Scientific Paper

Characterization of the floristic biodiversity of a farm of the southern circuit in Cumanayagua, Cienfuegos province, Cuba[1]

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Abstract

Objective: To characterize the floristic biodiversity of a farm of the southern circuit in Cumanayagua, Cienfuegos province, Cuba.

Materials and Methods: The study was carried out on a farm in Cumanayagua municipality, Cienfuegos province. The soil corresponds to the Brown type, without carbonate, typical red rendzina subtype (XIII A). The biodiversity monitoring methodology was applied with the use of transects designed from satellite photos. All flora species were surveyed and indices of relative abundance, origin, endemism and invasive potential were determined. Floristic biodiversity was characterized and biodiversity indicators (specific richness (S), Margalef's diversity index and Simpson's dominance) were evaluated.

Results: The farm has a total area of 67,1 ha, of which 38,6 % is under active exploitation. The main use includes miscellaneous crops (8,9 %), silvopasture (61,4 %) and animal husbandry (7,5 %). A total of 21 581 individuals and 321 species were identified, with a Margalef diversity index of 5,45. Simpson's dominance was 0,01, indicating the absence of significant dominance. Simpson's diversity index was 0,99, classified as high. The most represented families were Fabaceae (9,6 %), Malvaceae (6,5 %) and Cyperaceae (6,2 %). Six unique species were found, each belonging to a different botanical family. These unique species showed the floristic richness and genetic variability of the area.

Conclusion: The ecosystem shows high biodiversity and species diversity, with low dominance of any particular species. These characteristics are desirable and suggest that the ecosystem is robust and healthy, with good capacity to resist environmental changes and maintain its ecological functionality.

Keywords: agroecology, biodiversity conservation, indicators

Introduction

Transition towards agroecology and biodiversity conservation are fundamental aspects in the search for more sustainable agricultural systems that are more resilient to climate change. It is important to address how these practices relate to conventional agriculture and the need to develop more environmentally friendly alternatives.

Production systems based on conventional agriculture are characterized by their dependence on external inputs and technologies transferred from other regions. This can lead to less adaptability to local conditions and greater vulnerability to exogenous factors such as climate change. At the same time, agroecology proposes a more integrative approach, seeking to maximize natural resource efficiency and promote nature-based solutions (Altieri *et al*., 2021). However, the adoption of agroecological practices requires a profound transformation in farmers' ways of thinking and acting. It is necessary to commit to a new vision of agriculture that goes beyond simple food production, incorporating environmental conservation and biodiversity maintenance (Sierra-Reyes *et al*., 2023).

Altieri *et al*. (2012) stated that the agroecological approach can significantly contribute to the environmental and social sustainability of agriculture by promoting practices that strengthen soil biological infrastructure, reduce dependence on external inputs, and improve the resilience of agroecosystems.

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The transition to agroecological systems can have significant benefits for the local economy by encouraging local food production and consumption, reducing dependence on external inputs, and improving the quality of life of rural workers (FAO, 2018).

According to FAO (2023), diversified agroecological systems are more resilient, have greater capacity to recover from shocks, particularly extreme weather events such as drought, floods or hurricanes, and to resist attack by pests and diseases.

Biodiversity conservation plays a crucial role in this process. By maintaining a wide variety of species, ecosystems can provide essential services, such as climate regulation, water filtration, fertile soil and the maintenance of habitats for other forms of life. However, many ecosystems face increasing pressures, due to human activities, which can lead to significant losses of biodiversity and declines in these ecosystem services (Sierra-Reyes *et al*., 2023).

The objective of this study was to characterize the floristic biodiversity of the La Lima farm of the southern circuit in Cumanayagua, Cienfuegos province, Cuba.

Materials and Methods

Location. The La Lima farm is located at 21.83516 latitude and '80.10702 longitude, composed of two plots, one with an area of 13,4 ha, at X (592 186.48), Y (223 271.74). It limits to the north with the farm of the farmer Paula Oromi, to the south with the Basic Unit of Cooperative Production (UBPC, for its initials in Spanish) Camilo Cienfuegos, to the east with the Cienfuegos Water Utilization Enterprise, to the west with the UBPC Camilo Cienfuegos. It has a second plot, with an area of 53,7 ha in X (592 261.70), Y (226 289.06), with limits to the north with the UBPC Camilo Cienfuegos, to the south with the UBPC Camilo Cienfuegos and the farm of the farmer Armando Fontanil Guerrero. To the east it borders with the farm of Armando Fontanil Guerrero and to the west with the UBPC Camilo Cienfuegos in the Cabagán demarcation, being a productive form of the Sierrita Animal Husbandry Enterprise, which belongs to the southern circuit of the Cumanayagua municipality, in the Cienfuegos province.

