Grazing buffalo on flooded pastures in the Brazilian Amazon region: a review

A.P. CAMARAO[1], J.B. LOURENCO JR[1], S. DUTRA[1], J-L. HORNICK[2] AND M. BASTOS DA SILVA[2]
[1] *EMBRAPA Eastern Amazon, Belém-Pará State, Brazil*
[2] *University of Liège, Tropical Veterinary Institute, Liège, Belgium*

Abstract

There are almost 3.5 M head of buffalo in Brazil, half of which (±1.75 M animals) are in the north, particularly on Marajó Island, in the lower and middle Amazon, and on upland cultivated pastures, 16% in the south-east, 15% in the north-east, 13% in the central west and 6% in the south. The objective of this work was to review the important characteristics of the native pasture ecosystems grazed by buffalo in the flooded areas of the Brazilian Amazon. Data relative to environment, pasture characteristics and animal performance are presented. Three buffalo subspecies, bubalis (water buffalo — Mediterranean, Murrah, Jafarabadi), kerebau (swamp buffalo) and fulvus (Baio type) live in the Amazon Region, their ideal habitat. They are used for meat and milk and as a source of power, and are well adapted to wet conditions, producing and reproducing in flooded native pastures, where cattle don't usually survive.

Introduction

In the Brazilian Amazon, native pastures cover 75 M ha, of which 50 M ha are dry land and 25 M ha are subject to flooding (Serrão 1986). These pastures are classified into 3 main ecosystems according to hydrological, edaphic and vegetative characteristics: *1) the well drained savannas that represent two-thirds of the surface; 2) the badly drained savannas with flooded gradients where native gramineae develop at different levels on alluvial soils,* e.g. *pastures on Marajó— Island; and 3) the pastures on alluvial soils exposed to periodic flooding.*

Cattle breeding in the Brazilian Amazon began on Marajó Island in 1680 and later extended to the lower Amazon River. It was only from the 1970s onwards, with the opening of the Belém-Brasilia highway, that cultivated pastures on formerly forested areas were used in beef cattle production. Around 25–35 M ha of forest has been cleared to establish pastures and agricultural plantations in the Brazilian Amazon, destroying the native vegetation and damaging the environment (Skole and Tucker 1993).

The native pastures form stable ecosystems which have been utilised extensively for more than 300 years, mainly for beef cattle and buffalo, with limited levels of degradation. The native pastures on alluvial soils have played a particularly fundamental role in the development of cattle and buffalo husbandry in the Brazilian Amazon because they produce high yields of good quality forage (Camarão *et al*. 1998). This intensive but rational use of native pastures may reduce the need for deforestation of dry land and may increase meat and milk production.

The objective of the present study was to describe the environment, as well as both pasture and animal management, of native flooded pastures of the Brazilian Amazon region, highlighting the potential for buffalo to produce milk and meat.

1. Environment

1.1 Geographical distribution

Figure 1 shows the geographical distribution of the main types of vegetation in the Brazilian Amazon.

Correspondence: Dr Miriam Bastos da Silva and Dr Jean Luc Hornick, University of Liège, Tropical Veterinary Institute, Boulevard du Colonster, 20, Bât. 43, Sart Tilman 4000 Liège, Belgium. e-mail: miriam.bastosdasilva@skynet.be; jlhornick@ulg.ac.be

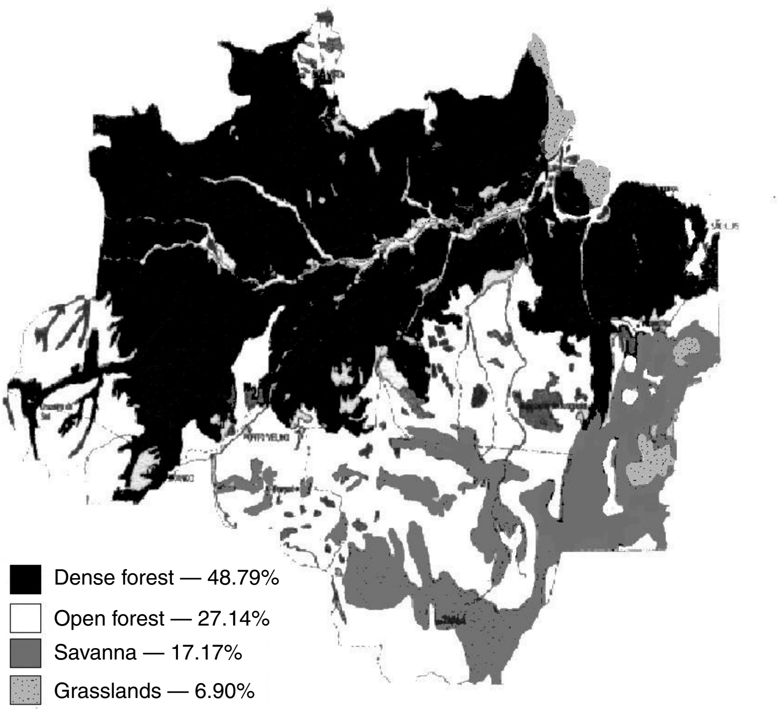

Figure 1. Geographical distribution of the various forms of vegetation cover in the Brazilian Amazon (Nascimento and Homma 1984).

