Scientific Paper

Study of biodiversity components in the agroecological farm La Paulina, Perico municipality, Cuba

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Abstract

In order to evaluate the components of biodiversity a study was conducted in the farm La Paulina, located in the Perico municipality –Matanzas province, Cuba–, which has an area of 26,84 ha dedicated to the production of food crops and fruits, as well as milk production. The functionality of biodiversity was evaluated, from the analysis of the components: tree diversity, production diversity and species richness. Through a diagnosis, the number of individuals of each species, which were characterized according to their functionality within the system, was quantified. The information was captured through semi-structured interviews, participatory observation and surveys. Shannon index was calculated for the components tree diversity (1,7) and production diversity (3,32), and Margalef index was used for species richness (5,03). The value of Margalef index confirmed that the system can be considered of high species richness. The characterization and inventory of biodiversity in the farm La Paulina showed the functionality of this agroecosystem, represented by diversification and agriculture-animal husbandry integration; this proved a directly proportional relation between species richness and production diversity.

Keywords: trees, diagnosis, diversification

Introduction

Modern agricultural technologies have allowed to improve agricultural production at global scale; nevertheless, in many countries small farmers have not been benefitted by these technologies. From this the urgency is derived to find alternative approaches that intensify production, while preserving the basis of natural resources, in addition to maintaining biodiversity and preserving traditional knowledge (Kohafkan, 2010).

In this context, agroecological practices allow to sustainably manage natural resources and contribute to the resilience of agroecosystems, for which small farmers choose this alternative.

One of the central principles of agroecology is to manage holistically agricultural systems, and in order to achieve this it is essential to go beyond the reductionist view that prevails in conventional agricultural sciences (Funes-Aguilar, 2016). In agroecology it is necessary to have practical tools that allow to evaluate systemically agricultural situations, and also the functionality of biodiversity components.

Biodiversity is formed by all the existing species that interact within an ecosystem; in recent years, scientists have started ascribing more importance to the role played by biodiversity in the functioning of agricultural systems, considering that it is precisely the fundamental principle of sustainable agriculture (Vergara-Ruiz, 2017).

In Cuba many farms have implemented diversified, integrated, sustainable agroecosystems, managed with local resources, with alternative energy sources and minimum input use (Funes-Aguilar, 2016), which has become a priority in recent years. That is why the study of biodiverse systems and their potential is identified as a necessary aspect in sustainable agriculture (Nova, 2016). Based on this, the objective of the study was to evaluate the functionality of biodiversity components in the agroecological farm La Paulina.

Materials and Methods

The study was conducted in the farm La Paulina, belonging to the CCS Ramón Rodríguez Milián located in the Perico municipality–Matanzas province, Cuba–, at 22º 48´ and 7” North latitude and 81º 2´West longitude, at 19,01 m.a.s.l.

The studied farm is a private property in which the following plants are cultivated: corn (*Zea mays* L.), cassava (*Manihot esculenta* Crantz), beans (*Phaseolus vulgaris* L.), squash (*Cucurbita pepo* L.), banana (*Musa* sp. L.), pigeon pea (*Cajanus cajan* L.), garlic (*Allium sativum* L.) and peanut (*Arachis hypogaea* L.). In it practices such as crop rotation, polycropping and cover crops, are used. It is also dedicated to cattle milk production.

The selection criteria to identify the farm object of study were the following: historical information, time of exploitation, biodiversity, use of traditional agroecological practices, productivity level, strategies in the rational use of natural and local resources, and its link to different innovation and local development projects.

The owner is the farmer José Antonio Hernández Navarro, who is 43 years old. The total labor force is five persons, two men and three women, who along with two children integrate a family nucleus of seven people.

A design of analysis of diversity indexes was taken as guide (fig. 1) elaborated by Salmón-Miranda *et al* (2012), in order to study diversity in the agroecosystem.

The diagnosis of the farm was carried out from many periodical visits, participant observation, and structured and semi-structured interviews. An inventory was made of all the species present in the agroecosystem, and the number of individuals per tree, crop and animal species was quantified; in addition, an analysis was made of land and water availability, labor force, housing conditions and the main limitations of the place.

For the interpretation of the results the ECOFAS methodology, recommended by Funes-Monzote (2009), was used.

Table 1 describes the formulas used for the calculation of species diversity in the system.

For the calculation of Shannon and Margalef indexes, described in the ECOFAS methodology by Funes-Monzote (2009), the number of species and individuals was characterized and quantified during 2015-2016.

The different functions of agrodiversity were identified according to the data obtained.

