MILK PRODUCTION FROM DUAL-PURPOSE SYSTEMS IN TROPICAL LATIN AMERICA

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In this paper, the term "dual purpose" refers to the traditional cattle production system in the lowland tropics of Latin America in which local cattle of mixed zebu, criollo and European inheritance are used for the production of milk and meat.

The exact contribution of the system to national milk production is difficult to assess because of lack of accurate statistics. However, in Venezuela for example, European dairy breeds account for less than 5% of the total population of cows in milk (Ministerio de Agricultura y Cría, 1981). Similarly, in Colombia, Panama and Nicaragua, dual purpose cattle are estimated to contribute 86%, 67% and 75%, respectively, of national milk yields (Ministerio de Agricultura, 1977; Schellenberg, 1983). That this tendency is general throughout the tropical region is indicated by the comparatively low yields of milk per cows in Central and tropical South America, compared with the temperate zone, where specialized dairying is generalized (Table 1).

The reasons for the predominance of the dual-purpose system are various. In the first place, milk prices are high across the tropical region, particularly in relation to beef (see Table 2). The system allows flexibility according to the variations in relative prices of milk and beef. This is important in a region where market trends are variable and notoriously unpredictable. Secondly, they require very little extra investment compared with beef production alone, often making use of labour which would otherwise be unemployed and, thirdly, they provide regular incomes which cover daily operational expenses and provide milk for household consumption.

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General Description of the Dual Purpose System

In order to provide a general description of the system, information from commercial farms in various parts of the region is summarized in Table 3a, b and c.

Location: Dual purpose farms are commonly found throughout the lowland parts of the region, below approximately 1000 m above sea level. Annual rainfall usually amounts to 800-2500 mm, with a clear seasonal distribution such that dry periods of 3-6 months' duration are prevalent.

Production resources: Family farms are common, especially in Central America, with little or only occasional hired labour. Otherwise, farms may be run by administrators and visited infrequently by the owner, a system which severely limits the efficiency of the operation. The educational level of owners, and especially of labourers, is low. The reserve wage in tropical Latin America is high and strong economic incentives are required before labour-intensive changes in the production system will occur.

Farm size varies considerably, tending to be very small in Central America and larger in the southern countries. Farms are commonly located on marginal lands, for which alternative uses are limited due to poor soil quality, accessibility or topography. The proportion of the farm devoted to crops is variable, but tends to be higher in Central America than in the south. The Bolivian data refer to the common system of "slash and burn" forest clearing, where crops are taken in the first few years and cattle then graze the naturalized and introduced grass species.

Following farm size, the number of cows kept also tends to be higher in the southern countries. The proportion of males over one year of age in the herd indicates the relative importance of beef production in each area. The cows are usually crossbreds of mixed zebu, criollo and European inheritance. The use of zebu and criollo bulls is widespread, despite its depressive effect on milk yield, so that the balance between native and European breeding may be kept.

Typically, land and cattle constitute the main capital investment in the system. In the Panamanian case reported (Seré et al., 1982) these two categories comprise 91% of the total capital. The remainder is mainly fences, sometimes a simple milking shed and a few minor tools. Thus farms are not at great investment risk. Land usually appreciates in value and cattle are easily tradeable. Very limited depreciations are needed as no elements become technically obsolete. The quality and amount of land and cattle largely determine the productivity of the system.

Feeding, management and health: Although improved pasture species are relatively widespread, some of them, such as *Hyparrhenia rufa* which predominates in the Venezuelan sample, are of poor nutritional value in the dry season. The area devoted to cut forage species is very small. Few farms apply fertilizers to pastures, but some form of weed control and rotational grazing is usually practised. Despite the poor quality of the grazing, relatively few farms feed concentrates or any other energy-protein supplement. The limited use of mineral supplements is of special significance in view of the prevalence of deficiencies throughout the region. Where feed supplements are given, they are usually fed to the milking cows only and perhaps to fattening steers. Thus, the young stock are comparatively neglected and fluctuations in pasture nutrient supplies are reflected in wide fluctuations in growth rates and body condition.

The whole herd may be kept in a single group even where, as in the Venezuelan study, the total number of cattle is large. Uncontrolled, natural mating is almost universal. Very few farms identify cattle or keep production records. Milking is carried out once daily with the calf present, generally by hand, although machine milking with the calves may be found in Venezuela and Brazil. The calf may be allowed to suck at the start or simply tied up near the cow to ensure "let-down". Sometimes a whole quarter is left for the calf, in other cases, a little milk is left in all four. The calf remains with the dam until the afternoon and may have to walk long distances to and from grazing areas. Calves are then enclosed for the night, frequently without access to feed or water. Hygienic conditions at milking are extremely poor. In the Venezuelan study, for example, the proportions of all farms which milked on earth floors with no source of water, did not wash udders or filter milk were 55%, 88% and 61% respectively. Thus, the initial quality of the milk, combined

with high ambient temperatures, presents serious problems for conservation and public health.

Very few farms implement adequate health programmes and even brucellosis and foot and mouth disease are not properly covered, although they are endemic in many parts of the region and official vaccination programmes exist to control them. Some degree of external parasite control is usual and more common than treatment for internal parasites. The latter are widely considered to be one of the major factors limiting production.

