IMPROVEMENT OF NADI BLUE GRASS *(DICHANTHIUM CARICOSUM)* PASTURES ON HILL LAND IN FIJI WITH SUPERPHOSPHATE AND SIRATRO: EFFECTS OF STOCKING RATE ON BEEF PRODUCTION AND BOTANICAL COMPOSITION

I. J. PARTRIDGE*

ABSTRACT

Animal and pasture performance were measured over a four year period from a natural Nadi blue grass (Dichanthium caricosum) *pasture and from Nadi blue grass oversown with Siratro* (Macroptilium atropurpureum) *and fertilised with superphosphate. Steers stocked at* 2.5 *beasts ha^{-1}* (10 *beasts to* 4 *ha*) *produced* 0.16 *and* 0.39 *kg liveweight gain head^{-1} day^{-1} on the natural and improved pastures respectively, and at half this stocking rate produced* 0.25 *and* 0.49 *kg head^{-1} day^{-1}. Liveweight gains head^{-1} were negatively correlated with stocking rate and the slope of the regressions was similar for both types of pasture.*

With increasing stocking pressure, the percentage contribution and presentation yields of Siratro declined but the naturalised legumes—hetero (Desmodium heterophyllum), D. triflorum, Alysicarpus vaginalis *and* Mimosa pudica—*increased, especially with superphosphate application.*

The optimum animal production for improved pasture was estimated to be 380 *kg liveweight gain ha^{-1} yr^{-1} at* 3.5 *beasts ha^{-1} but this pasture could not be termed Siratro-based. Hetero was prevalent at stocking rates which allow reasonable weight gains per head but declined, to be replaced by the other naturalised legumes, under very high grazing pressure.*

INTRODUCTION

The areas suited for beef production in the drier zones of Fiji are hill land with a nigrescent soil type. During the 1930's, much of the best hill land was ranched and Nadi† blue grass (*Dichanthium cariscosum*) was sown to improve pastures.

Nadi blue grass is native to the 'black cotton' clays across the north of the Indian sub-continent (Whyte 1968) and grows well on the thinner montmorillonitic 'nigrescent' clays, described by Twyford and Wright (1965), on hills in Fiji. The grass has a number of useful attributes, including its ease of establishment either vegetatively or from seed, good seed production and viability, low fertility requirement, tolerance of waterlogging, tolerance of heavy grazing, and good ground cover for control of erosion and weeds. The leaf morphology and slender flower stems allow good bite size, in contrast to the naturalised fire-climax species, mission grass (*Pennisetum polystachyon*). However it grows poorly during dry weather, being among the poorest of fifteen species tested with nitrogen fertilizer (Partridge unpublished data), and the establishment of legumes into the sward without cultivation is difficult.

Siratro was the most productive legume in cutting trials on hill land and became dominant when sufficient superphosphate was applied (Partridge 1973). This experiment was undertaken to measure animal production from unimproved and improved Nadi blue grass pasture, following the addition of Siratro and superphosphate, and to observe the stability and persistence of Siratro under grazing.

* Sigatoka Research Station, Department of Agriculture, Fiji.

† 'Nadi' is pronounced 'Nandi' under the Fijian system of pronunciation.

METHODS

The trial was carried out at Nawaicoba Research Station (17°55′S, 177°E) about 15 km southeast of Nadi town. Twenty-six hectares of Nadi blue grass pastures on rolling (to 17°) slope were subdivided, with provision of shade and water. Paddock sizes allowed the following stocking rates:

	Stocking rate (beasts ha^{-1})			
Improved pasture	5	2.5	1.25	
Natural pasture		2.5	1.25	0.83

There were two replicates, one being sited on a deeper nigrescent soil of the Koromavu series and the other on a thinner stony soil of the Dakadaka series (Chandra 1972). Chemical analyses of soils from each site are shown in Table 1.

