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Agrobiodiversity assessment in the Atlantic Rainforest region of Rio de Janeiro

Determinación de la agrobiodiversidad en la region del bosque atlántico de Rio de Janeiro

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Resumen

En la municipalidad de Teresópolis del estado de Rio de Janeiro se evaluaron los recursos genéticos de plantas en una dinámica económica y ecológica determinando para siete sistemas agrícolas la agrobiodiversidad. Se evaluó el uso y manejo de la agrobiodiversidad y los indicadores de recursos genéticos. Presentaron los mejores índices los sistemas agroforestal y silvopastoral. Los cultivos perennes ayudan a disminuir la presión sobre los fragmentos en áreas deforestadas. Estos sistemas también juegan un papel importante en los biocorredores e introducen un modesto nivel de biodiversidad en las áreas degradadas del Bosque atlántico de Rio de Janeiro.

Palabras clave: Agrobiodiversidad, biodiversidad, sistemas agrícolas, Bosque Atlántico.

Abstract

In the municipality of Teresópolis Rio de Janeiro the genetic resources of plants in a dynamic, ecological and economic complex was evaluated, and the agro-biodiversity in seven farming systems that occur within 7 agro-ecosystems and 2 natural systems was assessed. It was evaluated the use and management of biodiversity and indicators of agricultural crop genetic resources. The ecological farming systems, agroforestry, sylvopastoral systems, and perennial cultivations present the best indices and help to reduce the pressure on the fragments and deforested areas. Also, they play an important role as biocorridor and buffering reserves and it also introduces a modest biodiversity level in these depredated areas of the Atlantic forest.

Keywords: Agrobiodiversity, biodiversity, farming systems, Atlantic Forest

1. INTRODUCCION

The current world food crisis makes us reanalyze the way that we should continue to develop the agriculture at world level, and we meet again the importance of Agro-biodiversity to develop sustainable agricultural production systems. There is a need to suitably express the enormous importance of agrobiodiversity for the food security of future generations, for the sustainability and stability of the agricultural ecosystems of the world, and as a source of original material for breeding and innovations. Its conservation and sustainable utilization must be formulated as a political priority in all important areas of politics (Hammer 2003).

The objective of this paper was to evaluate genetic resources of plants in a dynamic, ecological and economic complex, and to assess agro-biodiversity in seven farming systems that occur within agro-ecosystems and natural systems. We assume the as hypotheses that agricultural systems can reduce the pressure on the fragments and deforested areas, improve the cycle of water, influence the dispersion of fauna and flora, offer better resources and habitat for the survival of plants and animals, and also play an important role as bio-corridor and buffering reserves.

2. METHODS

The study was conducted in the mountain region of Rio de Janeiro in the municipality of Teresópolis (Latitude of -22°24´43.2 and a longitude of 42°67´), an altitude of 871 meters above sea level. A totally of 108 Production units were evaluated. In the natural and agricultural systems only plant diversity was evaluated i.e. crops and plants, herbaceous cover, bush vegetation, and tree species inside the farming systems.

The evaluated farming systems in Teresópolis were: (i) Leaf vegetables systems (LVS), (ii) Fruit vegetable systems (FVS), (iii) Mixed Fruit and Leaf Vegetable Systems (MVS), (iv) Citrus Production systems (CPS), (v) Ecological Production systems (ECO), (vi) Cattle Production systems (CPS) and (vii) Sylvopastoral system (SPS). It was evaluated the use and management of biodiversity and indicators of agricultural crop genetic resources

a. *Use and management of biodiversity*

During two years 16 case studies were carried out and 164 rigid surveys were carried out as a main tool to characterize the production systems and management of resources. Moreover, 28 informal interviews were taken.