Results and Discussion

Table 2 shows the diversity of trees present in the farm per species and purpose; in the inventory 8 143 individuals were quantified, represented in 14 families. *Rutaceae* was the most represented family, with four species of the *Citrus* genus; nevertheless, the ones belonging to the *Fabaceae* family prevailed. Four fundamental uses of trees also stood out, which showed the general function of these species in the agroecosystem. In this regard, it should be

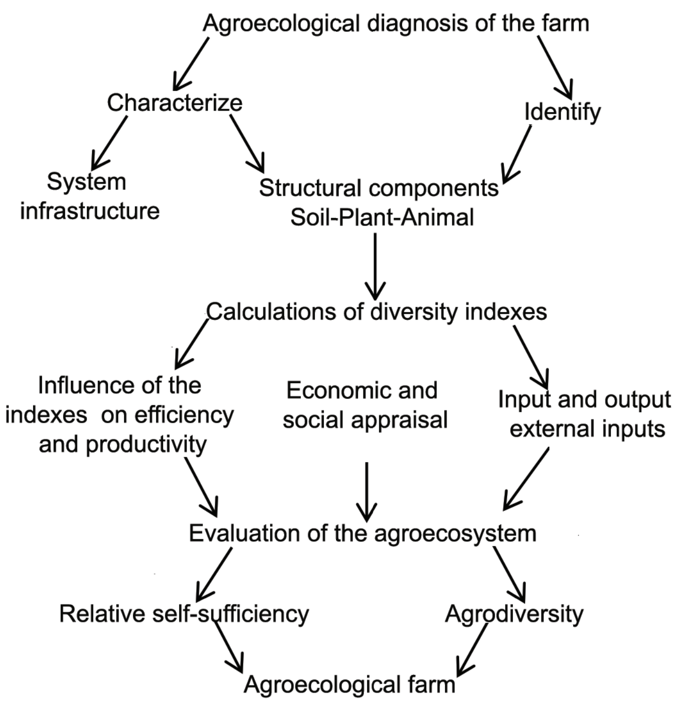

Figure 1. Model of analysis of the indicators.

Table 1. Evaluated biodiversity indicators.

Indicator	Unit	Calculation method
Species richness	Margalef index (IM)	Includes crop, tree and domestic animal species MI = (S -1)/LnN Where: S: total number of species N: total number of individuals of all the species, and includes animals, crops, fruit and forestry trees
Species diversity	Shannon index (H)	Includes the total production of each agricultural or animal husbandry product and total of the system H= ∑ (Pi/P) log (Pi/P) Where: S: number of products Pi: production of each product P: total production
Tree diversity	Shannon index (H)	Includes number of species of fruit, timber trees and living posts H= ∑ (ni/N) log (ni/N) Where: S: number of tree species Ni: number of individuals of each species Ni: total number of individuals

Table 2. Most representative species in the studied system.

Tree	Use	Scientific name	Family	Quantity
Avocado	Fruits	*Persea americana* Mill	*Lauraceae*	70
Cherry	Fruits	*Prunus cerasus* L.	*Rosaceae*	18
Cherimoya	Fruits	*Annona cherimolla* Mill	*Annonaceae*	20
Coconut	Fruits	*Cocos nucifera* L.	*Arecaceae*	200
Soursop	Fruits	*Annona muricata* L.	*Annonaceae*	35
Mamoncillo	Fruits	*Melicoccus bijugatus* Jacq.	*Sapindaceae*	35
Mandarin orange	Fruits	*Citrus reticulata* Blanco	*Rutaceae*	20
Mango	Fruits	*Mangifera indica* L.	*Anacardiaceae*	30
Sweet orange	Fruits	*Citrus sinensis* Osbeck	*Rutaceae*	25
Sour orange	Fruits	*Citrus aurantium* L.	*Rutaceae*	30
Grapefruit	Fruits	*Citrus paradisi* Macfad	*Rutaceae*	25
Copperwood	Timber	*Bursera simaruba* L.	*Burseraceae*	285
Quickstick	Timber	*Gliricidia sepium* Jacq.	*Fabaceae*	70
Ateje	Timber	*Cordia alliodora* Ruiz & Pav.	*Boraginaceae*	250
Cuban mahogany	Timber	*Swietenia mahagoni* L. Jacq.	*Meliaceae*	70
Cuban cedar	Timber	*Cedrela odorata* L.	*Meliaceae*	25
Blue mahoe	Timber	*Talipariti elatus* Sw.	*Malvaceae*	25
Royal palm	Timber	*Roystonea regia* Kunth	*Arecaceae*	200
American basswood	Timber	*Tilia americana* L.	*Malvaceae*	40
Spanish elm	Timber	*Cordia gerascanthus* Ruiz & Pav.	*Boraginaceae*	40
Leucaena	Living post	*Leucaena leucocephala* Lam de Wit.	*Fabaceae*	6 000
Mulberry	Living post	*Morus alba* L.	*Moraceae*	20
Mexican sunflower	Living post and forage	*Tithonia diversifolia* Hemsl	*Asteraceae*	610

emphasized that most of these trees were used as living posts and that there was a large variety of plant species which guaranteed part of the feed of the animals in the farm.

