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COMPOSITION, BIOMASS AND PRIMARY PRODUCTION OF SOME GRASSLANDS IN THE RUHUNA NATIONAL PARK, SRI LANKA.

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ABSTRACT

This paper presents the results of the first botanical studies conducted on the grasslands of the Ruhuna National Park, situated in the arid south-east corner of Sri Lanka, an area that receives low rainfall with pronounced rainy and drought seasons. Three contrasting Study Areas were chosen-inland sites at Kotabandiwewa (sandy soil) and Gallukadawewa (clay soil) and a coastal site at Gonalabba. The main conclusions were (1) the grasslands were dominated by different grass/sedge species-Kotabandiwewa by *Eragrostis viscosa* and *Chloris barbata*,Gonalabba by *Cynodon dactylon* and *Cyperus arenarius* and Gallukadawewa by *Ischaemum rugosum* and *Bulbostylis barbata*.The inland sites had greater species diversity and richness than Gonalabba, (2) biomass was low and seasonal changes at Kotabandiwewa and Gonalabba were, respectively, positively and negatively related with the prevailing rainfall pattern, (3) net primary production at Kotabandiwewa was estimated to be 238/g/m^2/yr and (4) all three grasslands were short-grass communities with a mean height never more than 6 cm.

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INTRODUCTION

Grasslands in Sri Lanka are found throughout the very varied range of environments within the island - from arid coastal regions to wet montane habitats at more than 2200m. The physiognomy and species composition of these grasslands vary considerably between these environmental extremes and have been most extensively studied by Holmes (1951). The origin and status of many Sri Lankan grasslands have not been satisfactorily resolved. There is controversy over whether at least some types are climatic or edaphic climaxes or are of secondary origin from degraded forests (Holmes 1951,Koelmayer 1957, de Rosayro 1957, Perera 1969).

The present study was undertaken to complement studies of the ungulate herbivores in the Ruhuna National Park (Balasubramaniam et al 1980, Santiapillai et al 1980). It is the first study of the Ruhuna grasslands and the objectives were to describe some of the different communities within the Park and to asses their importance as a food source for the herbivores.

RUHUNA NATIONAL PARK

The Ruhuna National Park is situated in the arid south-east corner of Sri Lanka. The annual rainfall is usually less than 1000 mm unequally distributed through the year. There is usually a drought from June to September, a rainy season from October to December and intermittent showers from January to May.

The Park is 1,160 Km^2 and is divided into several Blocks. The present study was carried out in Block 1 (140 Km^2). The vegetation of Block 1 consists principally of riverine forest, thorn scrub and grasslands. The latter are probably sub-climax communities maintained by seasonal flooding and by ungulate and small mammal grazing pressure. The most extensive community is the dense thorny scrub through which visibility rarely exceeds 20 m and is frequently less. This scrub is believed to have resulted from degredation (by over-grazing, burning,logging) of the semi-deciduous closed high forest which is the climatic climax community of this region (Gaussen et al 1968). Grasslands are found throughout Block 1 though they are more common in the central and coastal regions. They are small in size, the largest being about 0.5 Km^2. Together they comprise a small though unknown proportion of Block 1.

Ruhuna National Park supports a large biomass of herbivores, the most important being spotted deer(*Axis axis* Erxleben), water buffalo(*Bubalus bubalis* L), elephant (*Elephas maximus* L), wild boar (*Sus scrofa* L); sambar (*Cervus unicolor* Kerr) and Indian

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hare (*Lepus nigricollis* (Cuvier)). For a fuller description of Ruhuna see Comanor (1971) and Mueller-Dombois (1968 and 1972).

STUDY AREAS AND METHODS

The study was carried out from November 1979 (wet season) to the beginning of the drought in June 1980. Prior to the commencement of the study, preliminary observations had shown that there were at least two types of grassland communities - those surrounding the coastal (saline) lagoons and those in the interior of the Park. Accordingly one lagoon site (Gonalabba) and one inland site (Kotabandiwewa) were chosen for study (Fig. 1). Towards the end of the study a second inland site at Gallukadawewa was also studied. It become apparent that this was a third vegetation type because its flora remained lush whilst that at Kotabandiwewa was drying up.