b. *Indicator of agricultural crop genetic resources*

The *Shannon Diversity Index (H')* . H' has two properties that have made it a popular measure of species diversity: (i) H' = 0 if and only if there is one species in the sample, and (ii) H' is maximum only when all S species are represented by the same number of individuals, that is, a perfectly even distribution of abundances. (Merman 2004, Magurran 1988, Eiden 1994). The *Simpson* is a *dominance index*, which is suited for inter-varietal diversity combining the number of varieties planted with their relative importance (Meng *et al.* 1998). The *H'* and *E* indices, which are generally referred as *alpha diversity*, indicate richness and evenness of species within a locality, but they do not indicate the identity of the species and where they occur. Consequently, variation in composition of species among the different farms and systems was determined by computing *Beta diversity*. *Beta diversity (â)* expressed in terms of a similarity index between different habitats in the same geographical area.

3. FINDINGS

3.1. Biodiversity in farming systems

The clearly dominant system is cattle raising with 74% of the total agricultural surface of the basin. The horticultural systems are the second more important (24%), of which the leaf-vegetables systems are most important with 14%. The sylvopastoral system occupies only 2% and the ecological and organic cultivations less than 0.4% (Figure 1).

The Cattle or livestock grazing is one of the most widespread land uses in Brazil. In Teresópolis, cattle raising has greatest impact on regional biodiversity. Approximately 74% of land (1327 ha) is currently under pasture and in many areas pasture land is still expanding slowly.

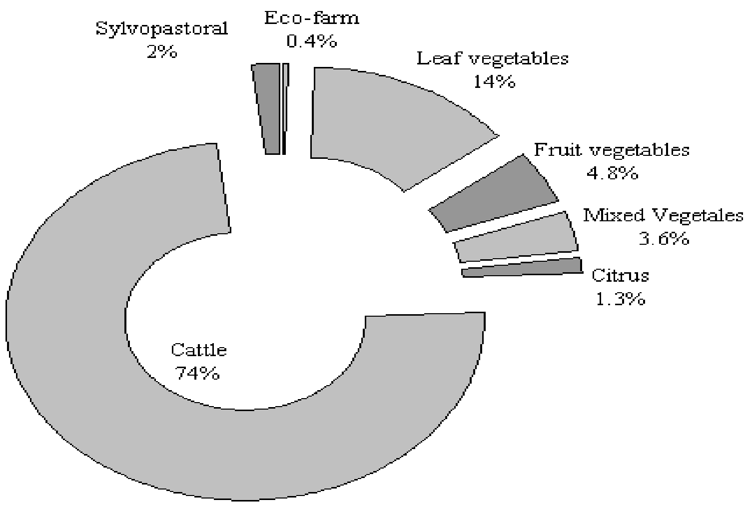

Figure 1: Relative importance of farming systems

Table 1: Diversity, richness, dominance and evenness indices compared across different farming systems in Teresópolis

	Diversity (H´)	**Richness** (R_{ch})	**Dominance** (1-D)	**Evenness** (E)
Ecological systems	3.19	96	0.93	0.70
Leaf vegetables	2.18	19	0.86	0.74
Fruit vegetables	2.01	19	0.81	0.68
Mixed vegetables	2.22	21	0.86	0.73
Citrus	0.1	8	0.03	0.05
Cattle	0.01	8	0.00	0.00
Sylvopastoral	0.08	34	0.01	0.03

H´=-(sum Pi*lnPi); Rch=N°sp; D=1-(sum Pi^2); E=H´/lnS

A complete list of the species is enclosed in annexe 8

The gradual transformation of forest into pasture and agricultural land has had profound ecological impacts in the region, changing the species composition of communities, disrupting ecosystem functions (including nutrient cycling and succession), altering habitat structure, aiding the spread of exotic species, isolating and fragmenting natural habitats, and changing the physical characteristics of both terrestrial and hydrological systems. Similar transformation processes have been reported by Fleischner (1994), Noss (1994), Gomez-Pompa et al. (1993), CCAD (1998). These changes, in turn, have often resulted in the reduction of both local and regional biodiversity.

The lowest dominance indices correspond to the cattle systems (0.00) and to citrus (0.01). It means that a few species dominate, in this case, *Brachiaria decumbens* and *Melinis minutiflor.* Both systems are also characterized by lowest richness, with only 8 species mostly herbaceous (Table 1).