Animal performance: Calving rates are most commonly in the range of 50-60%. The mortality rates shown for calves and young stock exceed the figures usually assumed for such systems, but are believed to be representative. Calf death not only represents a direct loss from sales of beef but also of milk, since it almost always terminates lactation.

Growth rate data are scarce but those shown are considered to be typical. First calving usually occurs when the animals are 3 years old or more and, if it does occur earlier because of lack of control, heifers often never recover to reach their normal adult weights or production potential.

The milk yields shown refer to saleable milk, excluding that consumed by the calf, and are commonly in the range 3-4 kg/cow/day and less than 1000 kg/lactation. Lactation length is poorly documented but is very variable, whether due to the death of the calf or not. Cows may cease to be milked because of limited forage availability or higher priority demands on labour, as was the case in the Bolivian study where the start of the rice harvest affected the number of cows milked, or, in other cases, cows giving as little as one kg/day continue to be milked because market and labour conditions are favourable.

The data tabulated show a range of annual production of 45-192 kg of beef and 182-746 kg of milk per hectare.

Economic performance: Information on economic performance is extremely scarce and economic parameters for these low-input/low-output systems are far more complex to define than biological indicators. The limited use of purchased

inputs makes results very sensitive to the valuation of land, capital and labour resources used. If market prices for land, labour and capital are imputed dual purpose systems can frequently be shown to produce negative net incomes. This type of analysis often neglects the fact that generally land with below-average opportunity costs is used. The same applies to the labour employed. The safety of the investment and cash-flow advantages tend to justify returns to capital below markets values. Taking these aspects into account, reasonable returns to management and family labour can be achieved as shown in the Panamanian case where the return per total man-day employed was of US$10, doubling the market wage. In spite of the low output per hectare or per cow these systems generate important incomes in the region due to the services they demand, labour for milking, weeding, fencing, milk transportation, etc. This is particularly attractive because it is a year-round operation thus creating continuous employment and therefore cash flow in the regional economy.

Dual purpose systems can be concluded to be systems of intermediate intensity, very efficient in the use of medium and poor quality forage resources fluctuating both in terms of quantity and quality to produce beef and milk at reasonable prices in the lowland tropics.

Marketing constitutes one of the most serious limiting factors in the system. Very scattered production, low volumes of milk per farm, poor initial quality and difficult communications restrict fluid milk sales to farms close to consumer centres. Otherwise, milk is made into cheese on the farm. Once refrigerated reception centres are set up, new farms start to milk their cows and milk is sent from over a wide radius, even where this implies considerable transportation problems in the rainy season. In some parts of the region, such as the Venezuelan lowlands, transport in the rains is impossible and cows are milked only in the dry season, despite the forage shortage. A similar situation can be observed in the Andean Piedmont of Colombia.

Research trends and priorities: In spite of the prevalence of dual-purpose systems throughout the region, they have been almost completely neglected in the allocation of research resources in the past. Recently, however, both disciplinary and systems research have been considerably strengthened by institutions such as CATIE (Costa Rica), FIRA (Mexico), IVITA (Perú), EMBRAPA (Brazil), ICA and CIAT (Colombia).

In the field of nutrition, increasing attention is being paid to improved pastures (Cubillos, 1982; Martínez and Delgado, 1982; CIAT, 1982, 1983), with emphasis on improving the seasonal distribution of forage as well as its nutritional value. Legumes, including tree species, have a most important part to play (Alvarez and Preston, 1976; Paterson and Horrel, 1981; Paterson et al., 1981, 1982) particularly due to the rising cost of N fertilizers and the shortage of alternative protein supplements. The potential contribution of legumes to dry season forage supply, particularly on poor, acid soils is demonstrated by work at CIAT (CIAT, 1983; Böhnert, 1983). The importance of adequate pasture management and the introduction of legumes is emphasized by the difficulty and cost of forage conservation (hay or silage) under lowland tropical conditions.

Early attempts to use ley systems in the tropics did not succeed but substantial advances in the understanding of tropical soil-plant interactions and the availability of forage legumes with high N fixation capacities and productivity, as well as rising fertilizer prices, are increasing the attractiveness of integrated crop-pasture systems. CIAT is now starting research in this field in the Eastern Plains of Colombia.

Interest is also focused on the use of crop and industrial by products as supplements for grazing cattle. Animal responses to the use of sugar cane by-products have generally been disappointing (Archibald et al., 1983; Martínez and Delgado, 1982). Regionally available materials such as straws and corn cobs (Escobar and Parra, 1984) and crops such as bananas (Cerdas and Ruiz, 1983) or sweet potatoes (Ruiz et al., 1981) which may be seasonally available surplus to market requirements and which have, in addition, valuable forage components, should be incorporated increasingly into cattle diets on a local scale.

Mineral deficiencies are widespread throughout the region (McDowell et al., 1979) but supplements are expensive and their chemical composition is often unsuited to local needs (Vaccaro et al., 1984). Thus, local requirements must be diagnosed and specific mixtures made available.

