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MILK AND PASTURES AT THE FRONTIER: THE CASE OF THE PERUVIAN FOREST MARGINS

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SUMMARY

The use of tropical grass–legume mixtures containing the grasses *Brachiaria decumbens* or *Andropogon gayanus* associated with a mixture of several herbaceous legumes was tested on farms in the rainforest area of Pucallpa, Peru. Pastures were established by farmers using manual labour and without fertilizer in previously deforested areas covered with secondary growth. The pastures, together with their grass-alone control, were incorporated by farmers into the normal paddock rotation, and were grazed by dual-purpose cattle of mixed breeding. Cows were milked once daily by hand and with their calves at foot. Following a training period, farmers kept records of milk yields. Frequent and unannounced visits at milking time by the research team were used to verify milk yields and to annotate events such as calving, drying out, sales and others. Across farms and years, grass–legume mixtures significantly outyielded grass-alone pastures by 9%. Milk yields on the mixed pastures were examined further by stepwise regression. A positive and significant effect of the proportion of crossbred cows in the herd was established, whereas soil quality (evaluated by the percentage of aluminium saturation) had a negative impact on milk yields. Two of the farms, which for different circumstances had poorer than average animal and pasture management, also had a significantly negative effect on milk yield. The interactions between animal and pasture management, and regional infrastructure are discussed. It is concluded that grass–legume mixtures increased milk yields on farms. Nevertheless, it is also hypothesized that they may have a more restricted niche than anticipated and that their adoption may be highly sensitive to the overall economic context of the region.

INTRODUCTION

It is well known that throughout the colonized areas of the South American tropical rainforest cattle play an important economic role (Hecht, 1993; Loker, 1992). The pervading presence of cattle throughout the lowland neotropics has led some authors to associate it with deforestation (Serrão *et al.*, 1993) and, although the intent of this paper is not to dispute this view, it should be noted that recent publications have raised doubts about a causal relationship between the phenomena (Kaimowitz, 1995; Smith *et al.*, 1994). Regardless of whether such a relationship exists, few doubt the economic rationale behind the abundant and increasing presence of cattle in the tropical frontier (Hecht, 1993; Kaimowitz, 1995; Locker, 1992).

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In some of the above areas, notably Bolivia, Colombia and Peru, most of the cattle owned by small homesteaders are run in so-called 'dual-purpose' production systems. These systems have been reviewed by a number of authors (Seré and Vaccaro, 1985) but, with the notable exception of the Caquetá (Colombia) case (Marsh, 1985; Michelsen, 1990) their historical evolution has been studied inadequately. Dual-purpose production systems are characterized by predominantly Zebu cattle, mostly Brahman types, frequently crossbred with European breeds. Despite the inherently low milk yields of these animals, dams are milked regularly if markets for fresh milk or processed products, mostly cheese, are available. In most documented cases in the South American rainforest areas, daily milk production seldom exceeds 4 kg, typically a once-daily milking with the calf at foot. When road or market conditions do not allow the sale of fresh milk or its byproducts, cows are not milked and calves are allowed continuous access to their dams. Thus, these are low-risk systems in high-risk environments (*sensu* Orskov and Viglizzo, 1994).

In the above systems, cattle are grazed throughout the year almost exclusively on grass-alone pastures. In the early 1980s, in Pucallpa, Peru, Peruvian institutions such as the Instituto Nacional de Investigaciones Agropecuarias (INIA) and the Instituto Veterinaris de Investigaciones del Tropico y de Altura (IVITA), together with CIAT, began an intensive programme for screening forage legumes and grasses suitable for these systems. No information on the contribution of persistent and adapted grass–legume mixtures to milk production in dual-purpose systems in tropical rainforest environments was available. Nevertheless Paterson and colleagues (1981) working in the Bolivian lowlands had shown increases in milk production of 11–20% per head during the dry season when cows had access to deferred paddocks containing a mixture of high-quality legumes.