KOTABANDIWEWA

Kotabandiwewa is a small villu (waterhole) surrounded by a small heavily-grazed grassland in the northern part of Block 1. The water in the villu is derived directly from rain and dries out during the dry season. The Study Area at Kotabandiwewa was situated in the south-eastern part of the grassland, between the villu and the fringing scrub. The soil was mainly sand with some clay and very little organic matter.

The species composition of the Study Area was recorded in November by visual assessment of (1) total vegetation cover and (2) the percentage cover of each species (as a proportion of (1) in 1/2x1/2m quadrats at 3m intervals along a transect line from the waters edge to the border of the surrounding scrub. Thereafter the composition was assessed by examining randomly placed quadrats. Biomass and productivity of the grassland were estimated by the paired-plot method (Milner and Hughes 1968) which sums all positive increments in the biomass of live material over each sampling period. Three pairs of sample plots were selected at each visit and the vegetation cut down to soil level in one plot of each pair. The uncut plot of each pair was lightly covered with thorny branches to prevent ungulates from grazing and the biomass recorded on the following visit. The cut vegetation was sorted into live and dead material and weighed after drying at 90^{0} C. All biomass and productivity estimates are given as g dry wt/m^2 .

The height of the vegetation was estimated by measuring the height of the tallest touching plant part on a rule placed vertically in vegetation. The average of 10 such measurements was taken as an estimate of the mean maximum vegetation height. Species diversity was

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taken to be the total number of species found during the study period. Species richness was recorded as the number of species present in the vegetative phase on each sampling date.

GONALABBA

Gonalabba is the largest of the saline coastal lagoons. It is not normally open to the sea, but is brackish due to the seepage of seawater through the bordering sand dunes. During the dry season the waters become hypersaline.

The Study Area at Gonalabba was situated on the northern shore of the lagoon about 250 m from the sea shore. The surface soil comprised almost completely of loose clean sand with little clay or humic content. The vegetation between the lagoon edge and the scrub consisted of two major zones-a flat area some 30 m wide bordering the lagoon and dominated by grass and sedge (to which studies were confined) and a slope to the edge of the scrub dominated by the woody perennial *Tephrosia purpurea* Pers.

Species composition,biomass, diversity and richness and vegetation height were assessed as at Kotabandiwewa. No estimate of net primary production was possible as the exclosures were always destroyed by ungulates. Access to this site was not always possible because of flooding.

GALLUKADAWEWA

This grassland in the central region of Block 1 contains several small villus that dry up during the drought period. The Study Area was situated on the southern side of the grassland in a part that continued to receive water as seepage from the surrounding scrub well into the drought periods. The soil in the Study Area was made up of a surface layer of clay (2-3 cm thick) overlying a layer of clean sand some 8-10 cm thick. Below this sand was a second layer of clay.

Species diversity and richness were recorded from March onwards whilst biomass was measured once (June).

RESULTS

SPECIES COMPOSITION

The species composition of the grasslands on each sampling date at Kotabandiwewa, Gonalabba and Gallukadawewa, together with estimates of frequency of occurrence and % cover of each species are shown in Table 1.

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The data show three major phenomena: (1) the three grasslands differed in their dominant communities, (2) species richness decreased after the October - December rainy period and (3) at least Kotobandiwewa and Gonalabba had different species diversity.