In the field of management, special attention has been directed to milking and weaning systems. Cows with zebu or criollo inheritance tend to

produce more total and saleable milk if milked without weaning their calves, a system which also reduces calf death rate and mastitis incidence (Alvarez and Saucedo, 1982). Restricted suckling after milking also gives satisfactory results (Ugarte and Preston, 1975; Alvarez and Saucedo, 1982). However, more information is needed on systems which optimize saleable milk yields, long term calf growth rates and the use of calf feed supplements. Calving intervals may be somewhat lengthened if the calf is not weaned (Alvarez and Saucedo, 1982), but it seems that post partum ovarian activity is not necessarily affected (Velazco et al., 1983). In any case, the increase in calving interval is insignificant compared with the advantages of the system. Once labour costs make machine milking a necessity, installations should be designed to permit the calf to be present, since variable results are obtained from milking cows with as much as 50% European inheritance without them. However, Carnevali and Bodisco (1966) showed with the Milking Criollo that the most productive cows will respond to milking alone and the rest might be considered candidates for culling in any case.

In the area of genetic improvement, there is an urgent need to standardize the measurement of performance in dual-purpose cattle and to study the inheritance of milk and calf production in systems where the cow is milked and suckled. European × zebu/criollo cows will produce most milk and live calves over a given time period (Vaccaro, 1979), even where conditions permit yields of 3000-3500 kg milk/lactation. Holstein crossbreds have proved superior to Brown Swiss crosses in age at first calving, survival and, usually in milk yield (Rubio, 1976; Rodríguez and Rincón, 1971; Cerrada et al., 1977; Vaccaro and Vaccaro, 1981, 1982; Cardozo and Vaccaro, 1983a,b) but it is not clear whether the use of high predicted difference bulls, proven in temperate zones, is justified. Despite the importance of crossbred populations, Cuba is the only country with crossbred bulls in artificial insemination and these have yet to be proven. In general, progress has been very slow in putting practical, scientific programmes into field practice. Simple effective plans such as farm selection of bull dams according to milk+calf production (Venezuela) or the distribution of high quality young crossbred bulls by national institutions (Brazil; Madalena, 1981) should be more widely promoted.

On-farm milk storage, collection, handling and marketing are other areas

requiring increased attention. At present, milk cooling is the only method of conservation, apart from turning the milk into cheese. Low-cost cooling techniques, such as those based on solar energy, might expand the areas supplying milk markets substantially and prove critical in shifting the trend towards twice daily milking. Additives to preserve milk should be developed and would probably be adopted if milk for the liquid market were clearly chanelled thereto and subjected to specific quality regulations rather than, as at present, to those appropriate for milk used in cheese and yogurt making.

Due to the complexity of small-scale pasture-based livestock systems, component research such as that described above can only be effective if developed and tested within actual farming systems. While ample experience exists with crops in farm level tests it is very limited in livestock systems and appropriate methodology needs to be developed.

The development of a dynamic dual-purpose sector requires a consistent policy framework, concerned with issues such as the allocation of research funds, importation policies for milk, dairy products, cattle, semen and concentrates, marketing policies, road construction, rural electrification, extension and credit policies. Substantial research is needed to understand the impact of these issues, so that decision makers may be helped to formulate consistent and effective policy packages.

Outlook: Per capita milk production of milk is low in tropical Latin America by international standards [approx. 75 kg produced per capita in tropical Latin America versus 180 kg in temperate Latin America over the period 1977/81 according to FAO (1981) data]. Nevertheless, important shares of food expenditures are spent on milk, dairy products and beef and they have high income elasticities, particularly among the low-income strata of the population. A series of large scale consumption surveys of major urban centres of Latin America documented that the expenditure for milk and dairy products within the lowest income quartile of the population amounted to 7 to 13% of total food expenditure. For the same population group income elasticity of demand for milk and dairy products was estimated to range between 0.87 and 1.16 (Nores and Rubinstein, 1980).

This strong consumer preference, together with population growth, leads to an increasing demand for milk. As demand outpaces supply in the region, local prices and/or importations increase. Due to the huge national debts in most countries, pressure for a higher degree of self-sufficiency in milk and dairy products is growing in the region. However, land at higher altitudes suitable for intensive production using European cattle is limited (except in Colombia) and has high opportunity costs for alternative agricultural and horticultural uses. Thus, the growing demand for milk must be met from the lowlands.

In the lowland areas, intensive systems continue to be tried and, usually, discontinued. Milk yields of 3000-4000 kg/lactation and reasonable calving intervals may be obtained using European or high-grade crossbreds (Prada, 1979; Verde, 1979; Wilkins et al., 1979) but heavy losses occur at all stages of life from conception (Vaccaro and Vaccaro, 1981; Cardozo and Vaccaro, 1983b; Vaccaro et al., 1983). Health and reproduction problems inflate production costs already high due to the high initial price of the cattle, heavy concentrate feeding and the large investment in infrastructure and machinery necessary to establish the complex cut and carry forage feeding systems required. Thus, income may not cover costs at all (Wilkins et al., 1979) or leave only a very small margin of profitability (Lovera and Fernández, 1983).

The fact that such systems can only operate successfully with very high milk prices or substantial subsidies, at the expense of low-income consumers or taxpayers, severly questions the desirability of such a development strategy from a national viewpoint. It is thus concluded that the gradual improvement of traditional dual-purpose systems through balanced efforts in research, extension and dairy policy, is the most appropriate way to supply consumers in the Latin American tropics with milk in the coming decades.