Climate characteristics. The average temperature from June to September is over 25 ºC on average. The minimum temperature is above 20 ºC from May to October, and maximum temperatures above 30 ºC begin in June and persist until September. In the study area, the average annual accumulated rainfall totals 1 608,1 mm. There is accentuated annual seasonality. There is a rainy season between May and October, in which 81,7 % of the total rainfall accumulates, and another rainy period from November to April with the remaining 18,3 % (Viera-González *et al*., 2024).

Evaluation of soil properties. The soil of the farm under study is Brown without carbonate, typical red rendzina subtype (XIII A). The formation process that originates it is humification, its coloration is from reddish brown to yellowish red, it shows organic matter content between 2 and 5 %, it is a soil saturated by bases, stony, moderately rocky and moderately eroded, elements that limit the effective depth to 20 cm. The corresponding textural class is kaolinite clay with a predominance of clays of the 1:1 type, hence it shows a cation exchange capacity between 20-45 cmol (+) kg^{-1}, which influences its natural fertility. The internal and surface drainage is evaluated as good, with strongly undulating slope (Hernández-Jiménez *et al*., 2015).

Experimental procedure. The floristic composition of the ecosystem was determined with the application of the biodiversity monitoring methodology using transects, proposed by Ferro-Díaz (2015) in his research manual. The field work was carried out with transects directed and designed from satellite photos of the area, which covered all the ecosystems and formations present in the area. The zoning was determined by the physical characteristics and levels of affectation of the sampled areas in order to establish parameters of naturalness and trophic relationships between species. All flora species were surveyed and relative abundance indices were determined, as well as their origin, endemism and invasive potential. In addition, biodiversity indicators were calculated (table 1).

Species identification was carried out by comparing the collected materials with those stored in the AJBC herbarium of the Botanical Garden of Cienfuegos and online with other herbariums in Cuba and the world, mainly New York, Berlin and Stockholm.

Results and Discussion

The farm has a total area of 67,1 ha, of which 38,6 % is under active exploitation. The main use includes food crops (8,9 %), silvopasture (61,4 %) and animal husbandry (7,5 %). Specific crops are *Cucurbita maxima* Duchesne (5,0 %), *Manihot*

Table 1. Calculation method for measuring biodiversity indicators.

Index	Formula	Meanings
Specific richness (S)	S=Nte	Nte: Total number of species obtained by a survey of diversity.
Margalef diversity index	$D_{Mg} = \frac{S-1}{\ln N}$	S= number of species. N= total number of individuals.
Simpson's dominance	$\lambda = \sum p_i^2$	pi = proportional abundance of the species i, that is, the number of individuals of the species i, divided by the total number of individuals of the sample.

esculenta Crantz (28,3 %) and *Musa* × *paradisiaca* L. (66,7 %). In addition, a significant portion is dedicated to silvopastoralism, which covers 61,4 % of the total area, indicating an important presence of agroforestry practices and integrated livestock management. Animal husbandry occupies 7,5 % of the total area, with a division between *Saccharum officinarum* L. and *Cenchrus purpureus* (Schumach.) Morrone for animal feeding (table 2).

Silvopastoral systems (SPS) are an agroecological alternative that contributes to solving environmental and productive problems by combining pastures with woody plants (trees, shrubs and palms) through the use of different plant strata. In them, animals interact with arboreal and herbaceous species through an integral and rational management, with the purpose of mitigating the adverse effects of climate that affect livestock productivity and the utilization of grazing areas (Castillo-Gallegos and Jarillo-Rodríguez, 2020).

Arboreal plants in SPS offer several benefits to livestock rangers and their families (Pacheco-Hernández and Jerónimo-Hernández, 2023). Their shade reduces the heat stress of the herd and improves its body condition, immune response to diseases and influences the reproductive behavior of the herd, which is manifested in higher animal productivity (Castillo-Gallegos and Jarillo-Rodríguez, 2020). They provide forage of high nutritional value, since legumes provide protein and manage

Table 2. Balance of areas and their use in the farm.