The native pastures on alluvial soils are localised on the margins of the Amazon River, in muddy lakes from its overflows and in the estuary. Most of these pastures are in the lower mid-section of the Amazon River and on Marajó Island. They are important sites for cattle husbandry and include Para State (Careiro Island) and Amazon State (the Altazes Region) as well as around 11.7% of Amapa State (Serrão and Falesi 1977; Rabelo and Chagas 1995).

1.2 *Climate*

Native pastures on alluvial soils occur mainly in areas with Am and Aw climates as classified by Köppen (Serrão *et al.* 1979). The average temperature varies between 24 and 28°C, with maxima generally between 29 and 34°C and minima between 16 and 24°C. The main rainy period occurs between December and May–June and annual rainfall varies from 1500 to 3500 mm/year, depending on the region, with a water surplus in January–June and a deficit in August–December. The relative humidity varies from 70 to 90% and the annual sunshine from 1500 to 3000 h. Figure 2 presents mean climatic data from Monte Alegre, Pará, Brazil, where native forage occurs on alluvial soils (Oliveira Junior *et al.* 1999).

1.3 *Soils*

Hydromorphic soils predominate, resulting from annual and daily sediment accumulation, respectively, in the lower-middle Amazon and in the estuaries. These sediments give rise to high soil fertility (Table 1) and high forage production (Serrão 1986).

1.4 *Water*

The levels of organo-mineral sediments in the water have a strong influence, as sources of nutrients, on pasture productivity. The waters of the Solimões River are richer in inorganic substances than the other rivers in the Brazilian Amazon. This river is extremely muddy and carries sediments originating from fertile soils in the Andes, at 50–150 mg/L. Consequently, the

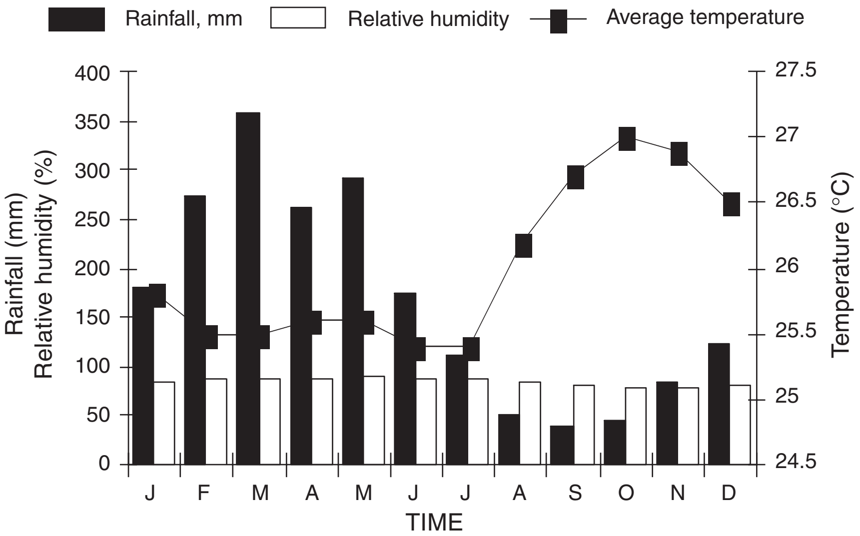

Figure 2. Medium-term (10 years) mean data for rainfall, relative humidity and temperature at Monte Alegre, Para State, Brazil (Oliveira Junior *et al*. 1999).

Table 1. Chemical composition of alluvial soils (0–20 cm) from typical floodplains (varzeas) of the Amazon Region (Serrão 1986).

Location	$Ca^{2+} + Mg^{2+}$	Al^{3+}	pH	K	P
	($mmol_c$/kg)	($mmol_c$/kg)	($H_2$0)	(mg/kg)	(mg/kg)
Monte Alegre, PA (Lower Amazon)	6.0	2	5.4	230	51
Marajó, PA (Amazon estuary)	7.4	–	4.9	168	18
Amapá, AP (Amazon estuary)	8.2	8	5.7	147	68
Barreirinha, AM (Mid-Amazon)	6.1	8	5.1	75	42

floodplain "várzeas" (Humic Gley and Low Humic Gley) and pastures served by this river generally have high fertility. Mineral levels in dryland soils are much lower (Table 2). Typically, the floodplain lakes receive two types of water: with sediments (muddy and mineral-rich) and without sediments (clear), and the proportions are dependent on the size and location of the lakes (Howard-Williams and Junk 1977). Furthermore, the primary productivity of the herbaceous stratum decreases as the water becomes clearer (Serrão 1986).

In general, the utilisation of flooded pastures is closely related to the river water level. In the lower-middle Amazon River, for example in Santarém, Pará State, there is a 5 m difference in water level between November–December, when the floodplains present excellent conditions for grazing livestock, and May–June, when pastures are continuously flooded (Figure 3).

Table 2. Mineral concentrations of suspensions in river water, plus sediments deposited on floodplains and dryland ("Terra firme") soils in the central Amazon. Adapted by authors from Howard-Williams and Junk (1977).

