department of Agriculture for the Year 1971.
15. ANON. (Undated d)—Sarawak Ministry of Agriculture & Drainage and Irrigation, Annual Report of the Research Branch Department of Agriculture for the Year 1972.

16. APPELMAN, H., and DIRVEN, J. G. P. (1962)—Slachtvee in Suriname. Verslag van onderzoekingen door de dienst veeteelt 1940-1962. *Landbouwproefstation Suriname Mededeling* No. 30.
17. BAILEY, D. R. (1969)—Knobweed control in tropical pastures. *Queensland Agricultural Journal* **95**: 540-545.
18. BARNARD, C. (1969)—“Herbage Plant Species”, Division of Plant Industry, C.S.I.R.O., Canberra.
19. BLASCO L., M., and BOHÓRQUEZ, A., N. (1967)—Composicion quimica de plantas forrajeras (gramineas) comunes en el Valle del Cauca. *Acta Agronomica, Palmira* **17**: 13-19.
20. BLASCO L., M., and BOHÓRQUEZ, A., N. (1968)—Pastos en el Amazonas. I. Análisis de algunos componentes químicos. *Agricultura Tropical* **24**: 175-177.
21. BOGDAN, A. V. (1958)—“A Revised List of Kenya Grasses”, Government Printer, Nairobi.
22. BORGET, M. (1966)—Rendements et caractéristiques de cinq graminées fourragères sur sables côtiers a Cayenne. *Agronomie Tropicale, Paris* **21**: 250-259.
23. BREDON, R. M., and HORRELL, C. R. (1961)—The chemical composition and nutritive value of some common grasses in Uganda—I General pattern of behaviour of grasses. *Tropical Agriculture, Trinidad* **38**: 297-304.
24. BREDON, R. M., and HORRELL, C. R. (1962)—The chemical composition and nutritive value of some common grasses in Uganda—II The comparison of chemical composition and nutritive values of grasses throughout the year, with special reference to the later stages of growth. *Tropical Agriculture, Trinidad* **39**: 13-17.
25. BREDON, R. M., TORELL, D. T., and MARSHALL, B. (1967)—Measurement of selective grazing of tropical pastures using esophageal fistulated steers. *Journal of Range Management* **20**: 317-320.
26. BRITON, N. W., and PALTRIDGE, T. B. (1941)—Preliminary note on photosensitisation of sheep grazed on *Brachiaria brizantha*. *Proceedings of the Royal Society of Queensland* **52**: 121-122.
27. BUTTERWORTH, M. H. (1963)—Digestibility trials on forages in Trinidad and their use in the prediction of nutritive value. *Journal of Agricultural Science, Cambridge* **60**: 341-346.
28. CATFORD, J. R. (1952)—Pasture management in Uganda in relation to western Equatoria. *East African Agricultural Journal* **17**: 183-187.
29. CROWDER, L. V. (1965)—Nitrogen fertilization of grasses in Colombia. *Proceedings of the Ninth International Grassland Congress, Brazil*, pp. 1533-1536.
30. CROWDER, L. V., CHAVERRA, H., and LOTERO, J. (1970)—Productive improved grasses in Colombia. *Proceedings of the XI International Grassland Congress, Australia*, pp. 147-149.
31. DAVIDSON, R. P. (1950)—Pasture work at Ngetta farm. Uganda Protectorate, Annual Report of the Department of Agriculture for the period 1st April, 1947-31st March, 1948. Part II—Experimental, pp. 78-80.
32. DIRVEN, J. G. P. (1959)—Grassen-collecties. Landbouwproefstation, Suriname, Jaarverslag 1958, p. 60.
33. DIRVEN, J. G. P. (1960)—Grassen-collecties. Landbouwproefstation, Suriname, Jaarverslag 1959, p. 79.
34. DIRVEN, J. G. P. (1962a)—Aanleg en onderhoud van grasland. Landbouwproefstation Suriname, Jaarverslag 1961, pp. 70-71.
35. DIRVEN, J. G. P. (1962b)—Grasland. *Landbouwproefstation Suriname Mededeling* No. 29.
36. DIRVEN, J. G. P., and APPELMAN, H. (1962)—Slachtveebedrijf Waneweg. Landbouwproefstation Suriname, Jaarverslag 1961, pp. 77-78.

37. DIRVEN, J. G. P., GLAVIMANS, E. J. H., and HENDRIKS, J. A. H. (1956)—Graslandverbetering op het Lelydorpplan in 1955. *De Surinaamse Landbouw* 4: 113-118.