The Kotabandiwewa grassland was dominated throughout the study by *Eragrostis viscosa* and *Chloris barbata*. The former species occurred infrequently at Gonalabba and the latter not at all. Instead Gonalabba was dominated throughout by *Cynodon dactylon* and *Cyperus arenarius*. From December onwards these were the only two species recorded from Gonalabba. The third grassland, Gallukadawewa, had a richer grass/sedge flora, being dominated by *Bulbostylis barbata*, *Eragrostis viscosa*, *E. unioloides* and *Ischaemum rugosum*. The last species was the most common at Gallukadawewa but was absent from the other two grasslands. Thus the three Study Areas were dominated by different grass/sedge species and in each there were species which occurred infrequently or not at all in the others - *Chloris barbata* at Kotabandiwewa, *Cyperus arenarius* and *Cynodon dactylon* at Gonalabba and *Ischaemum rugosum* and *Bulbostylis barbata* at Gallukadawewa.

The three grasslands differed not only in their grasses and sedges but also in their forbs. Most forbs (19) were recorded from Kotabandiwewa, although at least this number would likely be found at Gallukadawewa at the beginning of the west season. The first sample in this Study Area was taken in March when 11 species of forbs were recorded. The corresponding figure for Gonalabba in March was 2. Earlier samples were not taken at Gallukadawewa and therefore detailed comparisons of the three grasslands were not possible. However some broad differences were apparent - *Murdannia spirata* and *Eriocaulon quinquangulare* were dominant species at Gallukadawewa but were absent from Kotabandiwewa. At both of these grasslands the legume *Desmodium triflorum* was abundant. The forbs at Gonalabba were the poorest of the three Study Areas - only 9 species were recorded in November and none on subsequent samplings.

The second major point concerning the vegetation of the grasslands was that species richness decreased throughout the study period (Table 1). At Kotabandiwewa it decreased from 25 to 6 species between November and March and to 2 by June. At Gonalabba richness declined from 16 to 2 species in the space of 5 weeks between November and December and remained at that level to the end of the study. At Gallukadawewa richness decreased from 17 species in March to 10 in May and June. Thus at both Kotabandiwewa and Gonalabba the initial flourish of species in November was rapidly extinguished and no forbs survived to June. At Gallukadawewa however the decline in species richness was less rapid and 5 species of forbs were still flourishing in June. As these figures show, species diversity was greater at Kotabandiwewa (25) than Gonalabba (16) and Gallukadawewa (17). More species would probably be recorded from the last site at the beginning of the growing season.

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BIOMASS

The biomass of the live vegetation on the grasslands at Kotabandiwewa and Gonalabba on each sampling date is shown in Table 2 and represented graphically together with monthly rainfall totals in Fig. 2.

The data show three main features: (1) biomass totals at Kotabandiwewa and Gonalabba had bimodal distributions, (2) at Kotabandiwewa biomass fluctuations were positively correlated with the rainfall pattern and (3) at Gonalabba biomass changes were negatively correlated with rainfall.

At Kotabandiwewa both rainfall (375 and 65 mm) and biomass (84.8 and 106.8 g/m^2) were high in November and December respectively. Rainfall was less (37 mm) in January and zero in February and biomass declined rapidly to 18.4 g/m^2 in mid-March. Heavy showers in April and May (96.7 and 56.6 mm respectively) resulted in the regeneration of the vegetation to a peak of 60.8 g/m^2 in May. There was no rainfall in June and biomass dwindled to 5.3 g/m^2 by the end of the month.

At Gonalabba both biomass (87.6 g/m^2) and rainfall were high in November. In December however biomass declined to 19.6 g/m^2 whilst rainfall remained high. Following this, biomass increased to 120.8 g/m^2 in mid-March as rainfall fell to zero. After the high rainfall in April biomass at Gonalabba decreased in May. As rainfall fell to zero in June biomass remained high. Thus at Gonalabba high rainfall was associated with low or declining biomass and low rainfall with high or increasing biomass.

Biomass at Gallukadawewa was recorded only once, in June. Then it was 101.6 g/m^2 , the highest of all three Study Areas at that time of the year. Thus biomass remained high here despite the complete absence of rainfall in that month, a situation which at Kotabandiwewa had caused the virtual elimination of all live vegetation.

