A silvopastoral system in northern Costa Rica

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Abstract

In Central America, trees dispersed in pastures and used as live fences are typical elements in paddocks and constitute a component of a silvopastoral system. These elements were analyzed in cattle production systems of a lowland region of Costa Rica to characterize the tree component and its role in different systems. Three cattle systems were established: mixed (milk and crop production), specialized in milk and dual purpose (milk and meat). The area of pasture with trees was greater in dual purpose systems. The timber tree species Laurel was the predominant type in the pastures, although its density was low (11 trees ha^{-1}). In specialized milk systems, a significantly high density of shade trees was found compared to the other systems. No significant differences were observed in live fence species and the length covered per ha of pasture between the systems. The tree component plays an important role in cattle production systems of the region.

Keywords: cattle, live fences, trees in pastures, silvopastoral system

Introduction

A silvopastoral system is a specific form of agroforestry which encompasses the combination of pastures and animals with trees on a certain piece of land. Its main components are trees and shrubs, pastures, livestock and man, together with the environmental factors climate, soils and land form (Leeuwen & Hofsted, 1995). In Costa Rica, trees are found dispersed in more than 90 % of cattle farms to provide shade and generate additional farm income, e.g. through the sale of timber (Leeuwen & Hofsted, 1995; Ibrahim et *al.*, 1998). The main tree species found in humid tropics from Costa Rica are laurel (*Cordia*

alliodora (R & P) Oken) and cedar (*Cedrela odorata*) (CATIE, 1991). In more than 75 % of the cattle farms in Costa Rica, live fences can be found demarcating pasture areas. The main species used in humid tropics are the fodder trees *Erythrina spp.* (Poró) and *Gliricidia sepium* (Madero Negro) and in dry areas *Bursera simaruba* (Indio desnudo).

Trees in silvopastoral systems also help in conservation of biodiversity, providing habitats and food resources for birds, bats and other animals which participate in dispersing seeds and contributing to the natural regeneration of these trees (Harvey & Haber, 1999; Guevara et al., 1994).

Although several authors have commented on the occurrence of trees in pastures or have documented their importance to forest species (Marmillod, 1989; Montagnini, 1992), there have been few systematic surveys on isolated trees in pastures, such as on density and arrangement of these trees in paddock landscapes and how the tree component varies according to different animal production systems. This lack of information makes it difficult to evaluate the economical and ecological importance of these trees to the sustainability of cattle farms and limits the possibility for recommendations on reliable alternatives in the arrangement and use of pasture trees in different cattle farming systems.

This study characterized the tree component in cattle farms at La Fortuna de San Carlos, Costa Rica. Typical farms of the region were studied to evaluate and understand: the composition, density and distribution of isolated trees and live fences in different cattle farm systems and the role of these trees in each animal production system. This study was a part of a wide-ranging study on the contribution of trees on pastures to the economical sustainability of livestock farms.

Materials and methods

This study was conducted at La Fortuna de San Carlos in a northern tropical humid region of Costa Rica (10° 28'N, 84° 39'W; altitude, 250 m; rainfall, 2000-4000 mm; air temperature, 26°C; relative humidity, 80 %; volcanic soils – Andisoles associated with Inceptisoles).

In May 1999, thirty-five livestock farms were chosen randomly from nine zones of La Fortuna de San Carlos to obtain information on the production area, types of existing animal production systems, pasture, dispersed trees, live fences, cattle breeds and milk yields. Using this information a canonical discriminant analysis was carried out, where three different types of livestock systems were identified: 1) mixed (milk and crop production); 2) specialized milk production; and 3) dual purpose (milk and meat production).

In September 1999 10 farms (4 of mixed, 3 of specialized milk and 3 of dual purpose production) were selected, based on the three different types of cattle production systems found. Detailed study on the dispersed trees and live fences in pastures, aimed at identifying the existing species, their abundance, origin and distribution was carry out. In farms of smaller than 100 ha in size the sample size was 10 % of the surface area, and 5 % for the farms of more than 100 ha in size. The total sample included 42.4 ha of paddocks (9.6 ha in mixed systems; 4.2 ha in specialized milk systems; and 28.7 ha in dual purpose systems).