These results coincide with the ones obtained by Salmón-Miranda *et al*. (2012) when evaluating the components of biodiversity in an agroecological farm, who reported, in addition to the melliferous species, groups of plants represented by living posts, timber and fruit trees.

Farmers prefer to keep species that can offer multiple important economic functions in the farm, which coincides with the report by Russo (2015). In this sense, it is known that the predominance of trees and abundant vegetation allows high floristic diversity, which depends on the origin of the tree (remnant, natural regeneration or planted), density, distribution and management practices by the farmer.

Multipurpose trees provide shade, contribute forage and fruits, fix atmospheric nitrogen, recycle nutrients, lower the market cost, preserve and improve the soil and herbaceous vegetation, protect the hydric potential of the place and serve as habitat to the wild fauna (Salmón-Miranda, 2011).

It is valid to state that some forage tree and shrub species, besides producing an enormous amount of forage, show good nutrient balance and can reduce the dependence on imported inputs for livestock feeding.

The analyzed indicators of biodiversity are closely related to two of the largest environmental problems associated to agricultural monocrop models that the Cuban State has identified: biodiversity loss and deforestation, as stated by Salmón-Miranda (2011).

When evaluating the diversity indexes, it was obtained that the Shannon index for tree diversity (number of individuals per species, abundance) was 1,7 (table 3) and it was within the established range (1,5-3,5), which means that the species diversity in the farm was acceptable.

The tree diversity indicator plays an important role in the system diversification and has a positive effect on its productivity concerning energy and protein yields. On the other hand, trees exert an important role on the multi-functionality of goods and services they provide in the agroecosystem.

The data obtained through the Shannon-Wiener index showed the effect of management on diversity, besides indicating uniformity in the species distribution. Similar results were reported by López-Hernandez *et al*. (2017). Species diversity is a characteristic that shows the structure and distinguishes one community from another, for which it also receives the name species heterogeneity.

Production diversity [combination of the number of products or tree species (diversity) with the yield per product] was within the established range (1,5-3,5); however, its increase can improve food self-sufficiency, as well as lead to an increase of energy and protein production in the system. Such results confirm the potential of integrated animal husbandry and agriculture systems, essential to face the productive limitations of tropical regions (Funes-Aguilar *et al*., 2001) and the urgent environmental, economic and social limitations of sustainable agricultural development (Vera-Pérez, 2011).

When comparing the values obtained by Funes-Monzote (2009) and Blanco *et al*. (2014), it can be observed that they are similar to the ones in this research, because the former obtained 1,7 and 2,0 in integrated farms, and the latter reported 1,6 and 2,16 when using an intervention model implemented for the transition from animal husbandry farms to sustainable agroenergetic ones; these results could have been due to the marked influence exerted on these farms by the actions of projects executed by the EEPF-IH (PIAL and BIOMAS-CUBA).

The Margalef index had a value of 5,03 (table 3), considered as good, result that coincides with the report by Blanco (2014) and which ratifies the high diversity of the farm under study. This also showed the balance between the number of species present in the evaluated system and the number of individuals per species, in which an accelerated increase of the crops was observed.

In this context, López-Hernández *et al*. (2017) determined the composition and diversity of tree species in Mexico and obtained species richness values (1,35) lower than the ones found in the farm under study, which proved the high diversity in it. On the other hand, the value of Margalef index re-

Table 3. Performance of the agroecological and productivity indicators of the farm.

Indicator	Unit	Production system
Tree diversity index	Shannon index	1,7
Production diversity index	Shannon index	3,32
Species richness	Margalef index	5,03

affirms the report by this same author about the fact that values higher than five in such indicator can give an idea of high species richness in the systems.

Gutiérrez-Fleites *et al.* (2014), when evaluating the biodiversity of fruit trees in different agricultural production farms of the central region of Cuba, reported that for all the evaluated indicators (species richness, dominance and diversity) the values remained according to the established ones; nevertheless, they stated that the best results were obtained in the farms that belonged to the Program of Urban, Suburban and Family Agriculture, which are more diverse agroecosystems.

The results in this research coincide with the ones from other studies conducted in Cuba in recent years (Vera-Pérez, 2011), which indicate that when there is higher agrodiversity regarding crops, livestock and tree species, as part of integrated and multifunctional agricultural systems in agroecological systems with high levels of animal husbandry-agriculture integration and recycling, higher productivity and efficiency is reached.

Diversity is a significant component within the system (Blanco, 2014). According to Funes-Monzote *et al.* (2012), higher diversity does not necessarily have repercussions on higher productivity and efficiency, for which it is necessary to manage systems and increase their biodiversity.

Conclusions

The characterization and inventory of biodiversity in the farm La Paulina showed the functionality of this agroecosystem, represented by diversification and animal husbandry-agriculture integration.

The evaluation of the components of biodiversity and productivity in the farm La Paulina showed that there is a directly proportional relation between species richness and production diversity.

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