38. DIRVEN, J. G. P., and VAN AMSON, F. W. (1972)—Grasland op de gepodzoliseerde gronden van het Lelydorplandschap. *De Surinaamse Landbouw* 20(2): 2-22.
39. DIRVEN, J. G. P., and VAN HOOF, H. A. (1960)—A destructive virus disease of pangola-grass. *Tijdschrift over Plantenziekten* 66: 344-349.
40. DOUGALL, H. W., and BOGDAN, A. V. (1958)—The chemical composition of the grasses of Kenya—I. *East African Agricultural Journal* 24: 17-21.
41. DRADU, E. A. A., and HARRINGTON, G. N. (1972a)—Seasonal crude protein content of samples obtained from a tropical range pasture using oesophageal fistulated steers. *Tropical Agriculture, Trinidad* 49: 15-21.
42. DRADU, E. A. A., and HARRINGTON, G. N. (1972b)—Seasonal crude protein content of samples obtained from a tropical range pasture using oesophageal fistulated steers. *East African Agricultural and Forestry Journal* 38: 56-61.
43. DUNSMORE, J. R., and ONG, C. B. (1969)—Preliminary work on pasture species and beef production in Sarawak, Malaysia. *Tropical Grasslands* 3: 117-121.
44. FIELD, C. R. (1970)—A study of the feeding habits of the hippopotamus (*Hippopotamus amphibius* Linn.) in the Queen Elizabeth National Park, Uganda, with some management implications. *Zoologica Africana* 5: 71-86.
45. FIELD, C. R., HARRINGTON, G. N., and PRATCHETT, D. (1974)—A comparison of the grazing preferences of buffalo (*Syncerus caffer*) and Ankole cattle (*Bos indicus*) on three different pastures. *East African Wildlife Journal* 11: 19-29.
46. FORSTER, R. H., WILSON, P. N., and BUTTERWORTH, M. H. (1960)—Pasture grass investigations in Trinidad with special reference to pangola grass (*Digitaria decumbens*). *Proceedings of the Eighth International Grassland Congress*, England, pp. 390-392.
47. FRANZMANN, B. A. (1973)—Field studies of a *Schizaphis* on pangola grass in north Queensland. *Queensland Journal of Agricultural and Animal Sciences* 30: 85-89.
48. GRAHAM, T. G. (1951)—Tropical pasture investigations. *Queensland Agricultural Journal* 73: 311-326.
49. GRIEVE, C. M., and OSBOURN, D. F. (1965)—The nutritional value of some tropical grasses. *Journal of Agricultural Science, Cambridge* 65: 411-417.
50. GROF, B. (1968)—Viability of seed of *Brachiaria decumbens*. *Queensland Journal of Agricultural and Animal Sciences* 25: 149-152.
51. GROF, B., and HARDING, W. A. T. (1970)—Dry matter yields and animal production of Guinea grass (*Panicum maximum*) on the humid tropical coast of north Queensland. *Tropical Grasslands* 4: 85-95.
52. HARDING, W. A. T. (1972)—The contribution of plant introduction to pasture development in the wet tropics of Queensland. *Tropical Grasslands* 6: 191-199.
53. HARDING, W. A. T., and CAMERON, D. G. (1972)—New pasture legumes for the wet tropics. *Queensland Agricultural Journal* 98: 394-406.
54. HARDING, W. A. T., and GROF, B. (1977)—Effect of fertilizer nitrogen on yield, nitrogen content and animal productivity of *Brachiaria decumbens* cv. Basilisk on the wet tropical coast of north Queensland. *Queensland Journal of Agricultural and Animal Sciences* 34 (in press).
55. HARKER, K. W., and NAPPER, D. (1960)—“An Illustrated Guide to the Grasses of Uganda”, Government Printer, Entebbe, Uganda.
56. HARRINGTON, G. N. (1974)—Fire effects on a Ugandan savanna grassland. *Tropical Grasslands* 8: 87-101.
57. HARRINGTON, G. N., and PRATCHETT, D. (1972)—Cattle diet on Ankole rangeland at different seasons *Tropical Agriculture, Trinidad* 50: 211-219.

58. HARRINGTON, G. N., and PRATCHETT, D. (1974a)—Stocking rate trials in Ankole, Uganda. I. Weight gain of Ankole steers at intermediate and heavy stocking rates under different managements. *Journal of Agricultural Science, Cambridge* **82**: 497-506.