TABLE 1

Chemical analysis of soils at sites 1 *and* 2 *at Nawaicoba.*

	pH	Total N (%)	Avail P (ppm)	Avail K (m.e. %)	Avail Ca (m.e. %)
Site 1	6.05	.36	24	.23	14.5
Site 2	5.50	.21	12	.30	12.5

In October 1971, the Nadi blue grass sward of the improved paddocks was disced lightly and Siratro seed broadcast at about 3 kg per ha, together with superphosphate at 440 kg per ha. Establishment was generally poor because of grass competition and the pastures were grazed during the year. In October 1972, the swards were disced with heavy discs and the seed and fertilizer application was repeated. Establishment was good and three steers were introduced into each paddock in May 1973. The pastures were top dressed with 330 kg superphosphate ha^{-1} in late 1973 and 200 kg in 1974, followed by 90 kg 25% sulphurfortified superphosphate in 1975 and 120 kg sulphur superphosphate in 1976. These applications were based on the results of fertilizer experiments (author's unpublished data). Guava (*Psidium guajava*), the most serious woody weed of range land, was controlled by hand slashing and stump treatment. It was not included in botanical measurements as the weed control measures do not reflect trial treatments.

Animal management

The steers were weighed, after a 16 hour fast, at fortnightly intervals and changed annually in June-July. Except for one month in 1974, the paddocks were set-stocked continuously. Initially, part-Zebu steers of mixed type and age were used but after 1975 they were replaced with more even groups of Santa Gertrudis × Herefords. In early years, replacement steers averaged 220 kg body weight but in later years they averaged 190 kg.

All steers were drenched with an anthelmintic at the start of each grazing year and some steers at the highest stocking rate were drenched during the year.

In 1977, the trial at Site 2 was terminated as the land was required for an alternative use but grazing continued at Site 1 for another year.

Botanical composition measurements

Botanical composition was determined initially (1974-1976) with 1 m × 1 m quadrats in transects across the paddock, using the degree of abundance as the criterion. Abundance was difficult to classify because of the twining or creeping species which predominated. In June 1977, frequency (% presence) was assessed, percentage composition was estimated by the method of Mannetje and Haydock

(1963) and the presentation yield was measured using the comparative yield method of Haydock and Shaw (1975) in 1 m × 1 m quadrats on 0.5% of the total pasture area.

RESULTS

Liveweight gains

Annual liveweight gains per animal were negatively correlated with stocking rate (Table 2 and Figure 1). Table 2 shows the annual gains for each year separately at each site because of the large differences, while Figure 1 shows the correlation between liveweight gains (1973–1977) and stocking rate on improved and natural pasture.

TABLE 2

Annual liveweight gains of steers on improved and natural Nadi blue grass pastures at Nawaicoba.

Year and Rainfall	Stocking rate beasts ha^{-1}	Liveweight gain (kg head^{-1}) Site 1		Site 2		Mean	
		Improved	Natural	Improved	Natural	Improved	Natural
2/5/73-	5.0	84		61		73	
1/5/74	2.5	185	77	116	36	150	56
(2550mm)	1.25	210	137	168	49	189	94
	.83		130		84		107
25/6/74-	5.0	143		58		100	
24/6/75	2.5	206	114	134	55	170	84
(3146mm)	1.25	214	168	190	72	202	120
	.83		155		103		129
25/6/75-	5.0	92		17		55	
26/7/76	2.5	112	50	96	10	104	30
(2430mm)	1.25	160	97	156	45	158	71
	.83		98		112		105
27/7/76-	5.0	46		—15		16	
12/7/77	2.5	153	99	126	19	140	59
(2503mm)	1.25	167	118	175	56	171	87
	.83		86		91		89
13/7/77-	5.0	70					
4/7/78	2.5	137	132				
(1338mm)	1.25	155	101				
	.83		120				

The regression values, optimum liveweight yields per ha, and optimum stocking rate, calculated by the half intercept method of Jones and Sandland (1974), for each year for the two pastures are shown in Table 3.