The implementation of cattle systems is the cause for the fragmentation of landscapes, not only altering its functions but also the behaviour and dynamics of animal and plant populations inside the fragments (Birregard *et al*. 2001). The fragmentation also causes decrease of biomass production, especially on the fragment edge (Laurence *et al*. 1997). For the development of tropical ecosystems, cattle systems are ranked as the major driving force for the next 100 years (Sala *et al*. 2000). Smaller patches contain relatively more edges than larger patches. Abrupt forest edges also affect most ecological variables and indicators of forest dynamics, such as species distribution, tree mortality and regeneration, biomass loss, and community composition of trees. According to some recent estimates of the edge effects of fragments, only the largest forest fragments (>50000 ha) are immune from detectable ecological effects of isolation (Curran *et al*. 1999)

The sylvopastoral system maintains low indices of diversity, still dominated by grasses. The great difference with the cattle systems is the richness of species, being increased fourfold (Table 4.1.1). The most important sylvopastoral species are the folowing (i) pastos: *Melinis minutiflor and Brachiaria decumbens.* Timber: *Lonchocarpus sp, Tibuchina sp, Piptadenia gonoacantha, Cróton floribundus, Machaerium sp*. All species from sylvopastoral systems are listed in appendix 8a from annexe 8.

Thirty four timber species were identified in sylvopastoral systems. It indicates that in these systems a significant portion of the original biodiversity can be maintained within pastures, if they are designed and managed appropriately (Greenberg 1997; Harvey 1999). Pezo & Ibrahim (1998) listed additional positive effects for maintaining and conserving biodiversity e.g. producing timber, forage and fruits, providing shade for cattle, and promoting soil conservation and nutrient recycling.

Sylvopastoral systems provide structures, habitats and resources that may enable the persistence of some plant and animal species within the fragmented landscape, thereby partially mitigating the negative impacts of deforestation and habitat fragmentation. Marten (1986) additionally says that in these systems the species are used for construction materials, firewood, tools, medicine, livestock feed, and human food. Besides providing useful products, the trees in these systems minimize nutrient leaching and soil erosion and restore key nutrients by pumping them form the lower soil strata.

The management of natural regeneration timber species in sylvopastoral systems represents a low cost alternative for the producer. These systems can be applied especially for farmers with small long term investment capacity. *Lonchocarpus sp, Tibuchina sp, Piptadenia gonoacantha, Cróton floribundus, Machaerium sp*. are all species that possess good characteristics for the implementation of systems in the study region. Diverse other native species also possess positive characteristics for sylvopastoral systems and they should be evaluated in future. It is important to highlight that pasture fires are considered as an extremely noxious practice for the propagation of tree species.

Exotic species should be broadly investigated for their implementation like the case of eucalyptus (Andrade 2001). Carvalho (2001) recommends *Acacia mangium, A. auriculiformis* and *Mimosa artemisiana* for use in sylvopatoral systems. The latter three species would also have the capacity to synthesize atmospheric nitrogen.

The leaf vegetables lettuce, cabbage, broccoli, spinach, watercress and the fruit vegetables chayote, paprika and tomato are the base of the economy and occupy circa 40% of the agricultural area. The farmers manage on average 4 species per hectare (minimum average) up to 12 species per hectare (maximum average). Plots with as much as 18 cultivated species per hectare were also observed.

From 15 cultivated families the *Brassicaceae, Solanaceae, Fabaceae, Asteraceae, Fabaceae* and *Cucurbitaceae* are the most important ones with more than 60 species and 140 varieties of vegetables. This crop diversity is represented by y high diversity index (H´=2.18, 2.01, 2.22) for leaf vegetables, fruit vegetables and mixed vegetables, respectively. It represents a good value for agricultural systems. For the three variants of vegetable systems, dominance is not high (1-D= 0.86, 0.81, 0.86) and the species are equitably distributed. There exists a relative good quantity of species (R_{ch}= 19) in spite of weed control, most of these species being located on the edge of small plots (Table 1, annexe 1: appendix 1a, 1b).