Table 1. Production per milking cow in Latin America, Europe, United States and Australia. Average 1977/1981 (kg /year)

Country and Region	Production per milking cow
Tropical Latin America	**881**
Tropical South America	**836**
. Brazil	721
. Mexico	762
. Bolivia	1310
. Colombia	983
. Cuba	1389
. Dominican Republic	1589
. Ecuador	1329
. Paraguay	1907
. Peru	1104
. Venezuela	1192
Central America and Panama	**1001**
. Costa Rica	1480
. El Salvador	960
. Guatemala	895
. Honduras	590
. Nicaragua	905
. Panama	996
Caribbean	**871**
Temperate Latin America	**1763**
Latin America	**1070**
Western Europe	3586
United States	5259
Australia	2873

Source: Estimated from FAO, Production Tape 1981

Table 2. Farm gate price ratio of beef to milk in selected countries, 1982/1983

Region and Country	Price ratio (kg/kg)	Source:
Tropical Latin America		
Brazil	3.33	Rivas and Seré (1983)
Colombia	4.28	
Ecuador	4.00	
Panama	4.19	
Paraguay	1.13	
Peru	2.33	
Temperate:		
Australia	6.49	BAE (1983)
Germany FR	7.38	Agrarwirtschaft (1983)
United States	5.50	USDA (1981, 1982)

Table 3. Description of commercial dual purpose farms in tropical Latin America

a) Production Resources (Reference No.)	Honduras (1)	Honduras (2)	Costa Rica (3)	Panama (4)	Panama (5)	Bolivia (6)	Colombia (7)	Colombia (8)	Colombia (9)	Venezuela (10)	Brazil (11)
Number of farms in study	60	36-42	192	6	59	16	83	60	19	508	27
Owners:											
. % owner operators	-	-	-	100	60	-	-	89	-	67	-
. Education (years, $\bar{x}$)	-	-	4	-	-	-	-	-	-	-	-
. % illiterate	-	-	-	0	-	-	9[a]	24	-	63	-
. % receive technical assistance	-	-	13	100	25	100	37	54	-	15	-
. % receive institutional credit	-	-	40	100	56	-	63	75	-	20	-
Labour:											
. % farms with hired labour (permanent: P, temporary: T)	-	-	-	83	93	-	-	P 35 T 86	-	T 71[b]	-
. Family labour as percentage total	-	-	-	32	-	-	-	-	-	67[b]	13
. Man days[c]/ha	-	-	44	8	-	-	12	-	-	11[b]	9
. Man days/animal unit (or/cow (C))	-	-	38	5	-	-	C 21	-	-	12[b]	17
. % hired labour illiterate (administrators: A, labourers: L)	-	-	-	-	-	-	A 42[a] L 79	-	-	-	-
Land:											
. Total area ($\bar{x}$/farm; ha)	-	47	17	72	-	53	101	22	219	132	203
. % total area in pastures	-	56	53	93	97	39	88[a]	89	77	84	74
Cattle:											
. No. cows ($\bar{x}$/farm)	6	20	8	42	21	11	-	13	141	45	56
. Cows as percentage total herd	44	-	38	36	-	35	-	42	40	39	41
. Males >12 months, except bulls, as percentage total herd	-	-	20	12	-	-	-	7	13	18	19
. Native (zebu, criollo) cattle as percentage total (cows: C; bulls: B; all: A)	-	-	A 32	C 37	-	C 47 B 40	A 7[a]	C 27 B 47	-	C 2 B 39	-
. European-native crosses as percentage total (cows: C; bulls: B; all: A)	-	-	A 54	C 63	A 70	C 33 B 40	A 91[a]	B 37	-	C 83 B 48	-
Capital:											
. Investment (US$) per: (total: T; excluding land: EL)				T 850						T 1405	
- hectare	-	-	EL 457	EL 520	-	-	-	-	-	EL 914	-
- animal unit	-	-	EL 391	T 605 EL 370	-	-	-	-	-	T 1383 EL 1029	-
. % capital (T; EL) invested in:											
- land	-	-	-	T 39	-	-	T 46[a]	-	-	T 35	-
- cattle	-	-	EL 46	T 53 EL 87	-	-	T 35[a]	-	-	T 28 EL 46	-
- construction	-	-	EL 31	T 7 EL 11	-	-	T 10[a]	-	-	T 26 EL 40	-
- machinery/equipment	-	-	EL 18	T 1 EL 2	-	-	T 9[a]	-	-	T 9 EL 14	-
b) Feeding, Management and Health											
Pastures and supplements:											
. Cultivated as percentage total pastures (TP)	-	-	50	67	-	15	-	61	-	83	-
. Species for cutting as percentage TP	-	-	-	.03	-	-	-	-	.5	.4	3.4
. % farms with species for cutting	-	-	-	17	8	-	-	53	42	-	-
. % farms which:											
- fertilize pasture	-	12	10	50	8	-	-	27	-	8	-
- control weeds by hand	-	70	88	100	-	-	61	60	-	71	-
- use concentrate supplements	6	11	12	50	8	-	14	-	-	6	73
- use any energy-protein supplement	-	-	37	-	-	-	10	45	-	-	73
- use mineral supplement	62	43	-	83	-	-	72	73	-	23	77
- use common salt	-	84	-	100	83	-	85	100	-	100	93
Management and health:											
. % farms which:											
- run herd in single group	100	-	-	0	-	-	-	-	-	48	-
- use natural, free mating	100	90	-	100	-	-	-	>80	-	99	-
- keep production records	7	-	15	33	-	-	24	<20	-	2	-
- use any vaccine	56	<50	-	50	88	-	-	70	-	-	-
- vaccinate against brucellosis (B), foot and mouth (FM)	-	-	-	-	-	-	B 47 FM 94	B 15 FM 38	-	B 36 FM 74	-
- control external (E) and internal (I) parasites	E 56 I 48	E <50 I 78	-	E 100 I 100	I 81	-	E 70	E 70 I 54	-	E 64 I 47	-