There was little difference on average between the regression values for animals on improved or on natural pastures, so that, at any particular stocking rate, the former gained about 80 kg per head more than the latter.

The mean cumulative liveweight changes for each treatment for the year 1976–1977 are shown in Figure 2. Patterns of growth in other years did not differ greatly except that steers at five beasts per ha grew more quickly in earlier, wetter years. The steers on improved pastures at the lower stocking rates had relatively constant growth rates throughout the year while those on natural pasture tended to cease gaining in the dry weather after entering the trial in June, and then at the start of the next dry season when the stocking pressure was higher because of increased biomass and declining herbage yields.

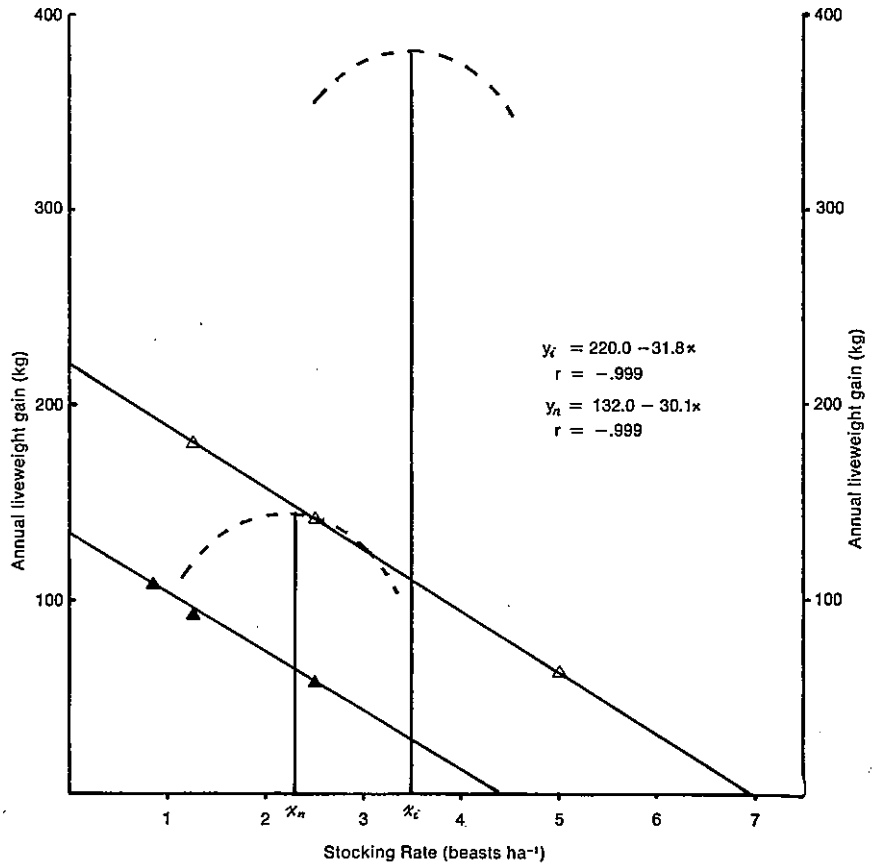

FIGURE 1

Mean annual (1973–77) liveweight gain per head (——) and per ha (– – –) of steers grazing improved (△) and natural (▲) Dichanthium pastures. Optimum stocking rate is shown as x_i (improved) and x_n (natural).

Botanical composition changes

The main species affected by stocking rate and fertilizer were Siratro (*Macroptilium atropurpureum*), hetero (*Desmodium heterophyllum*), *Desmodium triflorum*, *Mimosa pudica* and *Alysicarpus vaginalis*. Wire grass (*Sporobolus* sp.) was more prevalent in the natural pastures as it was reduced by discing for legume establishment.

Because of the difference in fertility and hence in stocking pressure, the results for Sites 1 and 2 are presented separately.