PHYSIOGNOMY

The heights and standard errors of the grassland vegetation at Kotabandiwewa and Gonalabba were estimated on each sampling date.

Although these localities were dominated by different species the physiognomy of each was similar. At Kotabandiwewa the mean maximum heights of the communities varied little throughout the season - from 4.5 ± 0.4 cm to 5.7 ± 0.7 cm. At Gonalabba heights were generally

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less - from 3.7 ± 0.4 cm to 4.8 ± 0.6 cm. On the last sampling date however (21 June) the vegetation at Gonalabba was significantly shorter (mean height 1.8 ± 0.3 cm)

Thus the grasslands of Kotabandiwewa and Gonalabba presented at all times the appearance of a close - cropped turf. The height of the vegetation at Gallukadawewa, though not measured, was similar to the others.

PRODUCTIVITY

The estimates for net primary production (P_N), excluding any losses due to insect and other invertebrate herbivores and litter production, at Kotabandiwewa are given in Table 3.

The total of 198 g/m^2, which also includes an estimate for the period preceding November 1979, must be considered an underestimate of the true total. This is for two main reasons - (1) the estimate for the period before November was taken to be the same as the biomass present on 24 November, assuming zero biomass at the beginning of the growing season (about mid-September). This could only be an underestimate as grazing had obviously taken place and (2) the coverings of thorny branches were only partially successful and may not always have provided complete protection.

Although P_N may be an underestimate, the patterns of production through the seasons were apparent. Production occurred during the rainy season up to the end of December. In 1979 the rains started in September, rather earlier than usual, and production would also have started then. From January to mid-March there was little or no production because of insufficient rainfall. Following the onset of rains once more in April and May there was another period of production which was terminated by the absence of rain in June.

As stated above the protective thorny coverings may not always have been 100% effective. However they did provide complete protection during the period 10 April to 23 May (during which time the vegetation grew to a height of 19.4 2.1 cm, compared to the more normal 4-5 cm in the grazed areas). The production during this time was 59.2 g/m^2 (9.9 g/m^2/ wk) and this figure may be used to provide another more realistic estimate of P_N during the growing season. This was about 15 weeks from mid-September to the end of December and 9 weeks in April and May, about 24 weeks altogether. This gave an estimate of P_N of 238 g/ m^2/ yr. Again this may be an underestimate as species richness was low in April and May compared to earlier in the season and therefore P_N was also perhaps lower.

The productivity data, despite their possible inaccuracies, nevertheless show important trends - (1) the growing season at Kotabandiwewa was short, not more than about 24 weeks and was dependent upon prevailing rainfall patterns and (2) total P_N for the year was low.

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DISCUSSION

Rather than presenting a uniform sward the grasslands of Ruhuna comprised a mosaic of at least three different communities. These were dominated by (1) *Eragrostis viscosa* and *Chloris barbata*, (2) *Cynodon dactylon* and *Cyperus arenarius* and (3) *Ischaemum rugosum*. They also varied in their associated forb species. None of these vegetation types has been described before from Sri Lanka as earlier studies have tended to be in upland, montane and/or wetter regions. Besides differing in their floristic composition the grasslands also varied in their biomass characteristics, reflecting the several ways in which they responded to identical conditions of rainfall and temperature.

The differences between the grasslands were most likely responses to variations in topography and soil conditions at the three Study Areas. The inland site at Kotabandiwewa was flat and the soil sandy, loose and porous. The vegetation was entirely dependent upon direct rainfall for its water as none was available as seepage from the nearby forest or villu. Thus without frequent rain the soil and vegetation quickly dried up. Hence biomass changes at Kotabandiwewa were closely and positively related to the rainfall pattern. There were two peaks of rainfall during the study with a short drought between them. During this drought the vegetation at Kotabandiwewa virtually disappeared but quickly re-established itself, albeit with lower species richness, during the second rainy period.