59. HARRINGTON, G. N., and PRATCHETT, D. (1974b)—Stocking rate trials in Ankole, Uganda. II. Botanical analysis and oesophageal fistula sampling of pastures grazed at different stocking rates. *Journal of Agricultural Science, Cambridge* **82**: 507-516.
60. HARRINGTON, G. N., and THORNTON, D. D. (1969)—A comparison of controlled grazing and manual hoeing as a means of reducing the incidence of *Cymbopogon afronardus* Stapf in Ankole pastures, Uganda. *East African Agricultural and Forestry Journal* **35**: 154-159.
61. HAWTON, D. (1976)—Atrazine for weed control in the establishment of *Brachiaria decumbens* and *Panicum maximum*. *Journal of the Australian Institute of Agricultural Science* **42** (in press).
62. HILL, G. D. (1970)—Improved pastures for Papua and New Guinea. *Papua and New Guinea Agricultural Journal* **22**: 31-58.
63. HORRELL, C. R. (1958)—Herbage plants at Serere Experiment Station, Uganda 1954-1957—I: Grasses. *East African Agricultural Journal* **24**: 41-46.
64. HOSKING, H. R., and STEPHENS, A. L. (1941)—Pastures and grasses on the Serere Experiment Station, Uganda. *East African Agricultural Journal* **6**: 213-219.
65. HOWES, J. R., and CAMPBELL, J. S. (1953)—Grass and its utilization in Trinidad. *Tropical Agriculture, Trinidad* **30**: 3-14.
66. HUNKAR, A. E. S. (1965)—Three *Brachiaria* sp. adapted to well drained soils. Bulletin No. 82 Landbouwproefstation, Suriname, pp. 193-196.
67. HUNKAR, A. E. S. (1969)—Grasland onderzoek. *De Surinaamse Landbouw* **17**: 37-40.
68. JOHNSON, W. L., and PEZO, D. (1975)—Cell-wall fractions and *in vitro* digestibility of Peruvian feedstuffs. *Journal of Animal Science* **41**: 185-197.
69. JUDD, B. I. (1975)—New world tropical forage grasses and their management. 6. Bahiagrass, Vaseygrass, Rivergrass, Signal grass. *World Crops* **27**: 175-177.
70. LANGDALE-BROWN, I. (1959a)—The vegetation of the Eastern Province of Uganda. Uganda Department of Agriculture, Memoirs of the Research Division, Series 2—Vegetation, No. 1.
71. LANGDALE-BROWN, I. (1959b)—The vegetation of Buganda. Uganda Department of Agriculture, Memoirs of the Research Division, Series 2—Vegetation, No. 2.
72. LANGDALE-BROWN, I. (1960a)—The vegetation of the West Nile, Acholi and Lango districts of the Northern Province of Uganda. Uganda Department of Agriculture, Memoirs of the Research Division, Series 2—Vegetation, No. 3.
73. LANGDALE-BROWN, I. (1960b)—The vegetation of the western province of Uganda. Uganda Department of Agriculture, Memoirs of the Research Division, Series 2—Vegetation, No. 4.
74. LANGDALE-BROWN, I. (1960c)—The vegetation of Uganda (excluding Karamoja). Uganda Department of Agriculture, Memoirs of the Research Division, Series 2—Vegetation, No. 6.
75. LANGDALE-BROWN, I., OSMASTON, H. A., and WILSON, J. G. (1964)—“The Vegetation of Uganda and its bearing on land-use”, Government Printer, Entebbe.
76. LONG, M. I. E., THORNTON, D. D., and MARSHALL, B. (1969)—Nutritive value of grasses in Ankole and the Queen Elizabeth National Park, Uganda, II—Crude protein, crude fibre and soil nitrogen. *Tropical Agriculture, Trinidad* **46**: 31-42.

77. MACKAY, J. H. E. (1973)—Register of Australian herbage plant cultivars. B. Legumes. 2. Desmodium. c. *Desmodium heterophyllum* DC (Hetero) cv. Johnstone (Reg. No. B-2c-1). *Journal of the Australian Institute of Agricultural Science* 39: 147-148.
78. MACKAY, J. H. E. (1974)—Register of Australian herbage plant cultivars. A. Grasses. 16. Brachiaria. a. *Brachiaria decumbens* Stapf. (Signal grass) cv. Basilisk (Reg. No. A-16a-1). *Journal of the Australian Institute of Agricultural Science* 40: 91-93.