The relative abundance of the species in May 1974, 1975 and 1976 showed little variation. In general, Nadi blue grass remained very abundant, while *Desmodium heterophyllum*, *D. triflorum*, *Mimosa pudica* and *Alysicarpus vaginalis* increased with stocking rate. Siratro declined from very abundant to being absent as the stocking rates of the improved pasture increased. The natural legumes were more abundant in the fertilized pastures.

The patterns of frequency of the main species in May 1977 (Table 4) were similar to the patterns for botanical composition dry weight percentage shown in Table 5 but are more exaggerated for the small naturalised legumes. *Desmodium*

TABLE 3

Regression values of liveweight gain per head (y) and stocking rate (x) for individual years, and calculated optimum liveweight gain per hectare and optimun stocking rate, for improved and natural Nadi blue grass pastures.

Year	Regression y=	r	Optimum gain (kg ha^{-1} yr^{-1})	Optimum stocking rate (beasts ha^{-1})
1973-1974				
Improved	227.5–30.9x	–.999	415	3.6
Natural	132.3–30.5x	–.999	142	2.2
1974-1975				
Improved	237.0–27.3x	–.999	515	4.4
Natural	152.8–27.4x	–.999	214	2.8
1975-1976				
Improved	182.2–26.3x	–.975	319	3.5
Natural	133.0–42.1x	–.975	110	1.7
1976-1977				
Improved	233.0–42.5x	–.990	320	2.8
Natural	107.3–19.0x	–.985	152	2.8
1973-1977				
Improved	220.0–31.8x	–.999	382	3.5
Natural	132.0–30.1x	–.999	145	2.3
Site 1				
Improved	224.5–26.3x	–.999	470	4.4
Natural	145.8–23.0x	–.866	234	3.2
Site 2				
Improved	216.0–37.5x	–.999	313	2.9
Natural	116.5–36.2x	–.917	92	1.7

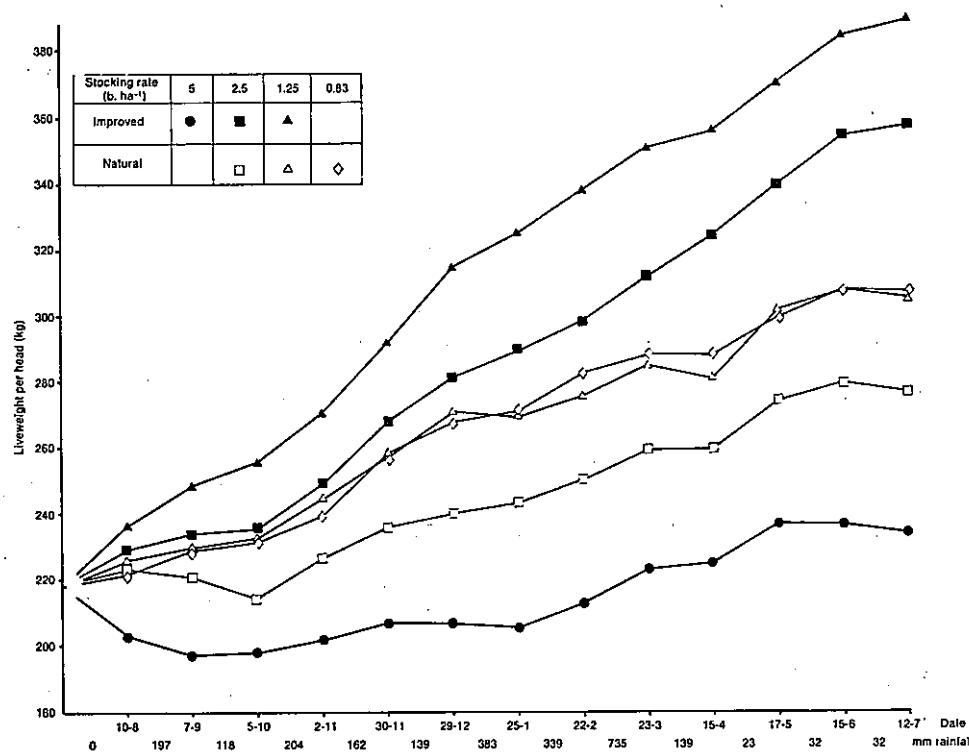

FIGURE 2

Mean liveweight changes of steers grazing improved and natural *Dichanthium* pastures (1976–1977) with rainfall (mm) for each 28 day interval.

triflorum and *Alysicarpus vaginalis*, with over 90% frequency, contribute only 10 to 16% of the yield.