The Pucallpa region and its farming systems have been characterized extensively in several studies (Gutierrez and Hernández, 1991; Riesco *et al.*, 1986). This paper reports the results of on-farm testing of grass–legume pastures assessed in terms of milk production in dual-purpose systems. Results on pasture management and the evolution of botanical composition during the first four years were reported by Reátegui *et al.* (1995), whereas the views of farmers regarding their production systems were analysed by Loker (1992; 1993).

MATERIALS AND METHODS

Collaborating farmers were selected along the first 130 km of the road that runs west connecting Pucallpa with Lima. Details on these farms were given by Reátegui *et al.* (1995).

Pastures were established at the beginning and in the middle of the 1987 rainy season; full details are described by Reátegui *et al.* (1995). In summary, farmers were offered a choice of either *Brachiaria decumbens*- or *Andropogon gayanus*-based pastures with and without a mixture of legumes consisting of *Stylosanthes guianensis*, *Desmodium ovalifolium* and three *Centrosema* spp.

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The selected farms ranged between 24 and 300 ha and had an average of 55 animal units per farm. At the start of the project, 45% of the pastures were native/naturalized, dominated by *Paspalum plicatulum* and other species, while the remaining pastures were mostly *B. decumbens* and *Hyparrhenia rufa*. The project farmers were provided with seed to establish the new pastures, barbed wire to fence them off and technical assistance in pasture establishment. Pasture establishment was carried out by the farmers themselves using their own labour with little or no assistance by the research team.

The entire milking herd was grazed in a rotation of pastures which included the experimental grass–legume paddocks, the grass-alone control, other sown paddocks and naturalized, *torourco,* grasses. Generally between four and eight paddocks of different sizes were part of the rotation and thus the experimental pastures constituted less than 15% of the total area grazed by the milking herd. In all cases, grazing of the grass–legume pasture was preceded by the control pasture and followed by other grass-alone pastures. For this reason, no contemporary milk yields for the control and experimental pastures are available, as this would have required splitting the herd, a practice that was unacceptable to farmers. Following local custom, calves were separated from their dams at around 17.00 h the preceding afternoon and cows were milked by hand early the following morning after allowing the calf to stimulate milk letdown. After a period of several weeks in which farmers became familar with the procedures, milk yields were recorded daily by the farmers or by the milkers. Each farm was provided with a simple spring balance and a tared bucket. Random, unannounced visits at milking time were made periodically by the researchers to check milk yields being recorded. At these times other events, such as calvings, weanings and drying out of cows, were recorded as well. Milk yields were recorded from October 1988, once the pastures were fully established, until April 1992, with occasional disruptions due to problems of security in the region.

Pasture management practices, such as hand weeding and burning, periods of rest and of occupation, and stocking rates were decided by farmers. These practices and the use of labour were recorded systematically by the research team. Cows in the milking herd were classified approximately as purebred or crossbred, based on information provided by farmers and on their phenotype. Researchers did not attempt intentionally to modify farmer management practices, with the exception of trying to discourage the use of fire in the grass–legume pastures. The latter effort was successful in one-half of the farms. Researchers also responded to information requests by farmers, the most frequent enquiries relating to animal health problems.

Milk yield records were grouped into successive years regardless of parity or stage of lactation at the beginning of the observation period. Numerous models and analyses were evaluated for statistical analyses of the milk yields, and the general linear model procedure of SAS (1988) was selected; the effects of year, pasture, year × pasture and the repeated effect of cow were used as sources of variation. In order to diminish residual effects on milk yield associated with the transfer of the herd between paddocks, the respective periods of grazing in each paddock were divided into fifths. Records of the first, fourth and last fifth were discarded, and those of the second and third fifth were used to compare yields between the two treatments. Visual and periodic quantitative assessments of forage on offer (Reátegui *et al.*, 1995) led to the conclusion that it was in the second and third fifths that the amount of forage on offer in the experimental pastures was most comparable with the grass-alone paddocks.