Chemical components	Sediments in suspension	Sediments deposited	Dryland soil ("Terra firme")
	(%)	(%)	(%)
Na	0.06	0.023	0.01
K	0.04	0.023	0.01
Ca	0.94	0.540	0.00
Mg	0.11	0.064	0.01
P	0.064	–	–
Fe	1.48	–	–

1.5 Vegetation

The most important forage grasses are listed in Table 3. "Amphibious" species (Black 1950) survive by floating or submersion during the floods. Thus, with the exception of *Paspalum fasciculatum,* which occurs in the upper areas of the floodplains, they are inaccessible to cattle. Only buffalo are able to efficiently use this forage during flooding (Camarão *et al.* 1997). However, these grasses are still vegetative as floodwaters recede, and during the dry periods, they become available for cattle (Serrão *et al.* 1991).

Table 3. The most important grasses on alluvial floodplains for animal production.

Scientific name	Common name
Echinochloa polystachya	Canarana verdadeira, canarana fluvial and canarana de pico[1,2,3,4]
Hymenachne amplexicaulis and *Hymenachne donacifolia*	Rabo-de-rato[1,2,3,4], paja de água and dal[2,3,]
Leersia hexandra	Andrequicé, pomonga, lambedora and barit[1,2,3,4]
Luziola spruceana	Uamã[1,2,4]
Paspalum fasciculatum	Mori, chigüirera, venezuela grass, gamalote and bamboograss[1,2,3,4,5]
Oryza alta	Arroz-bravo[1,2,3,4]
Oryza perennis	Arroz-bravo[1,2,3,4]
Oryza grandiglumis	Arroz-bravo[1,2,3,4]
Paspalum repens	Perimembeca and membeca[1,2,3,4]
Panicum zizanioides	Taboquinha[2,3,4]
Panicum elephantipes	
Eriochloa punctata	
Parathreria prostrata	

[1] Black (1950).
[2] Serrão and Simão Neto (1975).
[3] Serrão and Falesi (1977).
[4] Serrão (1986).
[5] Blydenstein (1966).

Other potential aquatic plant forages include: *Eichornia crassipes, Ceraptoopteris pteridoides, Salvinia auculata, Pontederia rotundifolia, Pistia stratiotes, Azolla microphylla, Limnobium stoloniferum, Utricularia foliosa, Ceratophyllum demersum* and *Phyllathus fluitans* (Junk 1979; Albuquerque 1981). Legumes such as *Teramnus volubilis, Mimosa* spp., *Annulled* spp., *Rhinchosia minima, Galactia* sp., *Vigna adenantha, Vigna vexillata, Aeschynomene sensitiva, Aeschynomene rudis, Clitoria amazon, Sesbania exasperata* and *Macroptilium* sp. can also be found. These are important forages for livestock (Serrão 1986).

Furthermore, *Luziola hexandra, Hymenachne amplexicaulis, Oryza perennis, Oryza grandiglumis* and *Panicum laxum* are C_3 plants, while *Echinochloa polystachya* and *P. fasciculatum* are C_4 (Hattersley and Watson 1975; Jones 1985; Piedade 1988).

2. Forage characteristics

2.1 Production

The native pasture grasses on varzeas, in particular, when planted in flooded soils, produce from 3.8–18 t DM/ha/yr (Nascimento *et al*. 1987a; 1987b; 1988), depending mainly on climate, fertility level of soils, forage species and duration of flooding. During the dry period of the year, pastures on alluvial soils of várzeas can produce more than 20 t/ha DM (Serrão 1986; Junk 1986), with *Paspalum fasciculatum* and *Echinochloa polystachya* producing 45 t/ha DM while *Oryza perennis*, *Hymenachne amplexicaulis* and *Paspalum repens* can produce 10 t/ha DM, and

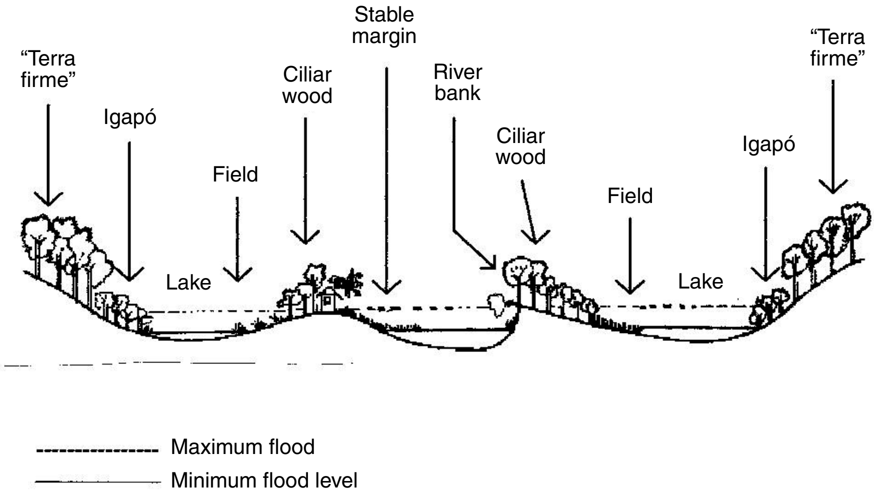

Figure 3. Cross section of a typical floodplain ecosystem in the regions of the lower and middle Amazon River (Sioli 1951).