79. MCTAGGART, A. (1942)—Plant introduction. 1. A review, with notes on outstanding species. Council for Scientific and Industrial Research Pamphlet No. 114, pp. 5-14.
80. MARSHALL, B., LONG, M. I. E., and THORNTON, D. D. (1969)—Nutritive value of grasses in Ankole and the Queen Elizabeth National Park, Uganda, III—In vitro dry matter digestibility. *Tropical Agriculture, Trinidad* 46: 43-46.
81. MEZ, C. (1904)—Gramineae africanae. V. A. Engler, *Botanische Jahrbücher für Systematik, Pflanzengeschichte und Pflanzengeographie* 34: 131-148.
82. MIDDLETON, C. H., and MCCOSKER, T. H. (1975)—Makueni—a new guinea grass for North Queensland. *Queensland Agricultural Journal* 101: 351-355.
83. MILES, J. F. (1949)—Plant introduction trials in central coastal Queensland 1936-46. Divisional Report No. 6, Division of Plant Industry, C.S.I.R.O., Melbourne.
84. MILLER, I. L. (1974)—Plant collection in Mexico, Venezuela and Colombia for the high rainfall zone of the Northern Territory. *Plant Introduction Review*, 10(1): 13-19.
85. MINSON, D. J. (1971)—The nutritive value of tropical pastures. *Journal of the Australian Institute of Agricultural Science* 37: 255-263.
86. MORGAN, G. W. (1974)—Crop productivity as affected by depths of topsoil spread for reclaiming bauxite-mined lands in Jamaica. *Tropical Agriculture, Trinidad* 51: 332-346.
87. NAPPER, D. M. (1965)—“Grasses of Tanganyika”, Ministry of Agriculture, Forests and Wildlife, Tanzania, Bulletin No. 18.
88. NG, T. T. (1972)—Comparative responses of some tropical grasses to fertilizer nitrogen in Sarawak, E. Malaysia. *Tropical Grasslands* 6: 229-236.
89. PRITCHARD, A. J. (1967)—Apomixis in *Brachiaria decumbens* Stapf. *Journal of the Australian Institute of Agricultural Science* 33: 264-265.
90. RATTRAY, J. M. (1960)—“The Grass Cover of Africa”, F.A.O. Agricultural Studies No. 49, Food and Agriculture Organization, Italy.
91. REID, R. L., POST, A. J., OLSEN, F. J., and MUGERWA, J. S. (1973)—Studies on the nutritional quality of grasses and legumes in Uganda. I—Application of *in vitro* digestibility techniques to species and stage of growth effects. *Tropical Agriculture, Trinidad* 50: 1-15.
92. RICHARDS, J. A. (1970)—Productivity of tropical pastures in the Caribbean. *Proceedings of the XI International Grassland Congress, Australia*, pp. A49-A56.
93. ROBERTS, O. T. (1970)—A review of pasture species in Fiji. I. Grasses. *Tropical Grasslands* 4: 129-137.
94. ROBYNS, W. (1932)—Contribution à l'étude des graminées du Congo Belge et du Ruanda-Urundi II.—Panicées. *Bulletin du Jardin Botanique de l'état Bruxelles* 9: 171-202.
95. ROBYNS, W. (1934)—“Flore Agrostologique du Congo Belge et du Ruanda-Urundi II. Panicées”, Goemaere, Bruxelles.
96. SANTHIRASEGARAM, K., DIEZ, J., PETERSEN, N. F., and TRIGUEROS, M. V. (1974)—Milk production from four tropical pasture systems. *Proceedings of the XII International Grassland Congress, U.S.S.R. Sectional Papers, Grassland Utilization II*, pp. 599-605.

97. SCHOFIELD, J. L. (1944)—The effects of season and frequency of cutting on the productivity of various grasses under coastal conditions in northern Queensland. *Queensland Journal of Agricultural Science* 1(4): 1-58.
98. SCHOFIELD, J. L. (1945a)—Protein content and yield of grasses in the wet tropics as influenced by seasonal productivity, frequency of cutting and species. *Queensland Journal of Agricultural Science* 2: 209-243.
99. SCHOFIELD, J. L. (1945b)—Preliminary grazing trials with *Stylosanthes guianensis*-grass mixtures. *Queensland Journal of Agricultural Science* 2: 250-255.
100. SCHOFIELD, J. L. (1946)—Mineral content and yield of grasses in the wet tropics as influenced by seasonal productivity, frequency of cutting and species. *Queensland Journal of Agricultural Science* 3: 44-79.