RESULTS AND DISCUSSION

Pasture management practices are summarized in Table 1 but have been discussed in greater detail by Reátegui *et al.* (1995). In essence, the data demonstrate the use of rotational grazing using four to eight paddocks and fairly long rest periods. The length of rest periods, and the stocking rates and levels of forage on offer maintained throughout the observation period are consistent with long-term pasture persistence shown by experimental work discussed by Reátegui *et al.* (1995). Nevertheless, one of the most intriguing results refers to farmers' perceptions regarding both the experimental grass–legume pastures and their influence on milk yield. There was a generalized perception that the grass–legume pastures were more 'fragile' and required more labour for weed control. These perceptions were not borne out by the records of labour use and stocking rates that the farmer themselves provided (Table 1), but it is clear that future extension programmes will have to address this view.

The main characteristics of the milking herd, summarized in Table 2, are very

Table 1. *Pasture management practices employed by farmers in experimental grass–legume and control grass–alone paddocks at Pucallpa, Peru*

Farm number	Pasture type	Grazing period (d)	Rest period (d)	Mean stocking rate (animal units ha^{-1})	Weeding labour (man days)
1	Experimental	11	76	1.24	2.5
2	Experimental	10	24	3.24	1.3
	Control	10	29	3.02	1.3
3	Experimental	10	39	1.37	2.0
	Control	8	49	0.86	2.1
4	Experimental	15	58	1.12	2.3
5	Experimental	10	32	2.05	3.5
	Control	9	41	1.77	2.5
7	Experimental	8	44	1.34	4.8
	Control	6	49	1.13	4.1
8	Experimental	4	57	0.88	3.2
	Control	8	48	1.27	3.4
Means	Experimental	10	47	1.78	3.01
	Control	8	43	1.61	2.68

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Table 2. *Type of cow and mean reproductive performance over the observation period, 1988–1992, at Pucallpa, Peru*

Farm number	Crossbred cows (% of herd)	Average lactation (d)	Mean calving interval (months)
1	100	343	17
2	100	253	17
3	33	364	16
4	21	279	17
5	22	378	21
7	58	323	20
8	94	300	16

similar to those recorded in numerous other locations of the tropical lowlands of Latin America (Seré and Vaccaro, 1985), and suggest that there is plenty of scope for improving reproductive performance given adequate economic and policy incentives which have also been discussed by researchers including Seré and Vaccaro (1985) and Seré and Rivas (1987). Nevertheless, and despite fairly long calving intervals, reproductive performance tended to be somewhat better than in beef herds located in comparable ecosystems (Vera and Seré, 1985). Reproductive parameters observed in our sample of farms were very similar to those reported for shorter, but more extensive diagnostic surveys conducted just prior to the start of our work in Pucallpa (Gutierrez and Hernandez, 1991; Riesco *et al.*, 1986; Zaldívar, 1989).

Daily milk yields are shown in Table 3. The most consistent trend was the increase in milk yields with consecutive years, except on Farm 5. It is hypothesized that pasture and animal management practices stabilized in the second year allowing somewhat higher yields. Fairly dependable significant differences between pastures were detected, with grass–legume pastures generally outyielding the control pastures by 7–10%. The magnitude of these differences, small in absolute terms, was similar to those found subsequently in controlled experimental work with Zebu or Brahman-based commercial herds in several locations in the neotropical lowlands (Lascano and Avila, 1992; Ullrich *et al.*, 1994; Ramírez, 1994). As in the case of pasture management, farmers' perceptions were somewhat different. In effect, farmers agreed unanimously that milk yield improved significantly while cows grazed the experimental pastures; in their words, they could '*see it in the bucket*'. This may have been the case in the first few days of grazing the experimental pastures when data were discarded from the present analysis in an attempt to eliminate residual effects. If farmers' perceptions were correct, the protocol followed in the present experiment may have underestimated milk yields in the experimental paddocks, further compounded by their small size and consequent short grazing period. Nevertheless milk records showed a suspicious constancy throughout periods of several consecutive weeks, which led researchers to pay more frequent and unannounced visits at milking time in an