Luziola spruceana 5–8 t/ha DM. These yields exceed those for native grasses on upland soils, *i.e.*, 0.66–1.6 t/ha DM (Teixeira Neto and Serrão 1984; Camarão *et al.* 1996). Camarão *et al.* (1991) obtained 2.7–4.7 t/ha DM over a 2-year period, from flooded pastures in the middle Amazon in 2 areas of the Monte Alegre town Region (Para), the most important grasses being *Paspalum fasciculatum*, *Paspalum repens*, *Echinochloa polystachya* and *Hymenachne amplexicaulis*.

2.2 Chemical composition and nutritive value

DM concentration in available forage varies with species, age (Table 4), plant parts (leaf or stem), soil type and location and whether the grass grows in water or soil (Junk 1970). For example, *Paspalum repens* has 2 growing forms (aquatic and terrestrial) that differ in morphology and DM concentration (Table 4). Moreover, leaf parts of most native grasses show generally higher CP levels, at about 6%, than stems (Camarão *et al.* 1998). No matter what the form, DM concentration is always higher in mature grasses than in young grasses, be it in flooded or dryland areas. *Paspalum repens* is very well adapted to aquatic environments, but when it is planted at different levels in flooded soils (high varzea, low varzea, igapo and restinga), it does not persist (Nascimento *et al.* 1987a, 1987b; Nascimento 1988). The aquatic form of *Echinochloa polystachya* has lower DM concentration (16.5%) than the terrestrial forms (22.6%), although the differences are less than for *Paspalum repens* (Junk 1979). However, *Leersia hexandra* usually has higher DM percentages (36%) and *Paspalum fasciculatum* has medium percentages, regardless of soil type (Nascimento *et al.* 1987a; 1987b).

Table 4. Dry matter concentration, stem length and stem thickness of aquatic and soil forms of *P. repens* in the Amazon (Junk 1970).

Parameter	Aquatic		Soil	
	Young	Mature	Young	Mature
Dry matter (%)	5	15	23	29
Stem length (cm)	197	573	305	474
Stem thickness (cm)	0.7–1.0		0.2–0.5	

The chemical composition of *Echinochloa polystachya* (canarana-de-paramaribo), at various stages of maturity, is shown in Table 5.

Table 5. Changes in the chemical composition (%) of *Echinochloa polystachya* (Aleman grass) with age (Mc Dowell *et al.* 1974).

Component	Age (days)					
	7	21	36	50	78	190
Crude protein	13.8	13.0	10.5	8.3	9.0	3.8
Crude fibre	32.0	31.6	33.4	35.6	–	33.6
Ether extract	4.2	2.9	3.0	2.1	2.9	1.3
Ash	12.7	13.3	12.9	11.5	–	8.7
Nitrogen-free extract	37.2	39.3	40.3	42.5	–	52.7
Neutral detergent fibre	–	59.1	59.1	68.8	67.8	–

Table 6 reports some published data on the chemical composition of grasses from floodplains. The proportions of CP are higher than those for typical sown tropical grasses on dry land, which are usually 6.0–9.0% (Minson 1981). However, *Echinochloa polystachya* (6.6%), *Paspalum fasciculatum* (6.3, 6.4, 5.8 and 6.9%) and *Leersia hexandra* (5.8 and 6.8%) had lower than the critical level of CP (7.0%) required to achieve maintenance in cattle (Milford and Minson 1966). It must be noted that the critical levels for buffalo are lower, at 5.2–5.8%, due to physiological differences between the 2 species and differences in the nitrogen requirements of rumen microflora (Moran 1983).

Camarão *et al.* (1998) evaluated the chemical composition of the native flooded pastures from the middle Amazon River over a 2-year period. The average DM percentage (23.0%) was similar to that of grasses planted on flooded soils (Nascimento *et al.* 1987b), while the average CP concentration in 160 samples was 10.3%. *Paspalum fasciculatum, Paspalum repens, Hymenachne amplexicaulis, Echinochloa polystachya, Oryza* sp. and *L. hexandra* grasses gave CP values of 6.7, 12.8, 11.0, 10.3, 9.4 and 13.2%, respectively (Camarão *et al.* 1998). CF proportions were similar to values for tropical cultivated grasses (33–37%) reported in the literature (Minson 1981) and NDF levels (70–80% according to age) were consistent with those for tropical grasses (Moore and Mott 1973). The average proportions of EE, NFE and ash varied, respectively, from 1–3%, 35–55% and 8–12% (Bogdan 1977).

The average gross energy (4164 kcal/kg DM) of the grass from the várzeas alluvial soils was slightly lower than the average value for 18 tropical cultivated grasses (4477 kcal/kg DM), reported by Butterworth (1964). Furthermore,

Table 6. Some published results on the chemical composition of aerial parts of native grasses on varzea alluvial soils. DM= dry matter; CP = crude protein; CF = crude fibre; NDF = neutral detergent fibre; EE = ether extract; NFE = nitrogen-free extract; A = Ash; and GE= Gross energy.