The ecological systems present the best indices of diversity. A dominant crop does not exist, rather, crops are equally distributed in number and area (1-D=0.93; E=0.7; Table 1). The system houses very high quantity of species (96). Finally, the Shannon diversity index (3.6) indicates clearly that this system combines a high number of cultivated and not cultivated species.

The most important species in the ecological systems are: (i) vegetables and annual crops; (ii) trees: *Acnistus arborescens* (marianera) is a plant with great potential for agroforestry systems. It is very fast growing, has easy reproduction and good biomass production, and is a good tutor for other cultivations like chayote. Finally, it produces good quantity of fruits for human consumption and for birds. *Ricinus comunis* is another very fast growing plant, it is important for the recuperation of fertility in fallow plots, and contributes with good quantity of organic matter to fertility restoration of the systems. Their great quantity of terpenes is also used for obtaining of bio-energy. Other important species in the region which can be found in ecological farms and agroforestry systems, are *Vernonia polianthes, Piptadenia gonoacantha, Lonchocarpus sp, , Luehea divaricata;*. (iii) herbaceous: *Cyperus rotundus L* (tiririca), *Melinis minutiflora*, *Artemisia vulgaris* (Losna), *Eleusine indica* (pê de galinha), *Siegesbeckia orientalis* (botao de ouro), *Amaranthus deflexus* (carurú), *Digitaria horizontalis* (mulambo), *Aristolochia clematitis* (papo de peru) all considered weeds. Some other plants can be found in ecological farms and in recovery areas, such as *Baccharis sp., Vernonia polianthes, Psidium cattleiano, Aeschynomene denticulate, Triunfeta sp., Lantana camara, Cecropia sp., Tibuchina sp.,* and *Euphorbia heterophylla.*

In ecological systems, biodiversity offers ecosystem service beyond the mere production of food, fiber, fuel, and income, by stabilising yield or income in case of incidences of disease and pests or when market prices are fluctuating (Wiersum 1982). This ecosystem service also helps recycling of nutrients (Alesandria *et al*. 2002), controlling of local microclimate, regulating of local hydrological processes, regulating of abundant undesirable organisms, and finally, detoxifying noxious chemicals. Reijntjes *et al*. (1992) states that the main strategy in ecological systems is to exploit the complementarities and synergism that result from various combinations of crops, trees and animals in spatial and temporal arrangements.

The richness and stability in ecological systems make them important sites for in situ conservation within eco-zones, and also offer better positive possibilities through the presence of numerous niches in which agro-diversity can survive. Trinh *et al.* (2003), Michon *et al*. (1983), Fernandes (1986) concluded in a similar way after having studied agro-diversity in home gardens. In concordance with Mac (2001) it was found that managing numerous species in ecological systems could provide a usable framework for maximizing their benefit to biodiversity.

The polycultures and agroforest patterns are characteristic of these systems. The high species richness of all biotic components of traditional and ecological agro-ecosystems is comparable with that of many natural ecosystems (Altieri 1999).

One way to reintroduce biodiversity into large-scale monocultures is by establishing crop diversity by enriching available field margins and hedgerows which may then serve as biological corridors allowing the movement and distribution of useful animals and insects.

There is wide acceptance of the importance of field margins as reservoirs of the natural enemies of crop pests. Many studies have demonstrated increased abundance of natural enemies and more effective biological control where crops are bordered by wild vegetation. These habitats may be important as over wintering sites for natural enemies and may provide increased resources such as alternative host, pollen and nectar for parasitism and predators from flowering plants (Landis 1994, Altieri 1999).