Table 3. *Mean daily milk yields (kg cow^{-1} d^{-1}) in three consecutive years for grass–legume, grass–alone and natural grass paddocks at Pucallpa, Peru*

Farm number	Pasture	Grazing evaluation (from mid 1988)			Pasture average	Statistical significance ($p <$)		
		Year 1	Year 2	Year 3		Year	Pasture	Y × P
1	Grass–legume†	4.30	5.41	5.33	5.18	0.04	0.03	0.44
	Grass–alone‡	4.05	5.14	4.45	4.93			
	Native grass§	na	4.55	4.77	4.58			
2	Grass–legume†	3.87	4.09		3.96	0.001	0.001	0.40
	Grass–alone‡	3.36	3.84		3.54			
	Grass–legume¶	3.10			3.10			
3	Grass–legume†	2.41	2.70	2.32	2.55	0.75	0.02	0.08
	Grass–alone‡	2.30	2.48	2.46	2.44			
4	Grass–legume†	1.94	2.23	2.27	2.11	0.05	0.12	0.75
	Grass–alone‡	1.87	2.18	2.24	2.01			
5	Grass–legume†	2.87	2.44	1.73	2.41	0.10	0.64	0.01
	Grass–alone‡	2.37	2.04	2.18	2.10			
7	Grass–legume†	2.90	3.18	3.10	3.09	0.002	0.51	0.74
	Grass–alone‡		3.85	2.67	3.10			
	Native grass	2.47	2.80	3.11	2.80			
8	Grass–legume¶	2.25	2.06	2.68	2.33	0.05	0.11	0.41
	Grass–alone‡		2.19	2.87	2.40			

†*Brachiaria* spp. + *Stylosanthes guianensis, Desmodium ovalifolium* and *Centrosema* spp.; ‡*Brachiaria decumbens* control; §*Paspalum plicatulum* and other species; ¶*Andropogon gayanus* + *S. guianensis, D. ovalifolium* and *Centrosema* spp.; na = not available.

attempt to verify milk yields. Discussion with farmers and observation of their behaviour led researchers to conclude that, rather than attempting to maximize milk output, farmers had a target in terms of milk quantity, and did not milk dams dry. Furthermore, Zebu-based cows milked with the calf at foot are notorious for being difficult to milk exhaustively by hand. In experimental herds it was shown clearly by Ramírez (1994) that improved feeding on grass–legume pastures equivalent to those used in this trial led to larger proportional increases in calf weaning weight than in actual milk yields. Additionally, Vera (1990) showed that cows gained significantly more weight on grass–legume pastures than on grass-alone controls, which in turn was associated with significantly shorter calving intervals. Clearly, shorter calving intervals, even with constant lactation yields, would lead to larger lifetime milk yields. None of these possibilities, namely, increased calf and cow weaning weights, shorter calving intervals and lifetime performance could be measured with the relatively simple experimental protocol necessary in an on-farm context. Investigation of these aspects of dual-purpose production will require orthodox designs and contemporary measurements of the above variables.

A further attempt to analyse milk yields in the grass–legume pastures was made by regressing daily milk yields on a number of animal and pasture variables summarized in Table 4. Also, dummy variables (Daniel and Wood, 1980) were

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Table 4. *Statistical descriptors of variables used in stepwise regression analysis*