At the other inland site, Gallukadawewa, the soil was made up of three distinct layers - clay on top, then sand followed by more clay. In addition the Study Area was an incline and received seepage from adjacent forest even in times of drought. The two clay layers ensured that the water neither drained away nor evaporated rapidly. Thus at the end of June, when the vegetation at Kotabandiwewa and many other inland sites had died off, there was still luxuriant growth and high biomass at Gallukadawewa. Even at this locality most of the vegetation had died off by June. Only those parts that received seepage supported vegetation in the drought.

The plant community and biomass characteristics were different again at Gonalabba, the coastal site. This Study Area was flat and the soil sandy and porous as at Kotabandiwewa. However the site was close to the saline lagoon which received water from both seawater seepage through the fringing dunes and from rainfall. The level of water in the lagoon was therefore variable, rising during times of heavy rain and falling during periods of drought. At the beginning of the study in November, both species richness and biomass were high, but declined sharply by the end of December. At this time the level of water in the lagoon was high and the Study Area was flooded with blackish water. This caused all forbs to be killed

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and the virtual disappearance of the dominants *Cynodon dactylon* and *Cyperus arenarius*. After December rainfall decreased and the water level receded. This resulted in the resurgence of the dominants although no other plants grew again. Even though the soil at Gonalabba was sandy it remained moist right through to June because of the high water table associated with the lagoon.*Cynodon dactylon* and *Cyperus arenarius* were able to tolerate the high salinity and therefore formed a salt marsh vegetation.

The biomass changes at Gonalabba did not follow the same pattern as at Kotabandiwewa. At the end of the rainy season in December biomass at Gonalabba was low due to the area being flooded with brackish water and much of the vegetation being killed. Biomass increased when the rainfall decreased and the water level of the lagoon receded. It remained high even during periods of drought due to the raised water table and the tolerance of the dominants to the saline soil.

The different responses of the grasslands to the topographical variations and rainfall are important to the grazing herbivores of Ruhuna. If all grasslands behaved as Kotabandiwewa then these animals would be able to find fresh forage only during periods of heavy rain. However as some grasslands received seepage from surrounding forests or lagoons fresh grazings were available during short droughts (January/February) and well after the beginning of the main drought (end of June). Grassland types such as Gonalabba and Gallukadawewa although smaller in extent than types such as Kotabandiwewa are important in the overall economy of Ruhuna. Perhaps an indication of the increased grazing pressure at Gonalabba in June, when other grasslands have dried up, was that the mean vegetation height at this time (1.8 cm) was significantly shorter than at any other time of the year. Gonalabba and other marsh communities therefore reduce the effective length of the drought periods.

The estimate of aerial P_N at Kotabandiwewa was 238 $g/m^2/yr$. With the growing season about 24 weeks this was equivalent to a daily production rate of 1.4 g/m^2 during this time. Bourliere and Hadley (1970) reported that African grasslands from arid and semi-arid regions had a daily net primary production during the growing season from 1 - 4 g/m^2. This suggests therefore that the Kotabandiwewa grassland was comparatively unproductive in relation to similar communities elsewhere. Overall, production was limited both by the poor soil and low rainfall, the latter limiting growth to about half the year at Kotabandiwewa. At Gonalabba and Gallukadawewa P_N, although not measured, was probably higher as the growing season was longer and generally biomass and plant cover were greater than at Kotabandiwewa. All these characteristics are directly related to annual production (Singh et al 1975).

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The total area of grassland at Ruhuna is not known, although small in relation to that of thorny scrub. Nevertheless they are important sources of food to grazing herbivores such as spotted deer, bufflo, wild pig and elephant, especially after the end of the June - September/October drought. Studies in Africa by Petrides and Swank (1965) and Strugnell and Piggot (1978) suggest that up to 60% of P_N may be available to grazing herbivores in short grass communities such as those at Ruhuna. Grasslands like Kotabandiwewa therefore provides a maximum of 143 $g/m^2/yr$ for grazing herbivores in 1979/1980.