Analyzing biodiversity within this context is an extremely complex task, but one which lies at the heart of all discussions concerning its sustainable use. This complexity arises because of the multitude of different ways and the range of different scales, both in time and space, in which any given resource can be viewed (Serageldin and Steer 1994). In terms of human uses and needs, biodiversity can be looked on as part of the entire capital stock on which development is based. This stock can be divided into: natural capital, living and non-living environmental assets, including biodiversity; fabricated capital, machines, buildings, infrastructure, human capital, human resources, and social capital, the social framework (Groombridge 1996).

In fallow land or forest areas in regeneration, plant diversity and density of individuals and species are influenced by the intensity and frequency of management operations. Vegetation of wild fallows that were not managed was clearly dominated by individuals of C*ecropia spp* (embaúbas), *Lonchocarpus sp* (timbó), *Vernonia polianthes* (Assa peixe), *Tibuchina sp, Piptadenia gonoacantha* (Pau Jacaré), *Croton floribundus* (sange de drago), *Aeschynomene denticulate* (angiquinho), and other early colonizing pioneer species.

The fallow land on agricultural areas include mostly herbaceous and shrub species like *Vernonia polianthes* (assa peixe), *Acnistus arborescens* (marianera). This enriched area normally contains forest species, bananas and varieties of citrus. In these areas more species were found than in the natural fallow areas, in agreement with Anderson (1992) and Pinedo-Vazquez (2000). The latter authors say that despite the assumption that human intervention in fallows lowers the species richness it is still possible that fallow land may contained higher levels of plant diversity.

Despite differences in forest use and in management practiced by farmers, forests in all sites showed high diversity of Shannon's Index (average H' = 2.59). These results were very similar to those reported for forest areas in other regions of Brazil as e.g. in the estuarine floodplains of neotropical forest (Anderson 1992).

In agricultural areas reconverting to secondary forest (about three years of age) the most important families and species were Leguminosae (Papilonoideae) (*Lonchocarpus sp*), Euphorbiaceae (*Croton floribundus*), Anacardiaceae (*Schinus terebinthifolius*), and Sapotaceae. In the bush stratum the most important families and species are Asteraceae (*Baccharis sp, Vernonia polianthes*), Myrtaceae (*Psidium cattleiano*), Melastomataceae (Tibuchina sp).

The ecologically most important families of the woody understory vegetation are Myrtaceae, Lauraceae, Rubiaceae, Melastomataceae, Arecaceae, Nyctaginaceae (BLUMEN, 2006)

3.2. Interactions among the land-use systems

Fragment-agriculture. In fact, the interaction of the agriculture with the fragments is very low. Certainly, the farming systems will influence the composition of species in the edges, but fragments are hardly used for extraction purposes by farmers. The environmental impact of the agricultural (horticultural) land on the fragment is rather low, since this land use system is usually located below the fragment. Thus, erosion and water quality impacts are rather inflicted on land use systems downstream within the river basins than on forest fragments. Not-quantified nutrients coming from the fragments are deposited on horticultural land, a benefit yet to be quantified.

Specific cultivations like chayote and tomato are examples of direct impact of farming activities on fragments, requiring stakes and posts to serve as tutors in the cultivation. The total area of these cultivations is low, as well as the No. of farmers extracting these materials. The requirements of extraction are about 620 posts of 2.3 m per hectare of chayote. For one hectare of tomato 10500 stakes of bamboo of 1.8 m, and 260 stakes of 2.3 m are extracted.

Fragment - cattle raising. Although at a very low rate, deforestation for pasture land is still going on. The dynamics of land use change could not be analysed, and so it can not be said, what kind of land is being lost, whether valuable old structured forests or recently re-established fragments with *Capoeira* (re-emerging bushland during fallow) characteristics.

A serious impact of beef cattle and horses was observed by accesses to water sources in the forest, where animals go drinking, ruminating and resting in the shadow, and grazing or browsing from what plants can offer there. Doing so, animal faeces contaminate the water sources which are often used as drinking water in the households below.