Table 3. (cont.)

c) Animal Productivity and Economic Performance (Reference No.)	Honduras (1)	Honduras (2)	Costa Rica (3)	Panama (4)	Panama (5)	Bolivia (6)	Colombia (7)	Colombia (8)	Colombia (9)	Venezuela (10)	Brazil (11)
Animal productivity:											
. Age at first calving (months, $\bar{x}$)	-	-	32	40	31-36	-	-	36	-	34	-
. Calving (%)	57	59	52[e] 39[f]	73	73	81	62	62	77	58	64
. Lactating cows as percentage all cows	-	-	-	66	62	-	-	60	-	48	64
. Abortion rate (%; cows: C; heifers: H)	-	-	-	C 4 H 9	-	-	-	-	-	-	-
. Death rates (%; calves: C; young stock: YS)	-	-	C 10[e] C 2[f]	C 20 YS 5	C 11	-	-	-	-	-	C 9 YS 1
. Body weight: (kg, $\bar{x}$)											
- calves (10: T; 12: TW months old)	-	-	-	TW 132	-	-	-	-	T 131	-	-
- young stock (18: E; 24: T months old)	-	-	-	E 165 T 184	-	-	-	-	-	-	-
- cows (lactating not pregnant)	-	-	-	321	-	-	-	-	-	-	-
. Milk yield:											
- kg/cow/day (wet season: W; dry season: D)	W 4-6 D 2-3	-	-	3	-	-	W 3.2 D 2.9	3	2.8	W 4 D 3	W 5.5 D 5.0
- kg/cow/lactation: L; or year: Y	-	-	Y 431[e] Y 186[f]	L 958	Y 1156	Y 712	-	-	L 749	-	-
. Lactation length (days, $\bar{x}$)	-	-	-	304	-	244	-	-	300	-	-
. Stocking rate (animal units/ha: head/ha: H)	1.4[d]	1.9	1.8[e] 1.4[f]	1.3	1.5	1.5	H 1.1	1.8	H 2.1	.8	0.8
. kg/ha/year:											
- beef production	-	-	192[e] 153[f]	62	-	-	-	-	-	45[b]	-
- milk production	-	746	652[e] 182[f]	276	622	385	365	-	749	290[b]	475
Economic aspects: (US$)											
. Gross income per:			270[e]								
- hectare	-	-	130[f]	125	149	-	-	-	-	152[b]	124
- animal unit	-	-	-	85	92	-	-	-	-	172[b]	221
. % product sold	-	-	34[e] 20[f]	89[g]	-	-	-	-	-	92[b]	95[g]
. Value of milk as percentage total livestock product	-	-	-	50	-	-	-	-	-	68[b]	55
. Net income[h] per:			-117[e] -43[f]								
- hectare	-	-		80	-	-	-	-	-	7[b]	-
- animal unit	-	-	-	54	-	-	-	-	-	7[b]	-
. Return per man-day of:											
- total labour employed	-	-	-	10	-	-	-	-	-	-	-
- family labour employed	-	-	-	21	-	-	-	-	-	-	-
. Net family income per hectare	-	-	155[e] 109[f]	-	-	-	-	-	-	-	-

a/ Data refer to total sample of 487 farms, 62% of which are dual purpose.
b/ Data refer to 15 case studies, selected from among the original 508 farms.
c/ Assuming 300 workdays/year.
d/ In rainy season
e/ Denotes less than 38 of the original farms which milk all cows throughout lactation.
f/ Denotes less than 38 of the original farms which milk some cows and only at start of lactation.
g/ Milk.
h/ Net incomes refer to return to management only in Costa Rica and Venezuela; in Panama return to land, capital, family labour and management.

References

(1) Comayagua valley; 800 m above sea level; dry, sub-tropical forest; 1035 mm annual rainfall; 24°C mean annual temperature. Farms represent 8% those in 5 municipalities; chosen at random. La Hoz and Alvarado (1981).

(2) La Ceiba and Olanchito districts, north coast; 25-275 m above sea level; 1067-2858 mm mean annual rainfall; 4-months dry season; farms selected at random from those with <50 cows. Gonzalez et al. (1981 a,b).

(3) Farms selected at random in 4 districts of Costa Rica from those with <50 ha or <25 cattle. Avila et al. (1979); Pezo et al.(1979); Ruiz (1982).

