Scientific Paper

Evaluation of biodiversity in agroecological pest management in a productive entity of Matanzas

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Abstract

Objective: To characterize the biodiversity and determine its degree of complexity, as basis for pest agroecological management in a farmer entity.

Materials and Methods: In the studied farm, belonging to the Colón municipality, Matanzas province, biodiversity was quantified during one year. Margalef and Shannon (H') indexes were applied and the methodology proposed by Vázquez and Matienzo (2010) was used to determine the degree of complexity of biodiversity in the farm, which considers five components: noxious, functional, functional introduced, auxiliary and productive.

Results: A richness of species grouped in 25 families was obtained, which stood out for their use as fruit, timber, forage and feed. In addition, the scarce number of biopesticide plants, of living barriers and fences, as well as the little complexity of functional and functional introduced biodiversity, was observed, which contributes to the incidence and inadequate agroecological management of pests in the productive system. Finally, the unit was qualified as moderately complex (31 %).

Conclusions: Biodiversity was represented mainly by species from the families *Poaceae* and *Fabaceae*, followed by *Anacardiaceae*, *Boraginaceae* and *Rutaceae*. The farm was classified as moderately complex. The most determinant biodiversity components of that performance were the functional, functional introduced and noxious ones, which had negative repercussions on pest management.

Keywords: biodiversity, pathogen organisms and pests.

Introduction

The industrial model of intensive production, which has prevailed in Cuban agriculture during 400 years, has caused soil degradation and compaction, deforestation, overexploitation of natural resources and rupture of the ecosystemic balance (Casimiro and Casimiro, 2018), factors that affect the development of sustainable agriculture.

According to Nicholls *et al*. (2015) and Fernández and Marasas (2015), in the world this model has contributed to homogenizing the landscape, simplifying biodiversity and transforming farms into artificial ecosystems, highly dependent on chemical pesticides, machinery, as well as on human intervention. This instability in agroecosystems has stressed the problems caused by pests, because the plant communities, modified to satisfy the needs of human beings, have become more vulnerable to the intense damage provoked by noxious organisms, because they have lost the self-regulation characteristics that were inherent to them in their natural community (Altieri and Nicholls, 2010). While these communities are modified, the ecological unbalances that are observed in simplified agricultural systems are more serious and frequent (Nicholls *et al*., 2015).

In order to counteract these effects, the agricultural sector in Cuba carries out a process of reconversion or transition towards sustainable, sovereign and resilient agricultural production, in which the rectification of conventional technological failures and the promotion of agroecological practices lead to the implementation and knowledge of complex systems, which preserve natural resources in the farm redesign. Nevertheless, in order to achieve this purpose it is important to diagnose in each farm the existing biological diversity, due to its importance in the reconversion and design of stable systems, as well as in the functionality of agroecosystems and, particularly, in the reduction of pests and conservation of their natural enemies (Vergara-Ruiz, 2017; Sarandón, 2018).

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Diverse studies have proven that it is possible to stabilize the populations of pest organisms, when plant architectures that can maintain the populations of their natural enemies or that have direct dissuasive effects on pest herbivores are designed and built. In Cuba, these studies have been conducted mainly in agricultural systems of urban, periurban and suburban production (Vázquez, 2015; Matienzo-Brito *et al.,* 2015a). However, it has not been like this in farms with animal husbandry-agriculture integration, like the ones that exist in Matanzas province, where these elements are still unknown or the available information about the topic is insufficient. Taking the above-explained facts into consideration, the objective of this work was to characterize the biodiversity and determine its degree of complexity, as basis for the agroecological management of pests in a farmer entity.

Materials and Methods

Farmer productive entity where the research was conducted. Farm from a farmer which belongs to the CCS Sabino Pupo, in the Colón municipality, Matanzas province, in Cuba. This farm has a total area of 42,3 ha. Only two of them are used for family self-consumption, and the rest for animal husbandry.

Selection criteria for the farm object of research. It belongs to the Local Agricultural Innovation Program (PIAL) Project in Matanzas province. Its history, time of exploitation and innovative character of the farmer and his leadership were considered.

Evaluation period. December, 2014 to December, 2015.