Grasses	Reference	Vegetation stage	DM	CP	CF	NDF	EE	NFE	A	GE
						(%)				(kcal/kg DM)
Echinochloa polystachya	Camarão *et al.* 1998	–	–	10.3	–	–	–	–	–	–
Echinochloa polystachya	Ohly and Hund 1996	Aerial part (30–50 cm)	14.4	13.6	–	34.6	2.0	–	–	–
Echinochloa polystachya	Camarão *et al.* 1987	Pre-flowering	–	9.8	37.5	–	2.2	42.5	8.0	–
Echinochloa polystachya	Howard-Williams and Junk 1976	–	–	6.6	–	74.0	–	–	–	4421
Echinochloa polystachya	Howard-Williams and Junk 1977	–	17.4	9.2	–	71.9	–	–	–	3920
Echinochloa polystachya	Dirven 1962	Leaf	–	23.5	30.4	–	3.8	–	–	–
		Stem	–	16.8	33.2	–	2.2			
Hymenachne amplexicaulis	Camarão *et al.* 1998	–	–	11.0	–	–	–	–	–	–
Hymenachne amplexicaulis	Ohly and Hund 1996	Aerial part (30–50 cm)	17.3	12.4	–	–	1.7	–	–	–
Hymenachne amplexicaulis	Camarão *et al.* 1991	Leaf	19.7	–	–	–	–	–	–	–
		Stem	16.2	–	–	–	–	–	–	–
Hymenachne amplexicaulis	Camarão *et al.* 1987	Pre-flowering	–	10.8	33.6	–	2.9	43.3	9.4	–
Hymenachne amplexicaulis	Howard-Williams and Junk 1977	–	13.9	21.2	–	65.6	–	–	–	3930
Hymecachne amplexicaulis	Dirven 1962	Leaf	–	22.6	32.4	–	2.8	–	–	–
		Stem	–	8.9	36.7	–	1.0	–	–	–
		Aerial part	–	15.8	34.6	–	1.9	–	–	–
Hymenachne amplexicaulis	Talapatra and Goswami 1949	Flowered	–	9.4	22.1	–	2.3	54.0	12.2	–
Hymenachne amplexicaulis	Talapatra and Goswami 1949	Feno, flowered	–	7.5	29.2	–	1.4	49.0	12.9	–
Hymenachne amplexicaulis	Talapatra and Goswami 1949	Silagem, flowered	–	6.9	27.8	–	1.8	45.6	17.9	–
Hymenachne amplexicaulis	Dirven 1963	–	–	15.1	31.5	–	–	–	11.9	–
Leersia hexandra	Camarão *et al.* 1998	–	–	13.2	–	–	–	–	–	
Leersia hexandra	Camarão *et al.* 1987	Pre-flowering	–	13.5	34.4	–	2.7	38.2	11.2	–
Leersia hexandra	Howard-Williams and Junk 1977	–	30.3	10.4	–	77.8	–	–	–	4920
Leersia hexandra	Howard-Williams and Junk 1976	–	–	13.1	–	75.0	–	–	–	4691
Leersia hexandra	Butterworth 1967	Beginning of flowering	–	5.8	28.4	–	2.1	47.7	16.0	–
Leersia hexandra	Dirven 1963	–	–	14.1	32.1	–	–	–	14.2	–
Leersia hexandra	Butterworth 1967	Feno	–	6.3	31.4	–	1.5	45.9	14.9	–
Leersia hexandra	Loosli *et al.* 1954	–	34.2	7.3	31.2	–	2.3	43.8	15.4	–
Leersia hexandra	French 1943	Non-flowering	30.0	10.1	25.6	–	1.8	52.1	10.4	–
Leersia spruceana	Camarão *et al.* 1987	Pre-flowering	–	11.0	31.7	–	2.5	46.8	8.0	–
Leersia spruceana	Dirven 1963	–	–	18.8	29.1	–	–	–	12.3	–
Oryza sp.	Camarão *et al.* 1998		–	9.4	–	–	–	–	–	–
Oryza sp.	Camarão *et al.* 1987	Pre-flowering	–	8.5	38.9	–	2.2	39.3	11.1	–
Oryza perennis	Howard-Williams and Junk 1977	–	16.1	8.1	–	66.5	–	–	–	3880
Paspalum fasciculatum	Camarão *et al.* 1998	–	–	6.7	–	–	–	–	–	–
Paspalum. fasciculatum	Ohly and Hund 1996	Aerial part (5–15 cm)	18.8	10.9	–	–	2.0	–	–	–
Paspalum fasciculatum	Camarão *et al.* 1987	Pre-flowering	–	12.5	34.9	–	2.0	38.2	12.4	–
Paspalum fasciculatum	Howard-Williams and Junk 1977	–	25.6	5.8	–	70.9	–	–	–	4100
Paspalum fasciculatum	Butterworth 1963	–	–	–	–	–	–	–	–	4240
Paspalum fasciculatum	Bateman and Garza 1962	56 days	21.2	8.3	29.5	–	1.0	51.2	10.0	3763
Paspalum fasciculatum	Butterworth 1962	–	32.0	6.9	28.3	–	1.3	48.8	14.7	–
Paspalum fasciculatum	Arroyo and Brenes 1960	40–60 days	17.7	6.4	–	–	–	–	–	3620
Paspalum fasciculatum	Harrison 1942	Mature	20.8	6.3	34.6	–	1.4	43.0	14.7	–
Paspalum repens	Camarão *et al.* 1998		–	12.8	–	–	–	–	–	–
Paspalum repens	Camarão *et al.* 1987	Pre-flowering	–	12.5	35.5	–	2.7	37.5	11.8	–
Paspalum repens	Howard-Williams and Junk 1977	–	16.7	9.8	–	69.2	–	–	–	3990
Paspalum repens	Howard-Williams and Junk 1976	–	–	9.7	–	60.0	–	–	–	4495
Average		–	21.0	12.0	32.0	67.0	2.0	45.0	13.0	4164