(4) Farms of 30-200 ha with credit from National Bank of Panama; located in Central Provinces; 0-200 m above sea level, generally acid soil types; 1500 mm rainfall; 5-months dry season; case studies selected among owner-operators without other important sources of income. Seré et al.(1982)

(5) Chiriquí, Veraguas and Azuero regions. Farms selected at random from those with <50 cows, <80 steers and <50 ha in crops. Dual purpose farms constituted 26% total selected. Delgado et al. (1979); Sarmiento et al. (1981).

(6) Small farms of colonists in technical assistance project. Santa Cruz area. 350 m above sea level; 1825 mm annual rainfall. Mean temperatures 29.7°C (max.), 18.8°C (min.). Alluvial soils, pH 4.2 - 5.02, deficient in P. Breinholt (1982).

(7) Data refer to farms of Bolivar and Atlántico Depts., 74% of which are dual purpose; 870-1200 mm annual rainfall; 5-6 months dry season; 28°C mean annual temperature; variable soils. Rivas (1974).

(8) Farms of 5-100 ha in foothills of Dept. Meta; variable elevation, some steep slopes, mean 500 m above sea level; 23-29°C annual mean temperature; 2500-5000 mm mean annual rainfall; soils pH 4.0 - 5.0, deficient in N, P, Ca, Mg. Kleeman et al. (1983).

(9) North Atlantic coast, 0-200 m above sea level; 1100 mm rainfall; marked dry season of 5-6 months; fertile soils; 32 purposively selected farms of which 19 are dual purpose farms. Schellenberg (1983).

(10) Farms chosen at random, after stratification for kg milk sold/day, from among those selling milk to reception or cheese making centres. Barinas State; 160-600 m above sea level; 1400-2650 mm annual rainfall; 3-4 months dry season; 26.5°C mean annual temperature. Soils variable, tending to be poorly drained. Cardozo et al. (1980).

(11) 27 Farms producing more than 100 kg milk per day in the Zona da Mata, Minas Gerais, 23°C annual mean temperature, 1487 mm annual rainfall, rolling country with mainly podzols and latosols. Cemente et al. (1980).

REFERENCES

Agrarwintschaft. 1983. Statistical appendix. September. Vol. 32 No.9, 293-296 pp.

Alvarez, F.J. and T.R. Preston. 1976. Leucaena leucocephala como suplemento protéico para la producción de leche y becerros destetados en raciones basadas en caña de azúcar. Producción Animal Tropical 1: 116-122.

Alvarez, F.J. and G. Saucedo. 1982. Sistemas de doble propósito para los trópicos húmedos. In Vaccaro, L. (Ed.) Sistemas de producción con bovinos en el trópico americano. Instituto de Producción Animal, Facultad de Agronomía, Universidad Central de Venezuela, Maracay p 113-135.

Archibald, K.A.E., P.O. Osuji and F.A. Neckles. 1981. Intensive milk production from sugar cane-based feeds in the Commonwealth Caribbean. In Smith, A.J. and R.G. Gunn (Eds.). Intensive animal production in developing countries. British Society for Animal Production, Thames Ditton, England p 343-348.

Avila, M.D. Pezo, M.E. Ruiz and A. Ruiz. 1979. Sistemas de producción en pequeñas fincas de Costa Rica. IV. Aspectos económicos de la producción lechera. Memoria Asociación Latinoamericana de Producción Animal 14: 44 (Abstract).

BAE: 1983. Quarterly Review of the Rural Economy. Vol. 5 No. 2. (May) p 205.

Böhnert, E. 1983. Untersuchungen über die selektive Futteraufnahne von Rindern unter Weidebedingungen auf unterschiedlichen Grass-Leguminosen-Mischungen amthropischen Standort der kolumbianisnchen Llanos Orientales. Dr. Agr. Thesis, Technische Universität Berlin 168 pp. Universität Berlin 168 pp.

Breinholt, K. 1982. Producción de leche anual y comportamiento reproductivo en pequeñas fincas en el trópico boliviano. Producción Animal Tropical 7: 283-291.

Cardozo, R., E. Moreno, L. Vaccaro, R. Vaccaro, A. Hurtado, C. Peña, J. Vilorio and E. Romero. 1980. Proyecto de desarrollo lechero del piedemonte del Edo. Barinas. Universidad Nacional Ezequiel Zamora, Barinas, Venezuela, Tomo I, II. 174, 191 pp.

Cardozo, R. and L. Vaccaro. 1983a. Producción de leche en un sistema intensivo de producción en los llanos occidentales. III Congreso Venezolano de Zootecnia, San Cristobal, Venezuela: F1 (Abstract).

Cardozo, R. and L. Vaccaro. 1983b. Vida útil en sistemas intensivos de producción de leche en el trópico. IX Meeting, Asociación Latinoamericana de Producción Animal, Santiago de Chile: GM-35 (Abstract).

Carnevali, A. and V. Bodisco. 1966. El apoyo sin becerro como norma de selección de vacas criollas. Agronomía Tropical 16: 329-333.