The marked effects of grazing on the presentation yields of edible herbage dry matter are shown in Table 5. Approximately 20% of the total standing herbage was classed as rubbish, being lignified stem or senescent dried leaf.

DISCUSSION

The regressions of liveweight gain against stocking rate conform to the pattern postulated by Jones and Sandland (1974). The calculation of optimum liveweight gains per hectare by the 'half-intercept' method allows a comparison of the animal production from each type of pasture at stocking rates different from the arbitrary rates chosen for the experiment, and shows a 100 to 200 per cent increase from the improvement. The actual weight gain increases are large with an average value of $92 per ha per year at the current price of F$0.40 per kg liveweight.

In comparison with some other Siratro pastures reviewed by Walker (1977), overall production in this trial is high and the regression coefficient (mean $b = -31.8$) is low, being similar to that of the natural pasture. Possible causes for this include the invasion of naturalised legumes such as *Desmodium heterophyllum*, *D. triflorum* and *Alysicarpus vaginalis* which are tolerant of close grazing, the unusually wet conditions and tropical temperatures, and the intense activity of dung beetles.

Under some conditions in other countries, the decline and loss of the planted legume through overgrazing causes a collapse of the system as nitrogen fixation ceases, and some grasses can also be grazed out (Eng *et al.* 1978). In this trial, the previous observation that *Dichanthium* is highly resistant to abuse was confirmed while the naturalised legumes continued to fix nitrogen. Dung beetles (*Pachylister chinensis*), introduced to Fiji in 1938, showed intense activity, even in the dry season, and incorporation of dung pats into the soil started within two to four days. Even at the high stocking rate of five beasts per hectare there were few dry pats on the surface and the animals were free to select herbage. This rapid breakdown and incorporation of faeces should allow rapid cycling of plant nutrients and lower nitrogen losses.

Steers stopped growing during the dry season at the higher stocking rates, especially on natural pasture, but improved pastures produced year-round weight gains at the stocking rates likely on farms. Because the trial spanned a series of wet years, the poor growth of Nadi blue grass in the dry season was less apparent; it suggested that oversowing a legume will overcome the main objection to the use of this grass species in pure swards. The trial indicates that good animal performance can be expected from improved grass pastures, not only on deeper soils in wetter sites such as occur on the nigrescent soils in the Uluisaivou Beef Scheme in north east Viti Levu, but also on the thinner soils with more extended dry seasons in the south-west.

In the improved pastures, plant population density and yields of Siratro declined with the increasing grazing pressure. Similar effects have been described in Queensland (Tothill and Jones 1977). On both sites, Siratro was vigorous at the low stocking rate of 1.25 beasts per hectare with a mat of trailing and rooting stems. It was satisfactory as individual plants at 2.5 beasts per hectare on the more fertile site. At heavier grazing pressures Siratro was eliminated although, in earlier years, occasional seedlings could be seen near dung pats which cattle avoided.

The persistence of Siratro on the shallow heavy self-mulching clays under rainfall exceeding 2500 mm per annum is notable. Generally Siratro is not recommended for the wetter zones because of attack by the *Rhizoctonia* fungus. Although patches of *Rhizoctonia* were common in the wet seasons, the effects were limited to leaf fall and the plants recovered in drier weather. The trial could not be continued for enough years to assess the longer term persistence of Siratro as trends were confounded with

TABLE 4

The effect of pasture improvement and stocking rate (beasts ha^{-1}) on the frequency of the main species at two sites (June 1977).