Results and discussion

Animal Production Systems

Based on the biophysical analysis three cattle systems: 1) mixed (milk and crop production); 2) specialized milk production; and 3) dual purpose (milk and meat production) were identified. The total area of the dual purpose farms were on average nine times greater than the total area of the other systems, with this difference being significant ($P<0.01$). The

average percentage area of pasture with isolated trees was significantly greater (P<0.001) on dual purpose farms (74 %) than on mixed (16 %) and specialized milk production farms (27 %) (Table 1). Mixed farms used, on average, 81 % of the total area for pasture production with the rest being used for crop production like yucca (*Manihot esculenta*) and banana (*Musa* AAB). A total of 90 % of the cattle farms preserved areas of virgin forest.

The average milk production per area (kg $ha^{-1}day^{-1}$) was greater on specialized milk (14.2) and mixed farms (12.6) in comparison to dual purpose farms (4.3) (P<0.05). On mixed and specialized milk farms 95 % of the cattle were European breeds (Holstein, Jersey, and Holstein × Jersey), while on the dual purpose system, more than 70 % of the herd were crosses of Holstein and Zebu. According to the farmers these crossbreds were better adapted to the climatic conditions of the region. The higher milk production per unit area from the specialized milk and mixed farms must have been due to the presence of specialized breeds and also due to a better management on the farms. There was a greater area under improved pastures (i.e. *Cynodon nlemfuensis, Brachiaria brizantha y Panicum maximum* cv. Tanzania), pasture fertilization and greater use of concentrates (3 kg cow $^{-1}$ day $^{-1}$) on specialized milk and mixed farms than on dual purpose systems (Souza de Abreu, unpublished data).

Table 1. Biophysical average production characteristics, according to types of production systems. La Fortuna, San Carlos 1999 (n= 30 farms)

Type of system	Farm area (ha)	Pasture area (ha)	Area of pasture with trees (%)	Milk yield / farm (kg $farm^{-1}day^{-1}$)	Milk yield / area (kg $ha^{-1}day^{-1}$)
Mixed (13 farms)	44 b* (10-102)	35 b	16 b (3.5 – 23)	442 b	12.6 b
Specialized milk production (9 farms)	50 b (10-106)	46 b	27 b (5.0 – 67)	651 b	14.2 b
Dual purpose (8 farms)	327 a (210-548)	273 a	74 a (29 – 78)	1188 a	4.3 a

*Averages within column with the same letter are not significantly different (P<0.05)

Species of trees dispersed on pasture

Pastures with natural shade and without shade were found in the region. The natural shade was made up of valuable species like laurel and cedar. The laurel and cedar found in these silvopastoral system originated from natural regeneration and no silvicultural techniques were used to improve tree-forms and vigor. The farmers maintained laurel in paddocks because it produced construction and cabinet timber. It shows also rapid growth, abundant natural regeneration potential, it is self-pruning in open-grown situations (Somarriba & Beer, 1987; Souza de Abreu, unpublished data) and it has a small open crown which makes it good for shade for the animals but causing little damage to the pasture (Souza de Abreu et al., 1999). In addition, the merchantable trees represented a financial reserve that could be realized in times of crop failure, and of unfavorable prices for milk, meat and crop.

The other tree species like higuerón (*Ficus spp.*), limón dulce (*Citrus sinensis*), guava (*Inga sp.*), guayaba (*Psidium guajava*), poró (*Erythrina spp.*) and other timber trees like lagarto (*Zanthoxylum belizense*), gavilán (*Pentaclethra macroloba*) and surá (*Terminalia oblonga*) were also found frequently dispersed in the pastures (Table 2). As laurel, other timber trees were used to generate additional income for the livestock farms.

Table 2. More common species of timber trees in the pasture of La Fortuna de San Carlos, Costa Rica (n=35).