Inventory of the biodiversity present in the farm and determination of the ecological indexes used. The number of species and individuals was quantified during one year (monthly) and were characterized according to their purpose. The indexes used to evaluate biodiversity were Margalef richness of species (MI) and Shannon diversity of species (H), according to the recommendations made by Moreno (2001). The calculation was done through the program *Diversity Species* & *Richnness* 3.02 (Henderson and Seaby, 2002).

Identification of biodiversity. The *Diccionario Botánico de Nombres Vulgares Cubanos* (Botanical Dictionary of Cuban Common Names) (Roig, 1975) was used.

Determination of the complexity degree of the biodiversity components in the farm. The methodology proposed by Vázquez and Matienzo (2010) for the quick characterization of biological diversity in the farms, as basis for the pest agroecological management, was applied. This methodology considers five components of biodiversity: productive (Bp), noxious (Bn), functional introduced (Bfi), functional (Bf) and auxiliary (Ba).

For each component different indicators were evaluated, to which according to the field value they acquired (absolute or percentage) degrees of complexity were ascribed, according to the scale shown by table 1. Afterwards, each degree of the scale was multiplied by the total number of indicators or components that had it, and at the end all the values that resulted from such multiplication were added. The degree of complexity of each component was obtained from the division of the resulting sum of the multiplication of each indicator between the value of the multiplication of the total components by the number of degrees of the scale (N=4). The degree of complexity of the farm was obtained from the division of the resulting value from the sum of the multiplication of each degree-indicator between the value of the multiplication of the total components (N=48) and finally, with the multiplication by one hundred to obtain the percentage value.

Diagnosis of insect pests and disease-causing agents. During the evaluated period and in a participatory way, there was interaction with the farmer to know the main noxious organisms that affect the crops in his farm and determine his knowledge about pests and the methods for their control.

Table 1. Scale for classifying the complexity of each indicator and component of biodiversity, as well as the farm.

Degree of complexity of the system	Absolute value	Percentage	Denomination of the degree of complexity of the system
0	0	0	Simplified
1	1-3	1-25	Little complex
2	4-6	26-50	Moderately complex
3	7-10	51-75	Complex
4	More than 10	More than 75	Highly complex

At the same time, monthly phytosanitary sampling was carried out and the pests and affected samples were collected. Those plants or their parts damaged by pathogen microorganisms were collected.

The gathered samples were transferred for their study to the plant protection laboratory of the Pastures and Forages Research Station Indio Hatuey. The identification of noxious organisms was carried out with the aid of taxonomic keys and criteria from diverse specialists (Alayo, 1970; Barnett and Hunter, 1998; Mound and Kibby, 1998; Peck, 2005; Triplehorn and Johnson, 2005; Cristobal-Alejo *et al.,* 2006; Barro and Núñez, 2011; Pérez *et al*., 2015; Vázquez *et al.,* 2015; Estrada and Ramírez, 2019).

That species of insect, mite, mollusk or another phytophagous animal, phytoparasite nematodes or fungi, bacteria, viruses and other phytopathogens, defined by the farmer as important for the plants of productive interest, according to his individual perception, which can differ from conventional criteria, was considered a noxious organism. This aspect was recommended by Vázquez *et al.* (2015).

Results and Discussion

Biodiversity. The inventory notified in the farm object of study 167 894 individuals, belonging to 65 species from 25 families. This value, along with the one reached by Margalef index (DMg) in this productive entity, which was 5,1, confirmed the diverse and considerable richness of species. These results, quantified with a value higher than five, are similar to those obtained by Salmón *et al.* (2012) and Milián *et al.* (2018) in Cuba.

Salmón *et al.* (2012), when evaluating the components of biodiversity in an agroecological farm in Las Tunas, reported a value of 5,7. Milián *et al*. (2018) obtained 5,3 in a study of the functionality of these components in a farm in agroecological transition in the Perico municipality, Matanzas province.

In this research, *Poaceae* and *Fabaceae* constituted the two most represented families, with 13 and 11 species, respectively, which reaffirms the importance they have as feed. In Cuba, these families group the highest number of edible plants, Fabaceae being the one on top of the list. It is followed, sometimes, by *Poaceae* or *Rutaceae,* as reported by González *et al.* (2018) when characterizing the integral functioning of a pre-mountain agroecosystem in the Limonar de Monte Rous community in Guantánamo.