the *in vitro* digestibility of dry matter (IVDMD) from aerial parts of these grasses varied from 23 to 70%, depending on factors such as species, plant age, location and time (Camarão *et al.* 1998).

3. Animal performance

3.1 Meat production

Moreira *et al.* (1984a; 1984b; 1984c; 1984d; 1984e) studied the weight gains of various types of male and female buffalo grazing native pastures on the várzeas alluvial soils (Table 7). These results demonstrate the high productivity of animals grazing pastures on floodplain alluvial soils. It has also been observed that Murrah-Mediterranean and Mediterranean buffalo gained more weight than cattle (Embrater 1979; Serrão *et al*. 1991; Costa *et al.* 1992).

Table 7. Liveweight gains of buffalo grazing native pastures on floodplain várzeas alluvial soil, Monte Alegre, Pará State, Brazil (Moreira *et al*. 1984a; 1984b; 1984c; 1984d; 1984e).

Buffalo types	Gender	N[1]	Daily weight gain	Live weight at 2 years
			(kg)	(kg)
Murrah-Mediterranean	M	9	0.57	453
	F	14	0.52	420
Mediterranean	M	73	0.49	394
	F	25	0.48	383
Baio	M	95	0.42	336
	F	105	0.39	320
Jafarabadi	M	12	0.42	341
	F	12	0.40	331
Carabao	M	23	0.42	349
	F	28	0.40	332

[1] Number of observations.

In Embrapa eastern Amazon, the performance of cattle and buffalo grazing native pastures on floodplain alluvial soils of the lower Amazon River, on well drained savannas and on cultivated upland was examined over several years (Table 8). Cattle performance was evaluated on pastures on the várzeas alluvial soils, which are composed mainly of *Luziola hexandra, Reimarochloa acuta* (capim marreca) and *Hymenachne amplexicaulis*, while buffalo performance was evaluated on pastures composed of 14% *Echinochloa polystachya*, 10% *Hymenachne amplexicaulis*, 33% *Paspalum fasciculatum*, 22% *Paspalum repens*, 12% *Luziola hexandra* and 8% *Oryza* sp. In well drained savannas, *Mesosetum altum* and *Axonopus purpusii* grasses predominated. The average daily gain (ADG) in the different animal categories varied from 0.45 to 0.74 kg/animal. These variations were mainly caused by hydrologic factors (Costa *et al.* 1987, 1992; Serrão *et al.* 1991).

In contrast to cattle, buffalo gained more weight on native pastures on alluvial soils than on cultivated pastures of *Brachiaria humidicola* (Table 8). Moore and Mott (1973) reported also that buffalo gained more weight on such pastures than on sown pastures. In comparison, cattle lost around 0.12 kg/animal/d on native pastures on well drained savannas, suggesting that such species are less adapted to this environment.

Table 8. Average daily gain (kg/animal) of cattle and buffalo on native *Brachiaria humidicola* pastures on well drained savannas (SWD) and floodplain alluvial soils (VAS) and cultivated *Brachiaria humidicola* pastures on dry land (CPTF), Monte Alegre, Para State (Serrão *et al*. 1991; Costa *et al.* 1992).

Year	VAS		SWD	CPTF	
	Cattle	Buffalo	Cattle	Cattle	Buffalo
1985	0.63	–	–0.06	0.55[1]	–
1986	0.45	0.74	–0.12	0.59[1]	0.61[1]
1987	0.66	0.58	–0.17	0.52[2]	–
1988	0.53	0.65	–	0.59[2]	0.67[2]
1989	–	0.73	–	–	0.52[3]
1990	–	0.69	–	–	0.53[3]
Median	0.53	0.72	–0.12	0.56	0.58

[1] ADG under stocking rates of 1, 2 and 3 animals/ha.
[2] ADG under stocking rates of 2, 3 and 4 animals/ha.
[3] ADG under a stocking rate of 3 animals/ha.