Scientific name	Common name	No. of farms*	Establishment method	Localization and distribution in pastures
Cordia alliodora	Laurel	35	Natural regeneration and plantation	Dispersed or live fences
Cedrela odorata	Cedro	33	Natural regeneration	Dispersed
Terminalia oblonga	Surá	19	Natural regeneration	Dispersed and river borders
Pentaclethra macroloba	Gavilán	8	Natural regeneration	Dispersed and river borders
Zanthoxylum belizense	Lagarto	5	Natural regeneration	Dispersed and river borders

* Refers to the number of farms, where the respective species were found.

The same species of trees were found in pastures of all different cattle production systems of the region and these species were randomly distributed in the pastures.

Density of the trees

Between 73 and 88 % of the trees found in pastures were timber trees. Laurel was the predominant species in all cattle farm systems of the region (Figure 1).

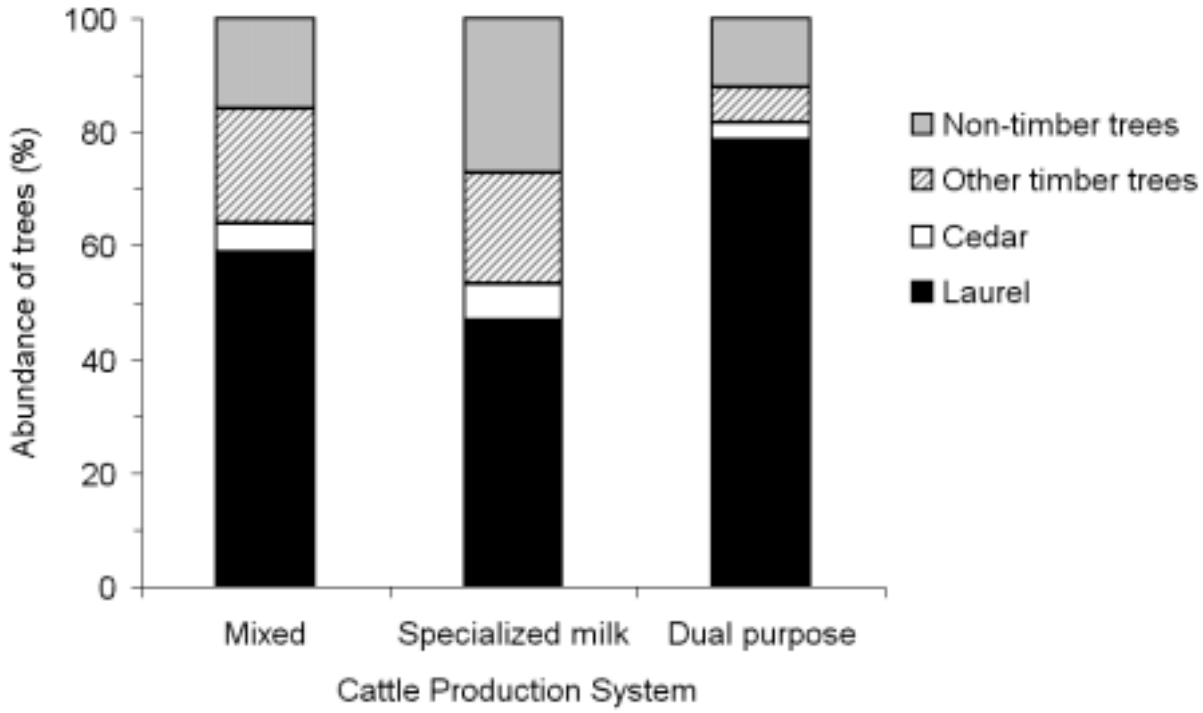

Figure 1: Abundance (%) of different types of trees in the three cattle production systems. La Fortuna de San Carlos, 1999. Other timber trees: Lagarto, surá, gavilán and poró. Non- timber trees (fruit and shade trees): Limón dulce, naranja, guayaba, guava and higuerón .