The natural and cultivated pastures (*Digitaria eriantha* Stent, *Paspalum notatum* Flüggé, *P. virgatum* L., *Sporobolus indicus* (L) R. Br., *Hyparrhenia rufa* (Nees) Stapf, *Urochloa distachya* L. T.Q., *Cynodon dactylon* (L), *Dichanthium caricosum* Pers. and *Megathyrsus maximus* (Jacq.) B. K. Simon & Jacobs), as well as the forage plants (*Saccharum officinarum* L.) and the hybrid of elephant grass *Cenchrus purpureus* (Schumach.) Morrone x *Cenchrus americanus* L. Morrone.) grouped the most numerous species. The grasses aimed at human consumption did not behave like that, from which only two were quantified (*Zea mays* L. and *Oryza sativa* L.).

The results from this work are in agreement with the ones obtained by Sánchez-Santana *et al.* (2019), who when evaluating the floristic composition in ten peasant farms referred that the pastures represented 80 % of the found species.

In the family *Fabaceae*, superiority of the species aimed at feeding cattle and improving soil quality was recorded [*Desmodium triflorum* (L) DC, *Alysicarpus vaginalis* (L.) DC., *Tamarindus indica* L., *Albizia lebbeck* Benth, *Leucaena leucocephala* Lam. de Wit, *Gliricidia sepium* (Jacq.) Walp., *Racosperma abbatianum* (Pedley) Pedle, *Dichrostachys cinerea* and *Cannavalia ensiformes* L.] compared with the ones the farmer used to feed his family [*Phaseolus vulgaris* L. and *Vigna unguiculata* (L.) Walp].

These results are supported by the fact that in the farms, whose main activity is cattle milk production, almost all the lands are used for cultivating pastures and forages and, to a lesser extent, in planting other agricultural crops aimed at animal and human consumption (Salmón *et al,* 2012).

This cultivated and associated diversity (pastures, grasses and annual crops) has incalculable value due to its multiple ecological functions, among which are erosion control, formation, maintenance of fertile soils and pest regulation through the preservation of beneficial insects and wild life (Iermanó and Sarandón, 2016).

In addition, in the farm object of study, biodiversity is formed by 41 crops, belonging to other 23 families, among which *Mangifera indica* L., *Spondias purpurea* L., *Anacardium occidentale* L.; *Pistacia atlantica* Desf. (Anacardiaceae)*, Swietenia macrophylla* King., *Melia azedarach* L, *Persea americana* Mill and *Sassafras albidum* (Nutt.) Nees (Lauraceae), *Cucurbita pepo* L., *Cucumis sativus* L. (Cucurbitaceae), *Ceiba pentandra* (L.) Gaertn. and *Guazuma ulmifolia* Lam. (Malvaceae), *Cordia alliodora* (Ruiz & Pav.) Oken and *Mysotis* *scorpioies* L. (Boraginaceae), *Prunus persica* L., *Pyrus communis* L. (Rosaceae), *Gmelina arborea* Roxb (Lamiaceae), *Morus alba* L. (Moraceae), *Moringa oleífera* Lam. (Moringaceae), *Citrus x limon* (L.) Burm. f. (pro.sp.), *Citrus reticulata* Blanco, *Citrus x sinensis* (L.) Osbeck (pro. sp.) and *Citrus aurantium* L. (Rutaceae). From these families, the last one constituted the most represented, with four species, result that coincides with that reported by Milián *et al.* (2018).

From the reported biodiversity, its multiple functionality also stands out. In the farm the presence of 12 uses was observed (figure 1). From them, fruit was the one that grouped the highest quantity of species (22 from 65 in total). It was followed by pastures (11), timber-forestry-living fences (9), forage (8) and roots and tubers, grains, vegetables, ornamental plants and biopesticides (three from each one) and, finally, green manure (one species). This distribution of the use of plants was higher than the one referred by Salmon *et al*. (2012) and Milián *et al*. (2018), because they only reported the presence of trees.

The existence of specific richness of fruit and other multipurpose trees in this farm ratifies the criterion expressed by Russo (2015), who stated that farmers prefer to maintain in their ecosystems species that can offer multiple economic functions, which confirms the importance of these plants in the productive entity.