Variable	Number	Mean	Standard deviation	Minimum	Maximum
Dependent variable:					
Milk yield (kg cow^{-1} d^{-1})	20	3.12	1.03	1.94	5.14
Independent variables:					
Forage availability (kg dry matter ha^{-1})	20	3032	720	2003	4646
Stylosanthes guianensis (%)	20	14.75	11.52	4	41
Desmodium ovalifolium (%)	20	7.8	10.59	0	34
Total legumes (%)	20	32.75	11.76	7	63
Weeds (%)	20	11.95	6.29	1	25
Stocking rate (cows ha^{-1} d^{-1})	20	1.66	0.81	0.81	3.24
Crossbred cows in herd (%)	20	59.5	34.79	21	100
Soil aluminium saturation† (%)	20	53.3	19.8	16.9	74.8

†Used as a proxy for soil fertility.

used to identify the effect of farm. The resulting stepwise multiple regression equation (adjusted $R^2 = 0.89$, $p < 0.001$) is shown in Table 5. The positive effect of the percentage of crossbred cows is consistent with the experimental work conducted by Lascano and Avila (1992) which has shown a positive interaction between animal breed and grass–legume pastures, whereby Holstein crossbreds show a larger response to improved pastures than cows of lesser genetic potential. The negative effect of soil aluminium saturation, used as a proxy for overall soil fertility, was expected since it is widely associated with reduced availability of essential plant nutrients and consequent low biomass production (Rao *et al.*, 1992). The negative effect of Farm 2 was probably associated with systematic overstocking of pastures (Table 1) and generally poorer than average animal and pasture management. The large negative effect of Farm 8 was also due to management constraints, in this case associated with its furthest location (77 km) from the Pucallpa market and periodic problems of political violence in its neighbourhood. These factors hindered access to markets and reduced incentives to exploit the combined effects of improved cattle and pastures. Market accessibility and animal genetic potential have proved to be important in at least one

Table 5. *Parameters of the stepwise regression of daily milk yields (kg cow^{-1} d^{-1}) on a number of variables (adjusted $R^2 = 0.89$, $p < 0.001$)*

Parameter	Parameter value	Standard error	P<	Standardized parameter values
Intercept (kg cow^{-1} d^{-1})	2.09	0.26	0.001	0
Crossbred cows in herd (%)	0.035	0.0031	0.001	1.17
Proxy for Farm 2	−0.797	0.269	0.01	−0.28
Proxy for Farm 8	−2.627	0.312	0.001	−0.78
Aluminium saturation (%)	−0.012	0.0045	0.02	−0.23

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other Amazonian location, that of Caquetá, Colombia. Analyses of survey data and secondary information by Michelsen (1990) demonstrated clearly the large and significant effects of improved breeding stock and of road infrastructure on milk output in the Caquetá region, now also ratified at the farm level for Pucallpa.

Results from a limited set of on-farm case studies are always difficult to extrapolate. Nevertheless, results presented here show that grass–legume pastures are of higher quality than local pastures and this is reflected by milk yields. It is also likely that, in an on-farm context, a number of other parameters, such as the liveweight gains of cows and calves and reproductive performance, are enhanced by grass–legume pastures. However, realization of their production potential requires more careful management. This may conflict with the extensive, low-input style of cattle raising found in frontier regions with difficult access to markets, as suggested by the negative effect of Farm 8. If this hypothesis is correct, promising technology may be highly sensitive to the overall economic and institutional context in which farmers operate in frontier regions.

The adoption constraints mentioned above may be increased by the multiple, but long-term and individually modest nature of the benefits of these grass–legume pastures. Although they enhance milk production, increase liveweight gain in cows and calves (Ramírez, 1994), improve reproductive performance (Vera, 1990) and also have soil-enhancing properties (Vela *et al.*, 1990; Fisher *et al.*, 1994), their impact individually is small and not overwhelming in any one area of farm performance. Farmers may not, therefore, perceive these benefits immediately.

In summary, persistent grass–legume mixtures tend to be of higher quality and productivity than existing pastures, but may require more complex management and possibly also grazing by animals with a greater nutritional demand. If this interpretation is correct such pastures may have a more limited niche than anticipated, and one that may be highly sensitive to the overall economic context of the region shown recently by Smith *et al.* (1996).

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