This study has shown that the seasonal rainfall pattern in Ruhuna was an important factor in determining the timing of events such as vegetation growth and decay and thefore seasonal patterns of productivity. Previous studies have shown that annual totals of production by grasslands were to a large extent dependent upon annual rainfall. As rainfall varies from year to year at Ruhuna, so will P_N. In grasslands such as Kotabandiwewa that are dependent on direct rainfall for plant growth and that have sandy porous soils, there may also be a minimum monthly rainfall that must be exceeded for production to occur. This would appear to be in excess of 37 mm as this amount fell in January 1980 but P_N for that month was zero.

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Table 1 Species composition, frequency (% quadrats in which the species occurs) and % cover (A, 1%; B, 10%; C, 25%; D, 50%; E, 75%) of each species at Kotabandiwewa, Gonalabba and Gallukadawewa, Ruhuna National Park, November1979–June 1980.

SPECIES	KOTABANDIWEWA					GONALABBA					GALLUKADAWEWA		
	Nov	Mar.	Apr.	May	June	Nov	Dec	Mar.	May	June	Mar.	May	June
AIZOACEAE													
Glinus oppositifolius (L)A.D.C.	8,A	20,B		20,A		9,A							
PORTULACEAE													
Portulaca oleracea L.	17,A												
TILIACEAE													
Corchorus aestuans L.	17,A					36,A							
MALVACEAE													
Sida cordifolia L.				10,A		9,A							
CAPPARACEAE													
Cleome viscosa L.	8,A												
LEGUMINOSAE													
Alysicarpus vaginalis(L)DC.						9,A					20,A		
Atylosia scarabaeoides(L)Benth.	8,A					9,A							
Cassia tora L.	25,B												
Desmodium triflorum DC.	42,B	50,B	100,B	100B		9,A					100,A	100,B	80,B
Dichrostachys cinerea(L)W&A.				5,A									
Indigofera tinctoria L.	75,B												
Zornia diphylla (L)Pers.	17,A												
EUPHORBIACEAE													
Euphorbia thymifolia Burm.												40,A	
Phyllanthus debilis Klein.						18,A							

Table 1 (continued)

SPECIES	KOTABANDIWEWA					GONALABBA					GALLUKADAWEWA		
	Nov	Mar.	Apr	May	June	Nov	Dec	Mar	May	Jun	Mar	May	June
POLYGALACEAE													
Polygala javana DC.	17,A												
BORAGINACEAE													
Heliotropium scabrum Retz.	33,B												
LABIATAE													
Geniosporum tenuiflorum(L)Merr.											20,A	20,A	
Ocimum sanctum L.	8,A												
SCROPHULARIACEAE													
Dopatrium junceum(Roxb)B-H											60,A		
Lindernia antipoda(L)Alston.	67,B										100,B	60,B	80,B
Lindernia crustacea(L)F.Muell.	42,A										100,B		
ACANTHACEAE													
Barleria mysorensis Roth.		10,B		10,A		9,A							
CAMPANULACEAE													
Lobelia L. sp.											20,A		60,A
RUBIACEAE													
Oldenlandia corymbosa	33,A										20,A		
COMPOSITAE													
Acanthospermum hispidum DC.	8,A												
Blumea bifoliata(L) DC.											60,B		
COMMELINACEAE													
Commelina diffusa Burm.						18,A							
Murdannia spirata(L)Brueckn.											100,C	100,B	80,B

Table 1 (continued)