Sardinha and Marques (1993) showed that weight gains of Mediterranean, Murrah, Jafarabadi and Carabao buffalo were 0.63, 0.54, 0.45 and 0.42 kg/animal/d, respectively, which were higher than gains in cattle. Cattle performance was evaluated on pastures on várzeas alluvial soils, which are composed mainly of *Luziola hexandra, Reimarochloa acuta* (capim marreca) and *Hymenachne amplexicaulis*, while buffalo performance was evaluated on pastures composed of 14% *Echinochloa polystachya*, 10% *Hymanachne amplexicaulis*, 33% *Paspalum fasciculatum*, 22% *Paspalum repens*, 12% *Luziola hexandra* and 8% *Oryza* sp. The CP proportion was 13% and the *in vitro* digestibility of organic matter (IVDOM) was 52%.

Camarão and Rodrigues Filho (2001) showed that availability of native forage on the várzeas alluvial soils of Monte Alegre, Para, varied from 2.9 to 4.1 t/ha DM. The dominant grasses in the pastures were: *Paspalum fasciculatum* (37%), *Paspalum repens* (22%), *Echinochloa polystachya* (18%), *Hymenachne amplexicaulis* (10%), *Luziola spruceana* (10%) and *Oryza* sp. (3%). Figure 4 illustrates the botanical composition of the diet of Baio buffalo as identified by microhystologic analysis. The more represented grasses were *Paspalum repens* (25%) and

Echinochloa polystachya (25%). *Luziola spruceana* was dominant (18.3%) until October but its proportions fell to 7% and 9% due to the high intensity of rain and flooding by the rivers in December and February, respectively. Consequently, animals had difficulty moving to areas where the grasses predominated. *Paspalum fasciculatum* contributed significantly to the diet in contrast to *Leersia hexandra*, which is regarded as a valuable species and is usually more palatable for cattle and buffalo, but is less available.

ADG was 0.3, 0.7, 0.5, 0.5 and 0.7 kg/animal ($P < 0.05$) in June, August, October and December 1995 and February 1996, respectively. The lower weight gain obtained in June was due to the elevated river tide levels, which made it difficult for animals to access the pastures, though there was adequate forage available. In the lower Amazon River, the best period for animal growth in pastures containing *Luziola spruceana* is July–December. However, it must be remembered that other factors influence animal performance, such as attack by hematophagous insects (*Culex quinquefasciatus*, *Tabanus* sp., *Haematobia irritans*) and rainfall. When the rain decreases, the gains would increase initially as the pastures became less waterlogged and decline afterwards as the pastures matured and quality dropped.

3.2. Milk output

Buffalo are not used intensively for commercial milk production in the Brazilian Amazon, although some farmers have obtained high yields of highly nutritious milk from animals raised on cultivated and fertilised pastures. In general, access to markets is a problem in these areas. On native pastures on floodplain alluvial soils of the middle Amazon, Carvalho *et al.* (1980) reported yields in Baio, in their first and second lactations, of 1024 kg milk (with 8.3% milk fat) over 253 days (4.1 kg/d), indicating that buffalo have good milk-producing capacity on this kind of pasture. The average milk output in the Brazilian Amazon on such pastures is 2–3 kg/d (Carvalho *et al.* 2001).