101. STAFF, O. (1919)—Vol. IX Gramineae (Maydeae-Panicaceae), pp. 385-576. In "Flora of Tropical Africa" (Ed. D. Prain), L. Reeve & Co. Ltd., England.
102. STURTZ, J. D., HARRISON, P. G., and FALVEY, L. (1975)—Regional pasture development and associated problems. II Northern Territory. *Tropical Grasslands* 9: 83-91.
103. TEITZEL, J. K. (1969)—Pastures for the wet tropical coast—3. *Queensland Agricultural Journal* 95: 464-467.
104. TEITZEL, J. K., ABBOTT, R. A., and MELLOR, W. (1974a)—Beef cattle pastures in the wet tropics—3. *Queensland Agricultural Journal* 100: 185-189.
105. TEITZEL, J. K., ABBOTT, R. A., and MELLOR, W. (1974b)—Beef cattle pastures in the wet tropics—4. *Queensland Agricultural Journal* 100: 204-210.
106. TEITZEL, J. K., FRANZMANN, B. A., BROADLEY, R. A., and PONT, W. (1972)—Bad year for pangola grass. *Queensland Agricultural Journal* 98: 601-603.
107. TEITZEL, J. K., MCTAGGART, A. R., and HIBBERD, M. J. (1971)—Pasture and cattle management in the wet tropics. *Queensland Agricultural Journal* 97: 25-30.
108. TEITZEL, J. K., and MORTISS, P. D. (1971)—Pastures for the Ingham coast. *Queensland Agricultural Journal* 97: 155-160.
109. TEITZEL, J. K., and WILSON, R. J. (1974)—An observation on the reaction of six grasses to aphids and rust in the wet tropics. *Queensland Journal of Agricultural and Animal Sciences* 31: 31-32.
110. THORNTON, D. D., and HARRINGTON, G. N. (1971)—The effect of different stocking rates on the weight gain of Ankole steers on natural grassland in Western Uganda. *Journal of Agricultural Science, Cambridge* 76: 97-106.
111. THORNTON, D. D., LONG, M. I. E., and MARSHALL, B. (1968)—Nutritive value of grasses in Ankole and the Queen Elizabeth National Park, Uganda I—Collection sites, soils and grasses. *Tropical Agriculture, Trinidad* 45: 257-267.
112. VAN AMSON, F. W., DULDER, I. G. H., and DORN, R. H. A. (1970)—Een onderzoek naar de mogelijkheden van schapegras (*Brachiaria decumbens*) op de witte zanden van de Zanderij-formatie. *Landbouwproefstation Suriname Mededeling* No. 45.
113. WALSH, S. R. (1959)—Improved pastures will fatten cattle in far north. *Queensland Agricultural Journal* 85: 576-592.
114. WHYTE, R. O., MOIR, T. R. G., and COOPER, J. P. (1959)—"Grasses in Agriculture", F.A.O. Agricultural Studies No. 42, Food and Agriculture Organization, Rome.
115. WINTER, W. H. (1976)—Preliminary evaluation of twelve tropical grasses with legumes in northern Cape York Peninsula. *Tropical Grasslands* 10: 15-20.
116. WINTER, W. H., EDYE, L. A., MEGARRITY, R. G., and WILLIAMS, W. T. (1977)—Effects of fertilizer and stocking rate on pasture and beef production from sown pastures in northern Cape York Peninsula. I. Botanical and chemical

- composition of the pastures. *Australian Journal of Experimental Agriculture and Animal Husbandry* 17: 66-74.
117. WINTER, W. H., EDYE, L. A., and WILLIAMS, W. T. (1977)—Effects of fertilizer and stocking rate on pasture and beef production from sown pastures in northern Cape York Peninsula. 2. Beef production and its relation to blood, faecal and pastures measurements. *Australian Journal of Experimental Agriculture and Animal Husbandry* 17: 187-196.
 118. ZERPA, D. M. DE (1952)—*Agron. Trop. Venez.* 2: 215. (Cited in DARLINGTON, C. D., and WYLIE, A. P. (1955)—“Chromosome Atlas of Flowering Plants”, Allen Unwin, London.)
 119. ZERPA, H., and VILLALOBOS, H. (1952)—Graminea forrajera nueva en Venezuela, para la instalacion de potreros, *Brachiaria decumbens*. *Agronomia Tropical, Maracay* 2: 117-121.