Trees improve the environment, as well as the physical, chemical and biological quality of soils. In addition, they increase the organic matter content. They are used as living fences, provide shade, contribute fruit, recycle nutrients, lower the cost of products in the market, protect the hydric potential of the place, serve as habitat to the wild fauna and provide beneficial goods and services for the human population (Braun *et al*., 2016). In the animal husbandry sector, forage shrubs improve the

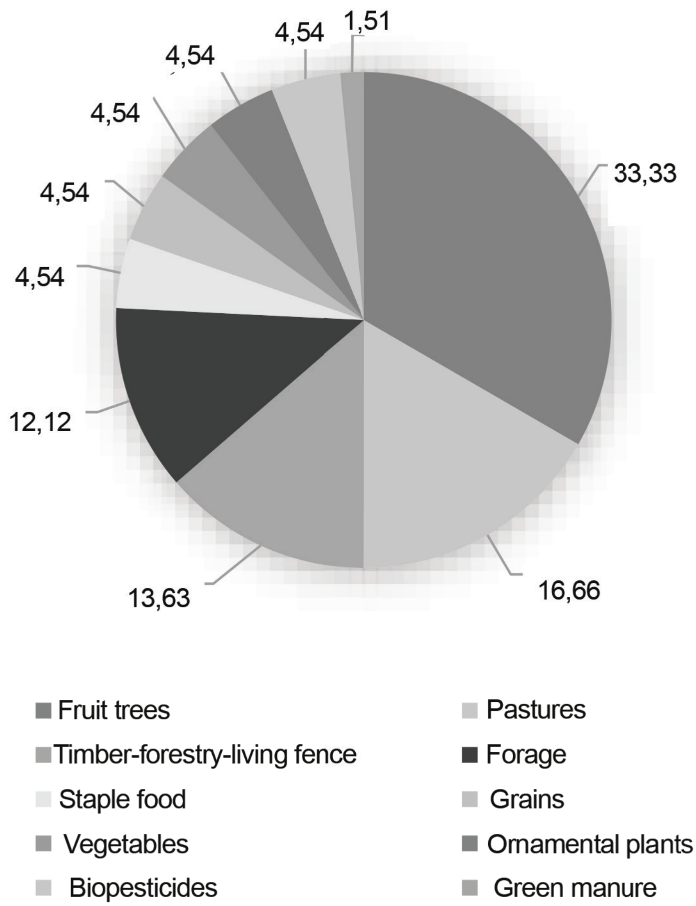

Figure 1. Distribution of uses in the evaluated farm.

quality and availability of the basis pasture (Loyola-Hernández *et al*., 2019), produce a large quantity of foliage and show crude protein and *in vitro* dry matter digestibility contents two or three times higher with regards to tropical pastures, which backs up the functionality of these species and their function in the agroecosystem. For such reason, upon planting the farmer conceived diversity of tree plants, with agrosilvopastoral potential, belonging to the genera *Leucaena, Albizia, Morus*, among others found and identified in this farm.

The timber trees present in the paddocks offer welfare to the animal, improve environmental conditions and constitute strategies that can mitigate the effect of climate change, as shown in the evaluated farm, where the existing trees fulfill those functions.

Regarding the important aspects for agroecological pest management, the scarce number of plants with biopesticide use could be noted, among which *M. azedarach*, *A. indica* and *S. albidum* were identified. The inexistence of others that are used as reservoirs of entomophages (functional biodiversity): basil (*Ocimum basilicum* L), pot marigold (*Calendula officinalis* L.), coriander (*Coriandrum sativum* L.), fennel (*Foeniculum vulgare* Mill), sunflower (*Helianthus annus* L.) and blackjack (*Bidens pilosa* L.). They are all essential for natural pest control (Vázquez, 2011).

Likewise, scarce interspecific diversity of crops, the ones that are used as feed and those that fulfill other functions in the agroecosystem, was recorded. They are ornamental plants, vegetables and grains, besides the ones that are used as barriers and living fences. The importance of the last ones is incalculable, due to the significant environmental services they provide: they delimit the property, limit the access of people and animals, contribute to the beautification of the landscape and serve as sources of forage for the animals. In addition, from the phytosanitary point of view, they also have biopesticide properties, because they act as physical barrier and trap plants (Vázquez, 2011; 2015).