SPECIES	KOTABANDIWEWA					GONALABBA					GALUKADAWEWA		
	Nov.	Mar.	Apr.	May.	Jun.	Nov.	Dec.	Mar.	May	Jun.	Mar.	May.	June
ERIOCAULACEAE													
Eriocaulon quinquangulare L.											100,B	60,B	100,B
GRAMINAE													
Alloteropsis cimicina Presl.	25,B												
Brachiaria distachya(L)Stapf.						27,B							
Chloris barbata Sw.	66,C	75,B	100,B	100,B	100,B								
Cynodon dactylon(L)Pers.						100,D	100,B	100,E	100,E	100,E	20,A	20,B	
Dactyloctenium aegyptiacum Willd.	25,B	30,B				65,B							
Eragrostis uniolodes(Retz)Nees.	33,B										20,A	20,A	20,A
Eragrostis viscosa(Retz)Trin.	100,C	100,C	100,D	100,D	100,B	9,A					100,C	100,C	60,C
Ischaemum rugosum Salisb.											100,C	100,E	100,D
Sporobolus diander(Retz)Beauv.	17,B												
CYPERACEAE													
Bulbostylis barbata(Rottb)Clarke.	91,B					18,A					80,B	40,A	60,B
Cyperus arenarius Retz.						82,C	100,B	100,E	100E	100,D			
Cyperus iria L.						27,B							
Cyperus killyngia Endl.													60,B
Cyperus stramineus Nees.	67,B												
Lipocarpha chinensis(Osb)Mern.											20,A		
TOTAL NUMBER OF SPECIES	25	6	3	7	2	16	2	2	2	2	17	10	10
% VEGETATION COVER	70	15	50	50	5	65	15	90	100	80	80	70	70

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Table 2 *Biomass (g dry wt/m^2) of grassland vegetation at Kotabandiwewa and Gonalabba, Ruhuna National Park, November 1979 - June 1980.*

Date	Kotabandiwewa (g dry wt/mt^2)	Gonalabba (g dry wt/m^2)
24 November	84.8	87.6
30 December	106.8	19.6
7 February	37.6	-
15 March	18.4	120.8
10 April	59.2	-
23 May	60.8	150.8
21 June	5.3	78.8

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Table 3

Net primary production (g dry wt/m^2) at Kotabandiwewa, Ruhuna National Park, November 1979 - June 1980. (B_1 = biomass of vegetation from control plot, B_2 = biomass from covered plot, P_N = net primary production.

Date	B_1	B_2	$P_N(B_2-B_1)$
24 November	0	84.8	84.8
30 December	84.8	108.8	24.0
7 February	106.2	40.0	0
15 March	37.6	14.8	0
10 April	18.4	48.4	30.0
23 May	59.2	118.4	59.2
21 June	60.8	5.3	0
		TOTAL	198.0

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FIGURE LEGENDS

Figure 1 Map of Block 1, Ruhuna National Park, showing Study Areas ( ) , tourist bungalows ( ), boundary (....) and main roads (- - - -).

Figure 2 Biomass (g/m^2) of grassland vegetation at Kotabandiwewa and Gonalabba and monthly rainfall (mm), . Ruhuna National Park, November 1979 - June 1980. (..... , rainfall; , Kotabandiwewa; X X, Gonalabba).