Cerdas, R. and M.E. Ruiz. 1983. Suplementación con banano verde a vacas lecheras en diferentes estados de lactancia. IX Meeting, Asociación Latinoamericana de Producción Animal, Santiago de Chile: R-45 (Abstract).

Cerrada, G., V. Bodisco, A. Brun and O. Abreu. 1977. Producción de leche de mestizos comerciales en el trópico seco. VI Meeting, Asociación Latinoamericana de Producción Animal, La Habana, Cuba. Vol. 1; 58 (Abstract).

CIAT 1984. Annual Report 1983. Tropical Pastures Program, Cali.

Cubillos, G. 1982. Sistemas de producción de leche en las zonas tropicales. In Vaccaro, L. (Ed.). Sistemas de producción con bovinos en el trópico americano. Instituto de Producción Animal, Facultad de Agronomía, Universidad Central de Venezuela, Maracay p. 59-74.

Delgado, A., M. Ruiloba and M. Avila. 1979. Diagnóstico de las explotaciones lecheras de doble propósito en tres regiones de Panamá. Asociación Latinoamericana Latinoamericana de Producción Animal Memoria 14: 45-46 (Abstract).

Escobar, A. and R. Parra. 1984. Uso de los residuos agrícolas fibrosos (RAF) en la alimentación animal. Producción Animal Tropical (in press).

FAO. 1982. Production Yearbook 1981. Rome.

Gemente, A. C., L. C. T. Yamaguchi and P. J. Ribeiro. 1980. Acompanhamento a fazendas productoras de leite na Zona de Mata de Minas Gerais, Circular Tecnica No.06. EMBRAPA - Centro Nacional de Pesquisa de Gado de Leite. Coronel Pacheco - M.G.

González, C., A. Serrano and M. Avila. 1981a. Manejo y comportamiento reproductivo de vacas doble propósito. VIII Meeting, Asociación Latinoamericana de Producción Animal, Santo Domingo: F-1 (Abstract).

González, C., O. Toro and M. Avila. 1981b. Diagnóstico de la ganadería bovina de la Dar No. 4 en Honduras. VIII Meeting. Asociación Latinoamericana de Producción Animal, Santo Domingo: E-3 (Abstract).

Kleeman, G. (Ed.), E. Krain, R. Kuchenreuther, A. Otero, H. Sauter, J. Thaysen and A. Warner. Situación actual y potencial de la producción lechera en explotaciones de doble propósito en el pie de monte llanero (Meta, Colombia). Institut für Sozialökonomie der Agrarentwicklung. Technische Universität Berlin. 309 pp.

La Hoz, E. and M. Alvarado. 1981. Diagnóstico ganadero de pequeñas propiedades en el Valle de Comayagua (Honduras). VIII Meeting, Asociación Latinoamericana de Producción Animal, Santo Domingo: E-6 (Abstract).

Lovera, L. and L. Fernández. 1983. Estudio técnico económico de una empresa lechera de carácter intensivo: Estado Portuguesa. Universidad del Zulia, Maracaibo, Venezuela.

Madalena, F. E. 1981. Crossbreeding strategies for dairy cattle in Brazil. World Animal Review 38:23-30.

Martínez, R.O. and A. Delgado. 1982. Sistemas de producción de leche carne con uso intensivo de pastizales en Cuba. In Vaccaro, L. (Ed.). Sistemas de producción con bovinos en el trópico americano. Instituto de Producción Animal, Facultad de Agronomía, Universidad Central de Venezuela, Maracay p 187-210.

McDowell, L.R., J.H. Conrad, J.K. Loosli and E.S. Pollak. 1979. Results of mineral research in Latin America. Latin American Short Course, University of Florida, Gainesville, Fla., USA. 19 pp (Mimeo).

Ministerio de Agricultura. 1977. Programas Ganaderos. Bogotá, Colombia.

Ministerio de Agricultura y Cría. 1981. Anuario Estadístico Agropecuario. 1978. Ministerio de Agricultura y Cría, Carácas Venezuela. 773 pp.

Paterson, R.T. and B. Horrel. 1981. Leguminosas forrajeras en Santa Cruz, Bolivia. Producción Animal Tropical 6: 46-57.

Paterson, R.T., C. Samur and O. Bress. 1981. Efecto de pastoreo complementario de leguminosa reservada sobre la producción de leche durante la estación seca. Producción Animal Tropical 6: 135-140.

Paterson, R.T., C. Samur and G. Sauma. 1982. Leucaena leucocephala para la complementación de pastos existentes. Producción Animal Tropical 7: 9-14.

Pezo, D., M. Avila, M.E. Ruiz and A. Ruiz. 1979. Sistemas de producción en pequeñas fincas de Costa Rica. III Aspectos biológicos de la producción lechera. Asociación Latincamericana de Producción Animal Memoria 14: 43-44 (Abstract).

Prada, N. 1979. Programa de cruzamiento lechero en Cuba. Asociación Latinoamericana de Producción Animal Memoria 14: 163-167.

Rivas, L. 1974. Some aspects of the cattle industry on the north coast plains of Colombia. Technical Bulletin No. 3, Centro Internacional de Agricultura Tropical, Cali, Colombia. 142 pp.

Rivas, L. and C. Seré. 1983. Análisis de precios de productos e insumos ganaderos en localidades donde se desarrollan ensayos regionales. CIAT. (Mimeo).