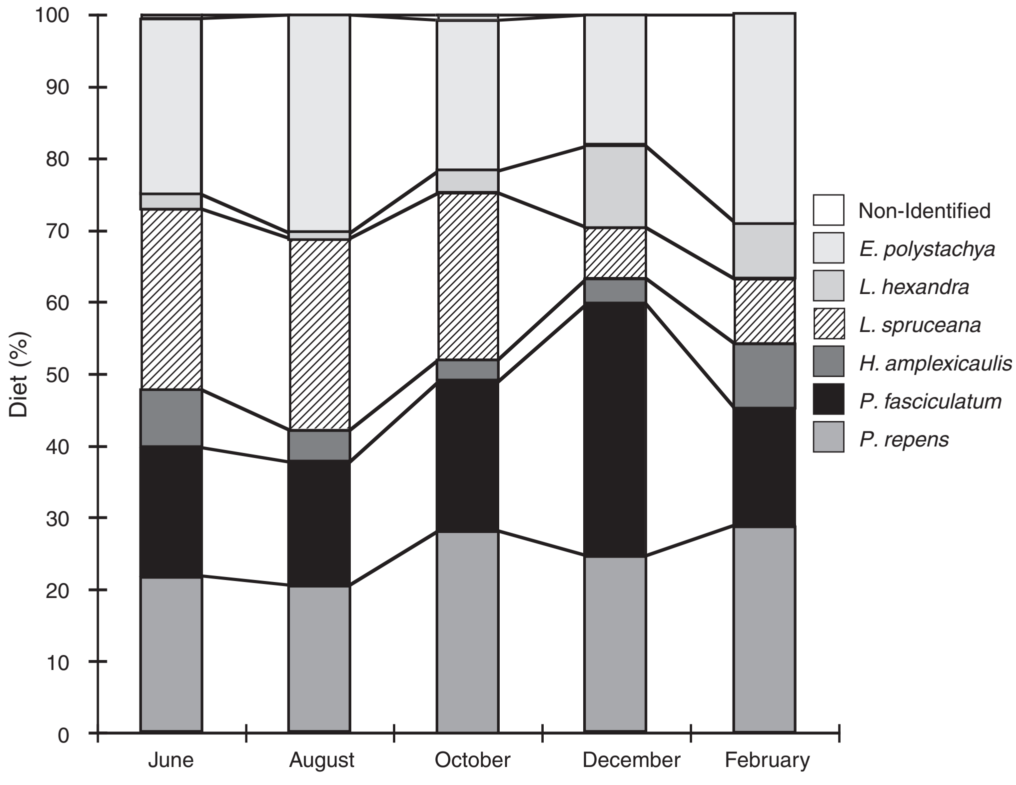

Figure 4. Botanical composition of diet ingested by buffalo (Baio type) grazing pastures on floodplain alluvial soils from the middle Amazon, Monte Alegre, Para State, Brazil, 1995–96 (Camarão and Rodrigues Filho 2001).

4. Animal and pasture management

Livestock farming is a very important activity for the socio-economic development of the regions studied. The cattle (Nelore, Gir, Indubrasil and Guzerá) and buffalo (Mediterranean) populations numbered 781 000 head in 1993 (PPM 1996). Survival rates at birth are 60%, with mortality rates of 13% until 1 year and 4% from 1 to 2 years. Cattle are slaughtered at 34 months of age at an average weight of 350 kg while buffalo are slaughtered at 27 months, weighing 420 kg (Arima and Uhl 1996).

The animals in these regions show no symptoms of nutrient deficiencies and the most acute problem encountered is the flooding of the pastures. Indeed, these pastures have played a fundamental role in the growth of cattle and buffalo. However, during flooding, farmers can maintain only a limited number of animals (around 27 head), mainly on the floodplains or in elevated corrals, named "marombas", where they are fed with cut native grasses. An alternative would be to transfer the cattle from the floodplains to native pastures on well drained savannas or to sown pastures of *Brachiaria humidicola*. Both systems give economical and productive performance and buffalo can reach 450 kg at less than 24 months (Table 9).

The productivity of the upland areas can be increased substantially through using a combination of: an intensive rotational management system, good pasture management and animals of high genetic potential, plus controlling weeds and fertilising with N, P and K. In Belém, Pará, Nelore cattle, grazing on fertilised *Brachiaria brizantha* at 4.1–4.6 animal units (AU)[1]/ha/yr, produced 852 kg/ha/yr and a daily weight gain of 0.5 kg/animal. Murrah buffalo grazing pastures of fertilised *Panicum maximum* cv. Tobiatã gained 0.8 kg/d and reached 500 kg live weight at 18 months, at a stocking rate of 3–5 AU/ha/yr to produce 1000 kg/ha/yr and a net income of R$416.0/ha/yr (US$ 1.00 = R$ 2.50). Returns were more than 8 times those from the livestock output system in the Brazilian Amazon (Costa *et al.* 1998).

Conclusions

Cattle and buffalo differ in their ability to cope with flooding of native pasture areas in the Amazon Region of Brazil. When flooding occurs, cattle have to be moved to native or cultivated pastures in non-flooded areas, while buffalo are able to handle flooding and continue to produce and reproduce satisfactorily under these conditions.

[1] An Animal Unit is equivalent to one adult cattle (450 kg live weight).

Table 9. Production parameters of integrated systems of native pastures on várzeas alluvial soils and cultivated uplands "terra firme" (Costa *et al.* 1987).

Parameters	System 1[1]	System 2[2]	System 3[3]	System 4[4]
Flooded soil (168 days)				
– Initial weight (kg)	200a[5]	189a	210a	176a
– Final weight (kg)	322a	328a	319a	–
– Daily gain/animal (kg/d)	0.7a	0.8a	0.7a	–
Uplands (196 days)	–	–	–	–
– Initial weight (kg)	322a	328a	319a	–
– Final weight (kg)	453a	448a	427a	–
– Daily gain/animal (kg/d)	0.7a	0.6a	0.6a	–
– Total gain in 196 days (kg)	131c	121b	108a	–
– Total gain/ha (kg/ha)	131c	241b	324a	–
Total experiment period (364 days)	–	–	–	–
– Initial weight (kg)	200a	189a	210a	176a
– Final weight (kg)	453a	448a	427a	320b
– Daily gain/animal (kg/d)	0.7ab	0.7a	0.6b	0.4c

[1] **System 1** — Native pasture on alluvial floodplains plus sown pasture of *B. humidicola* on non-flooded land, at a stocking rate of 1 animal/ha.
[2] **System 2** — As for System 1, but at a stocking rate of 2 animals/ha.
[3] **System 3** — As for System 1, but at a stocking rate of 3 animals/ha.
[4] **System 4** — Traditional system, grazing native pasture on floodplain alluvial soils throughout.
[5] Within rows, means followed by the same letter do not differ significantly, according to Tukey test ($P < 0.05$).

The integration of native flooded pastures during the dry season with cultivated pastures during the wet season allows buffalo to reach acceptable slaughter weights by 24 months of age.

It is obvious that both quality and quantity of native pastures in flooded areas of Brazil are high. While current production from these pastures is also high, productivity could be enhanced by implementing improved pasture and livestock management systems in this environment.

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