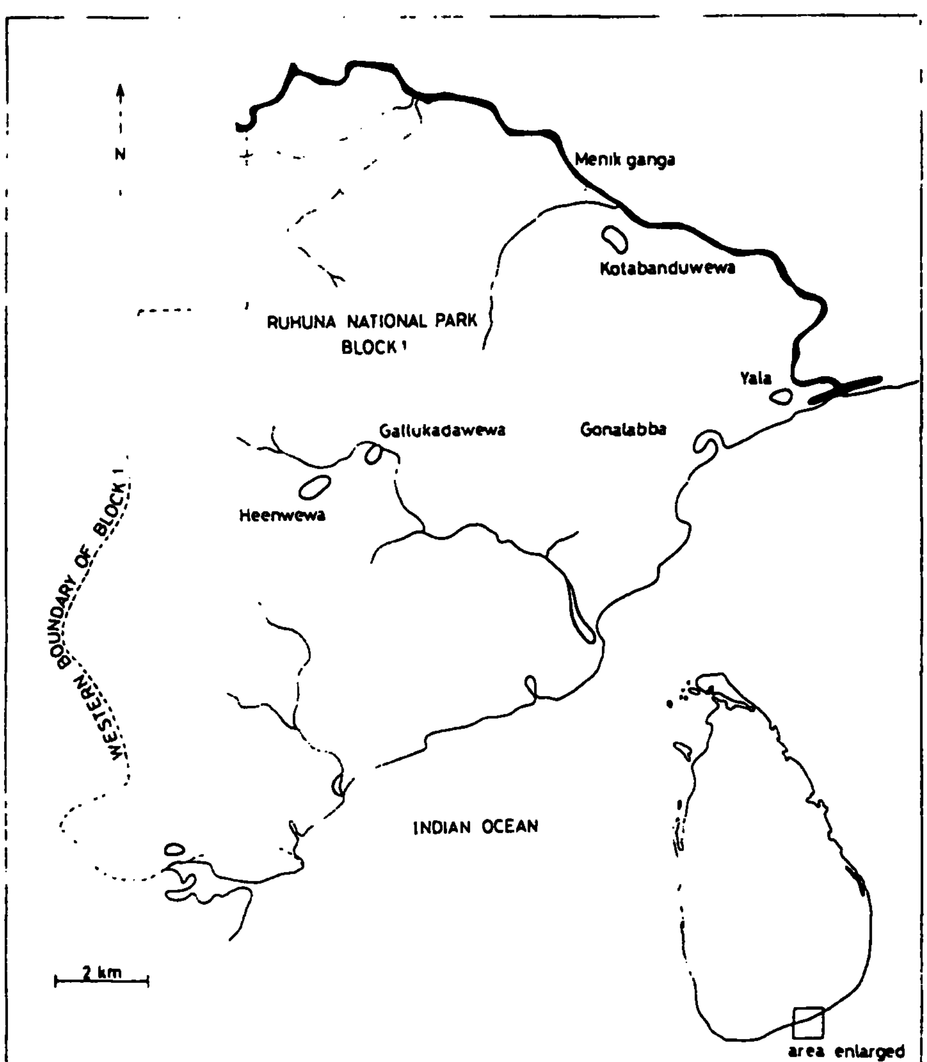

Fig. 1. Chambers, Balasubramaniam, Santiapillai & Ishwaran (1982). Composition, biomass and primary production of some grasslands in the Ruhuna National Park, Sri Lanka.

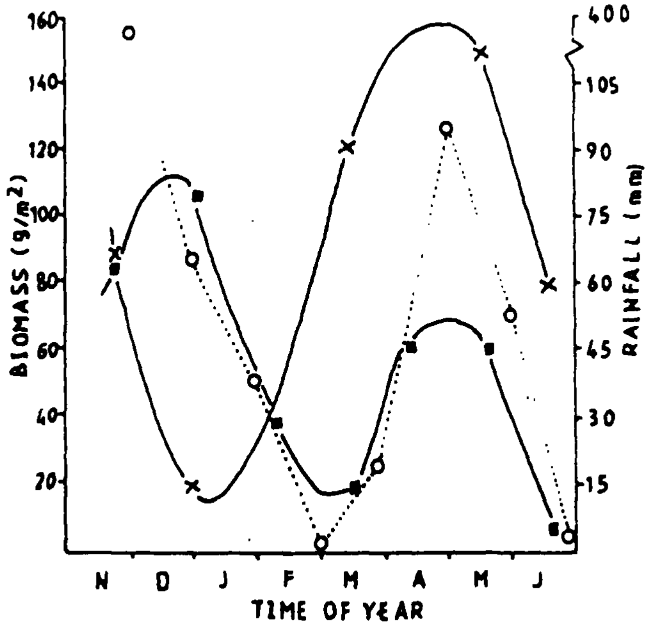

Fig 2 Chambers et al., (1982) Composition, biomass and primary productivity of some grasslands in the Rubuna National Park, Sri Lanka.