Compared to the dual purpose and mixed systems, the specialized milk production system presents a higher abundance of non-timber trees which provide more shade than laurel. This can be justified, because such farms have pure exotic milk breeds which need more shade to minimize the heat stress (Gregory, 1995; McArthur, 1991; Souza de Abreu et al., 1999).

The density of trees was greater in specialized milk production and dual purpose systems (Table 3). A higher density of laurel was found in the dual purpose system, which can be interpreted as a strategy of the farmers to reduce risks of the meat and milk price fluctuations through diversification with high value timber trees (Pezo et al., 1999).

Table 3. Abundance of trees by cattle production system. La Fortuna San Carlos, 1999. (Average number of trees/ ha)

Trees	Mixed (n =4)	Specialized in milk production (n =3)	Dual purpose (n=3)
Laurel	7.33 b[1]	10.34 b	16.08 a
Cedar	0.63 a	1.44 a	0.62 a
Other timber trees[2]	2.51 a	4.33 a	1.26 a
Non-timber trees[3]	1.99 b	6.00 a	2.51 b
Total	12.46 a	22.11 b	20.47b

[1] Values with the same letter in the same row are not significantly different (P<0.05).
[2] Lagarto, surá, gavilán and poró.
[3] Limón dulce, naranja, guayaba, guava and higuerón (fruit and shade trees).

In general the density of laurel and cedar in cattle farms is considered low, taking into account the high economical value of these species and that their canopy architecture allows for a high solar radiation transmission until the pasture stratum (Bronstein, 1984). Most of the cattle farms had star grass (*Cynodon nlemfuensis*) which maintains high soil cover causing competition and mortality of the small laurel plants. The management of the pasture with a high grazing intensity or grass cutting before the flowering of the trees could be a practical management strategy recommended to increase the density of timber trees in pastures (Camargo et al., 2000).

Live Fences

In 85 % of the farms were found lives fences, where two species were predominant: poró (*Erythrina spp.*) and madero negro (*Gliricidia sepium*). The poró was the species usually used (94% of 35 farms). Only 3.5 % (n=35) of the farms had Laurel sown as live fence. According to Botero et al. (1999) it is expected that with the increase in labor costs for the

livestock farmers, timber trees will increasingly be sown as live fences to generate more income.

The average total length of live fences was significantly greater (P<0.01) in the dual purpose systems compared to the specialized milk and mixed systems. However, the percentage of live fences length per ha of pasture varied only a little between the different systems (Table 4). The tendency of less live fences in milk production farms could be explained by the greater use of electric fences in the management of the cows.

Table 4: Extend and percentage of live fence used by cattle production systems. La Fortuna de San Carlos, 1999.

Type of system	Average total length of live fences (km)	Average area of pastures (ha)	% of live fences in relation to the pasture area
Mixed	5.6 b	35 b	15.7 a
Specialized milk	8.6 b	46 b	18.7 a
Dual purpose	51.8 a	273 a	19.0 a

*Averages within column with the same letter are not significantly different (P<0.05)

Conclusions

The area of pastures with trees and the abundance of the tree component in the pastures of the cattle systems in La Fortuna de San Carlos differed according to the type of the cattle system found on the farm. The area of pasture with trees was significantly greater in dual purpose systems than in other systems, but the abundance of dispersed trees in pastures was higher on the dual purpose and specialized milk systems. The role of the trees was different depending on the type of the cattle system. In dual purpose systems Laurel was the predominant tree species, indicating the importance of timber for this type of systems. In specialized milk systems, the greatest number of shade trees and fruit trees were found, which helped to minimize the heat stress in exotic breeds like Holstein and Jersey. The least abundance of trees in pastures was found in mixed systems and the predominant tree species was Laurel, suggesting a low degree of relevance of trees in pastures in these systems. The length of live fences per area of pasture did not differ

significantly between the three types of cattle systems and the same species were used across systems. Information on the predominant species in the pastures, their abundance and use in the different production systems is important for the evaluation of current and potential value of the trees to the economical and ecological sustainability of the cattle farming systems in the region.

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