	Site 1						Site 2					
	Improved			Natural			Improved			Natural		
Species	1.25	2.5	5	.8	1.25	2.5	1.25	2.5	5	.8	1.25	2.5
Dichanthium caricosum	99	100	100	100	98	97	100	100	100	100	99	100
Macroptilium atropurpureum	88	94	—	—	—	—	97	3	—	—	—	—
Desmodium heterophyllum	1	21	70	8	7	55	25	95	82	19	14	31
Desmodium triflorum	—	2	67	—	—	11	4	72	92	2	6	45
Mimosa pudica	16	40	90	5	5	27	11	19	39	—	1	—
Alysicarpus vaginalis	—	—	61	1	1	29	3	53	94	—	14	60
Atylosia scarabaeoides	—	19	14	60	56	37	8	34	27	26	39	50
Sporobolus indicus	3	14	12	44	57	75	4	11	—	22	34	—
Sedges (*Kyllingia sp*)	3	5	31	35	50	33	9	59	80	61	80	73
Psidium guajava	9	29	2	26	26	17	—	17	8	15	17	20

TABLE 5

The effect of pasture improvement and stocking rate (beasts ha^{-1}) on the percentage contribution to dry matter yield of the main species and on the presentation dry matter yield of herbage at two sites (June 1977).

	Site 1						Site 2					
	Improved			Natural			Improved			Natural		
Species	1.25	2.5	5	.8	1.25	2.5	1.25	2.5	5	.8	1.25	2.5
Dichanthium caricosum	70	62	62	68	67	52	58	49	56	68	70	67
Macroptilium atropurpureum	26	26	—	—	—	—	34	—	—	—	—	—
Desmodium heterophyllum	—	6	11	1	—	15	5	27	10	7	2	2
Desmodium triflorum	—	—	10	—	—	—	—	11	16	—	—	5
Mimosa pudica	2	3	12	1	—	1	1	1	—	—	—	—
Alysicarpus vaginalis	—	—	2	—	—	1	—	5	10	—	9	8
Atylosia scarabaeoides	—	1	—	8	8	4	1	1	4	3	4	4
Sporobolus indicus	—	—	—	12	14	21	—	1	—	5	5	—
Edible material (t ha^{-1})	5.7	2.8	.6	2.7	3.0	1.9	4.5	.9	.2	3.7	1.6	.4

a return to more normal drier weather, but it is suggested that a fairly stable situation was reached at each stocking rate.

Improvement of pastures with superphosphate encouraged other legumes, some of which became important at the higher grazing pressures. The order of increasing tolerance to grazing was hetero, *Mimosa pudica*, *Desmodium triflorum* and *Alysicarpus vaginalis*, while *Atylosia scarabaeoides* was of little importance. They survived because of their low growth habit, or in the case of *Mimosa*, the presence of thorns.

Hetero contributes to pasture yield at stocking pressures which still allow acceptable weight gains per beast but the other species occurred mainly at excessively high stocking rates. It is difficult to assess the value of *Mimosa*; cattle nibble the shoots and the roots bear large and active nodules. Increasing *Mimosa* could be a less desirable result of topdressing pastures with super and grazing heavily. *Desmodium triflorum*, studied by Williams and Yunus (1975), would be more suited for sheep than cattle grazing and its leaf shatters in dry weather to provide little feed at this time. *Alysicarpus vaginalis*, described by Martin and Torssell (1974), remains green during dry weather and, although of poor appearance under heavy grazing, will grow to 10 cm height with *Dichanthium* under suitable grazing pressures.

The optimal animal performance from the improved pasture was achieved at a stocking rate of about 3.5 beasts per hectare. At this rate, very little Siratro was present and the pastures could not be termed 'Siratro-based'. This suggests that some of the lower-growing legumes, though of less impressive appearance, are capable of effecting better animal production than expected from cutting trial yields.

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