Indicator	Area, ha	Percentage of the total
1- Total area	67,1	100
Under exploitation	25,9	38,6
2- With food crops	6,0	8,9
C. maxima (squash)	0,3	5,0
M. esculenta (cassava)	1,7	28,3
Musa × *paradisiaca* L. (banana)	4,0	66,7
3- Animal husbandry	5,0	7,5
S. officinarum (sugarcane)	3,0	60,0
C. purpureus (king grass)	2,0	40,0
4- Fruit trees	1,5	2,2
Annona squamosa L. (sweetsop)	0,0	1,3
Annona muricata L. (soursop)	0,2	13,3
Annona cherimola Miller (cherimoya)	0,4	26,7
Melicoccus bijugatus Jacq. (Spanish lime)	0,8	53,3
Others	0,1	5,3
5- Silvopasture	41,2	61,4

to reduce between 20,0 and 38,0 % of greenhouse gas emissions (Sandoval-Pelcastre *et al*., 2020). By consuming the appropriate level of tannins, they protect nitrogen from rumen degradation, stimulate its utilization and control some internal parasites (López-López, 2023).

Fruit trees represent 2,2 % of the area. The presence of *M. bijugatus* stands out as the most extensive crop in this category, followed by *A. cherimola* and *A. muricata*, among others. This diversification in land use is evidence of an agricultural and animal husbandry management strategy that seeks to optimize available resources, promoting agricultural production and environmental sustainability in the farm.

Floristic diversity of the farm. The presence of an important number of species was observed, which makes it a diverse farm with good representation of species (table 3).

Table 3. Species diversity in the farm.

Variable	Value
Total number of individuals, N	21 581
Total number of species, S	321

The Margalef diversity index with a value of 5,45 indicates high biodiversity, as values greater than five are considered evidence of significantly high diversity. This suggests that the ecosystem has a large number of different species, which is generally positive, as it can contribute to the ecosystem's resilience to environmental disturbances (table 4).

Simpson's dominance measures how dominant certain species are in a community. A low value, such as the 0,01 obtained here, indicates that no species significantly dominates over the others, which is desirable from the point of view of maintaining a balanced and healthy biological community. Low values of dominance are usually associated with more diverse and resilient communities.

This Simpson's diversity index is complementary to the previous one and is used to measure species diversity in a community, taking into account species richness as well as relative abundance. A value of 0,99, close to 1, indicates very high diversity, as values above 0,67 are considered indicative of high diversity. This reaffirms the observation of a rich and balanced biological community, where many species coexist without any dominating excessively.

The family with the highest representation was Haloragaceae, with 4,3 %, indicating that this species is relatively abundant compared with the others (table 5). However, the percentage difference among species was quite small, suggesting an even distribution of species in the area. This is indicative of a healthy ecosystem, where no species overly dominates the others. Among the listed species, some are of particular interest due to their ecological and economic characteristics. For example, *Rhizophora mangle* L. (red mangrove) plays a crucial role in mangrove ecosystems, providing habitat for a large number of wildlife and protecting shorelines against erosion. *Arundo donax* L., although less abundant, is known for its use in the manufacture of musical instruments and as an ornamental plant. As for fruit trees, the most represented family was Annonaceae, with four genera and 572 specimens, very abundant with a marked acceptance in the inhabitants of the entire region.

The Fabaceae family is the most representative in this study, with 34 genera and 2 061 species (table 6). Their importance lies in their ability to fix atmospheric nitrogen, thanks to symbiosis with bacteria of the Rhizobiaceae family, especially the genera Rhizobium, Bradyrhizobium and Azorhizobium. These bacteria infect and nodulate plant roots, establishing a symbiotic relationship (Mayea *et al*., 1982; Estrada-de-los-Santos *et al*., 2001). This diversity of nitrogen-fixing organisms is fundamental for the ecosystem, as it improves soil fertility and reduces dependence on synthetic chemical fertilizers.

Six plant species were identified that are unique specimens in the ecosystem (table 7), each belonging to a different botanical family. This diversity of species showed the floristic richness and genetic variability present in the area where these plants are

Table 4. Biodiversity indexes of the farm.

Index	Value	Assessment
Margalef diversity index	5,45	Biodiversity is considered high, because the value is higher than 5
Simpson's dominance	0,01	Dominance is low, because the obtained value is within the range from 0,01 a 0,33
Simpson's diversity	0,99	Diversity is high, because the obtained value is higher than 0,67

Table 5. Most abundant species in the farm's ecosystem.