Cattle raising – agriculture. The agricultural systems and cattle have very little interaction. The manure is not used in the agriculture, it remains in the pasture areas. The agriculture residuals are kept in the cultivation field for organic matter incorporation. Sugarcane and *Capim gigante (Penisetum purpureum)*, as stated before, are the only cultivated forage crops requiring arable land and are thus, directly competing with alternative cropping systems.

Horticulture production requires large amounts of organic matter which is obtained by truckload from other regions, even neighbouring states such as São Paulo and Minas Gerais.

Organic matter is certainly an economically highly significant matter. More interaction among animal husbandry and horticulture systems is assumed to be required for overall agricultural productivity and profitability improvement. Ecologically, it would be highly welcome to substitute long-distance transports of manure with local supply.

Settlements – fragments. For house construction and tools the farmers usually use the wood of the fragments. They also extract some medicinal plants and occasionally eat some animals.

3.3. Environmental perception of farmers

The environmental perception of farmers was assessed in individual interviews and a workshop held with the farmers of the study area.

*Farmers observations of landscape***.** 81% of the interviewees stated that during the last 30 - 50 years the landscape has changed a lot. Major changes observed were urbanization – construction of many new houses Forest used to be more dominant in relation to pasture and agriculture (50 years ago). The practice of burning bush land is nowadays more widespread than5-10 years ago. Orchards with citrus have emerged only recently.

Farmers observations of forest fragments. In the past, large and “beautiful” tree species were found in the forests, many of them with great economic value, some of them being scarce and having already disappeared from the fragments as for example: Brauna, Cambota, Garapa, Ipê, Cedar, Maçaranduba, Jacaranda, Peroba, Oricana, candeia, Cinzero, and some others that the farmers were not able to specify.

Conservation attitude. 92% of the interviewees answered that they preserve their fragments. They prevent hunting and deforestation because they are aware that they need the forest to preserve water sources. Reforestation practices are absent. Main reasons for applying conservation measures are: water source, legislation, and emotional value of forest. 72% of the farmers do not know that the agriculture could contaminate and cause damage to the environment and only 13% know that inappropriate agriculture practices can cause damage. The remaining percentage did not answer. One out of each 150 productive units has organic production, 33% have heard about organic agriculture and agro-forestry and are inclined to change but they lack the required know-how. 48% do not want to change the production to organic agriculture, considering such efforts as not necessary. The remaining producers consider such a change not possible because of adverse physical conditions and difficulties.

Fragment value to farmers. The most important value of the fragments is as water source (96 % of the interviewees agreed). The second most important use is the wood extraction for construction timber of low quality. The third use is medicinal plants extraction, although 37% state not knowing the medicinal plants from the forest.

4. CONCLUSIONS

From the biodiversity point of view, the ecological farming systems, agroforestry- and sylvopastoral systems, and perennial cultivations help to reduce the pressure on the fragments and deforested areas. It improves the cycle of water, and it has also positive influence on the dispersion of fauna and flora. They offer better resources and habitat for the survival of plants and animals than the cattle and horticultural systems. Also, they play an important role as biocorridor and buffering reserves and it also introduces a modest biodiversity level in these depredated areas of the Atlantic forest, where at the moment a single grass (*Brachiaria decumbens*) dominates more than 35% of the surface.

Also, the diversity and structure of ecological, agroforestry, and sylvopastoral systems contribute additional benefits to the local population, microclimate, flow of nutrients, dissipate the dynamics of plagues and diseases, and decrease the effects of fluctuating prices of the market.

The agricultural subsystems, cattle and forest are not very interrelated to each other, giving place mainly to trade-offs rather than providing synergies. The cattle systems do not contribute from any point of view with the conservation of biodiversity. To the contrary, it is the most degenerative practice that threatens biodiversity in the region. It is the main cause for forest fragmentation, also presents bigger soil erosion, and breaks the dispersion of flora and fauna.

In general, farmers appreciate biodiversity positively, but they have no exact knowledge of their benefits. At the moment, the forest fragments represent for the farmers mainly their water source, and are considered very less important as wood source or supply of other by-products like fruits or medicines.

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