Rodriguez, C.J. and E.J. Rincon. 1971. Producción de leche de vacas mestizas Criollas x Pardo Suizo y Holstein mantenidas a potrero en el Estado Zulia. Agronomía Tropical 21: 210-213.

Rubio, R. 1976. Ganado Costeño con Cuernos. In: Razas Criollas Colombianas. Manual de Asistencia Técnica No. 21. ICA, Bogotá, Colombia. 83-106.

Rubinstein, E. and G. Nores. 1980. Gasto en carne de res y productos lacteos por estrato de ingreso en doce unidades de América Latina. Mimeo. CIAT, Cali.

Ruiz, A. 1982. Sistemas de producción de doble propósito para pequeños productores. In Vaccaro, L. (Ed.). Sistemas de producción con bovinos en el trópico americano. Instituto de Producción Animal, Facultad de Agronomía, Universidad Central de Venezuela, Maracay. p 137-157.

Ruiz, M.E., E. Lozano and A. Ruiz. 1981. El uso de camote (Ipomea batata (L) Lan) en la alimentación animal. III Adición de diversos niveles de raíces y urea al ensilaje del forraje. Producción Animal Tropical 6: 259-269.

Sarmiento, M., S. Rios, B. Pinzon, M. De Gracia, P. Guerra, M. Avila, H. Li Pun, V. Mares and O. Mature. 1981. Diagnóstico de sistemas de producción de pequeñas y medianas explotaciones ganaderas en Panamá. III Comparación de sistemas de producción animal. VIII Meeting, Asociación Latinoamericana de Producción Animal, Santo Domingo: E-3 (Abstract).

Schellenberg, R. 1983. Untersuchungen zur Milch- und Fleischerzeugung in Rinderbeständen Landwirtscaftlicher Betriebe des Tropischen Tieflandes Nordkolumbiens. Dr. Agr. Thesis, Thechnische Universität Berlin. 207 pp.

Seré, C., R. Schellenberg and R.D. Estrada. 1982. Ganadería doble propósito - Diagnóstico de sistemas de las provincias centrales, Panamá. Estudio cooperativo, Banco Nacional de Panamá (BNP) y Centro Internacional de Agricultura Tropical (CIAT). Información Preliminar. Centro Internacional de Agricultura Tropical, Cali, Colombia.

Ugarte, J. and T.R. Preston. 1975. Amamantamiento restringido. 6. Efectos sobre la producción de leche, comportamiento reproductivo e incidencia de mastitis clínica a través de la lactancia. Rev. Cubana Cienc. Agríc. 9: 17-26.

Vaccaro, L. 1979. El papel del mestizaje en la producción de leche en el trópico. Resumen de la Discusión y Comentario. Asociación Latinoamericana de Producción Animal Memoria 14: 169-177.

Vaccaro, L. de, B. de Andina, J.F. Arias, R. Cardozo, J.R. Casal. L.S. Faria, S. Fariñas, W. García, J. Guerrero, E.A. Mejía, F. Morales, F. Rodríguez, R. Rodríguez, L. Urriola and M. Venegas. 1984. Deficiencias minerales como factor limitante de la producción bovina en una parte de los llanos Venezolanos. I. Características de las fincas, producción y niveles sanguíneos de Ca, Mg y P. Producción Animal Tropical (in press).

Vaccaro, L., R. Cardozo, R. Vaccaro y M.A. Benezra. 1983. Vida útil en sistemas intensivos de producción de leche en el trópico. 1. Hembras Holstein Friesian importadas y nacidas localmente. IX Meeting, Asociación Latinoamericana de Producción Animal, Santiago de Chile: GM-36 (Abstract).

Vaccaro, L. and R. Vaccaro. 1981. Pérdidas hasta el primer parto en Pardo Suizo x Cebú y Holstein Friesian x Cebú en un sistema intensivo de producción lechera en el trópico. Producción Animal Tropical 6: 337-347.

Vaccaro, R. and L. de Vaccaro. 1982. Edad al primer parto, reproducción y sobrevivencia prenatal en mestizas Holstein Friesian y Pardo Suizas en un sistema intensivo en el trópico. Producción Animal Tropical 7: 201-207.

Velazco, J., J. Calderon, S. Guevara, M. Capriles, M. Capriles, N. Martinez, L. Paredes and S. Lopez. 1983. Efecto del amamantamiento restringido sobre el crecimiento de becerros, producción de leche, actividad ovárica y nivel de progesterona en vacas Holstein y Pardo Suizo. Instituto de Producción Animal, Facultad de Agronomía, Universidad Central de Venezuela. Informe Anual 1981: 43-44 (Abstract).

Verde, O. 1979. Cruzamiento de bovinos productores de leche en el trópico: resultados de Venezuela. Asociación Latinoamericana de Producción Animal Memoria 14: 155-161.

Wilkins, J.V., J.A. Alí and C. Vaca Díez. 1979. El cruzamiento para la producción de leche en los llanos de Bolivia. VII Meeting, Asociación Latinoamericana de Producción Animal, Panamá, Seminario sobre cruzamiento de bovinos productores de leche en el trópico. 7 pp (Mimeo).