Family	Scientific name	Common name	Quantity	Percentage
Haloragaceae	*Myriophyllum pinnatum* (Walter) Britton, Sterns & Poggenb.	Cutleaf water-milfoil	933	4,3
Rhizophoraceae	*R. mangle*	Red mangrove	856	4,0
Poaceae	*A. donax*	Giant cane	456	2,1
Cyperaceae	*Cyperus cuspidatus* Kunth	Coastal plain flatsedge	451	2,1
Malvaceae	*Urena lobata* L.	Caesarweed	411	1,9
Annonaceae	*Annona squamosa* L.	Sweetsop	399	1,8
Bromeliaceae	*Tillandsia recurvata* (L.) L.	Small ballmoss	399	1,8
Fabaceae	*Dichrostachys cinerea* (L.) Wight & Arn.	Sicklebush	394	1,8
Anacardiaceae	*Comocladia dentata* Jacq.	Guao	391	1,8
Combretaceae	*Laguncularia racemosa* (L.) Gaertn. F.	White mangrove	384	1,8
Fabaceae	*Gliricidia sepium* (Jacq.) Kunth	Mexican lilac	356	1,6
Cyperaceae	*Cyperus aggregatus* (Willd.) Endl.	Inflatedscale flatsedge	346	1,6
Burseraceae	*Bursera simaruba* (L.) Sarg.	Almácigo	301	1,4
Acanthaceae	*Avicennia germinans* (L.) L.	Black mangrove	294	1,4
Malvaceae	*Sida rhombifolia* L.	Arrowleaf sida	291	1,3
Arecaceae	*Roystonea regia* (Kunth) O.F. Cook	Royal palm	288	1,3

Table 6. Most abundant families and genera in the farm's ecosystem.

Family	Genus	Quantity	Percentage
Fabaceae	34	2 061	9,6
Malvaceae	14	1 409	6,5
Cyperaceae	6	1 344	6,2
Asteraceae	12	1 120	5,2
Bromeliaceae	5	915	4,2
Poaceae	6	843	3,9
Apocynaceae	8	687	3,2
Combretaceae	4	668	3,1
Boraginaceae	9	583	2,7
Annonaceae	4	572	2,6
Burseraceae	2	543	2,5
Amaranthaceae	7	518	2,4
Euphorbiaceae	17	500	2,3
Anacardiaceae	6	483	1,7
Arecaceae	5	429	2,0
Convolvulaceae	9	385	1,8

found. Such diversity highlights the importance of conserving and studying the local flora to better understand ecological interactions and to take advantage of natural resources in a sustainable manner.

Conclusions

The studied ecosystem has high biodiversity and species diversity, with low dominance of any particular species. These characteristics are desirable and

Table 7. Species represented by unique specimens and their role in the ecosystem.

No	Family	Scientific name	Common name	Role
1	Acanthaceae	*Sanchezia nobilis* Hook.	Sankesia	It is known for its plants with striking flowers, which are attractive for pollinators
2	Asparagaceae	*Beaucarnea recurvata* Lem.	Elephant's foot	It is remarkable for its peculiar shape that reminds of an elephant's foot. It is well adapted to arid conditions and used as ornamental plant.
3	Bignoniaceae	*Bignonia diversifolia* Kunth	Trumpet vine	It is a climbing plant that can cover broad areas with its foliage and colorful flowers, for which it contributes to the landscape and provides habitat for the local fauna.
4	Combretaceae	*Combretum indicum* (L.) DeFilipps	Rangoon creeper	It is valued for its medicinal properties as well as for its ornamental beauty. Its flowers change color, making it especially attractive in gardens and landscapes.
5	Convolvulaceae	*Turbina corymbosa* (L.) Raf.	Christmasvine	This plant is a vine that produces tubular bell-shaped flowers. It is known for its psychoactive properties and has been used in ceremonial rituals in some cultures. It is a species of fig tree, which can form important part of local ecosystems, because it provides food and shelter for the fauna
6	Moraceae	*Ficus trigonata* L.	Jagüey	

suggest that the ecosystem is robust and healthy, with good capacity to resist environmental changes and maintain its ecological functionality. The conservation and sustainable management of these ecosystems is crucial to preserve their biological richness and the ecosystem services they provide.

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Conflict of interests

The authors declare that there is no conflict of interests among them.

Authors' contributions

- Jorge Luis Prieto-Duarte. Generation of the idea, measurements, search for bibliographic information, drafting and revision of the manuscript.
- Tania Sánchez-Santana. Information search, analysis and critical revision of the manuscript.
- Yhosvanni Pérez-Rodríguez. Generation of the idea, search for bibliographic information, drafting and revision of the manuscript.
- Diadelys Carpio-Quintana. Measurement, search for bibliographic information, drafting and revision of the manuscript.
- Juan Antonio Mateo-Rodríguez. Performed measurements, searched for bibliographic information, drafted and revised the manuscript.

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