The deficient interspecific diversity observed in this research was corroborated when evaluating Shannon index (H'), whose final result was 1,7. This indicates that there is not a uniform distribution of all the species. Besides, as it is a value lower than two, it is considered that there is low species diversity, according to the criterion expressed by Moreno (2001). This was ratified by proving that the most abundant crop was *Z. mays* (with 63 904 plants) followed by *S. officinarum* (with 31 250 individuals). In lower quantity, they were followed by drumstick tree (*M. oleifera*), forget-me-not (*Myosotis sylvatica* L.) and silk cotton tree (*C. pentandra*), with only one individual. Meanwhile, multipurpose trees did have higher interspecific diversity, and approximately more than 1 000 individuals were quantified. This result was lower than the one reported by Salmón *et al.* (2012) for the case of fruit trees (244 *vs*. 400), but higher for timber trees (935 *vs.* 400).

The evaluated farm is the result of the intensification of the conventional model, and although the farmer tries to diversify it, the homogenization and simplification of the landscape, characterized by the extension of natural pasture monoculture, forages and other crops of importance for animal feeding, is shown.

Table 2. Evaluation of the farm according to the degree of complexity of its biodiversity.

Maximum degree of the scale	4
Products of multiplying each degree by the number of indicators that have it:	
0x17 (simplified)	0
1x15 (little complex)	15
2x8 (moderately complex)	16
3x3 (complex)	9
4x5 (highly complex)	20
Sum of the products from multiplication of each degree	60
Total evaluated indicators	48
Product from multiplying the total indicators by the number of degrees of the scale	192
Degree of complexity	31
Classification of the farm with regards to the degree of complexity of biodiversity	little complex

Complexity of the farm. The farm was classified as moderately complex (table 2), category in which two of the studied components (Bn and Ba) were grouped, and three were included in the little complex one (Bn, Bf and Bfi).

Regarding the negative influence of Bn and Bf on obtaining the simplified complexity degree, the results of this research coincide with the ones reported by Galindo-Maturell *et al*. (2019), who in a similar context to the above-described one studied productive entities of a suburban agroecosystem belonging to the Santiago de Cuba province.

In the current moments, the studies related to the complexity of biodiversity in the animal husbandry farms are highly important. In this sense, Cuba has implemented diverse strategies, among which are the delivery of land to usufructuaries and animal husbandry-agriculture integration, which require this knowledge for the efficient and sustainable management of the productive entities based on this type of integration.

Figure 2 shows the performance of the components of biodiversity during the research. The Bn showed a percentage value of higher complexity than the one exhibited by Bfi and Bf, as well as an inversely proportional performance with regards to such components.

According to Rodríguez-Saldañas *et al.* (2014), this interpretation is positive, because the increase of noxious organisms is related to the decrease of the activity of biological controls or bioregulators in the farm, only to mention some examples.

Among the identified insect pests (16, in 15 crops) are *Prosapia bicincta fraterna* (Say) and *Remigia latipes* (Guenée). Fundamentally, they were found associated to the pastures *C. dactylon, D. caricosum, P. notatum, P. virgatum* and *M. maximus*; *Spodoptera frugiperda* (J. E. Smith) and *Helicoverpa zea* (Boddie) were recorded in corn; *Erinnyis ello* (L.) in cassava, *Pseudacysta perseae* (Heidemann) in avocado and *Hypothenemus hampei* (Ferrari) in coffee. In sweet potato *Cylas formicarius* (Fabricius) and *Typophorus negritus* (Frabicius) were identified, and in beans, *Omiodes indicata* (Fabricius). *Thrips palmi* Karny and *Bemisia tabaci* (Gennadius) were found in cucumber and tomato, and *Diabrotica balteata* J. L. LeConte in the latter crop. *Atta insularis* Guérin-Méneville was recorded in *L. leucocephala*. *Diaphania hyalinata* L. and *Aphis gossypii* Glover were found in squash. Vázquez *et al*. (2015) reported similar results in different production systems in Havana province, in Cuba. Similar data were notified by Vargas *et al*. (2019), who also identified *C. formicarius, H. zea, T. negritus, D. hyalinata* and *D. balteata* among the insect species that affected the existing vegetation in two suburban farms in Santiago de Cuba.

The incidence of phytopathogenic fungi, parasites and diseases in animals constituted another significant indicator in the component Bn. Although it was classified as little complex, harmful agents of relevance for the evaluated productive system are included here. This is the case of *Pseudoperonospora cubensis* Berk & Curt cucumber crop, *Erysiphe cichoracearum* DC in squash and *Mycospaherella fijiensis* Morelet in banana, microorganisms that are also considered noxious

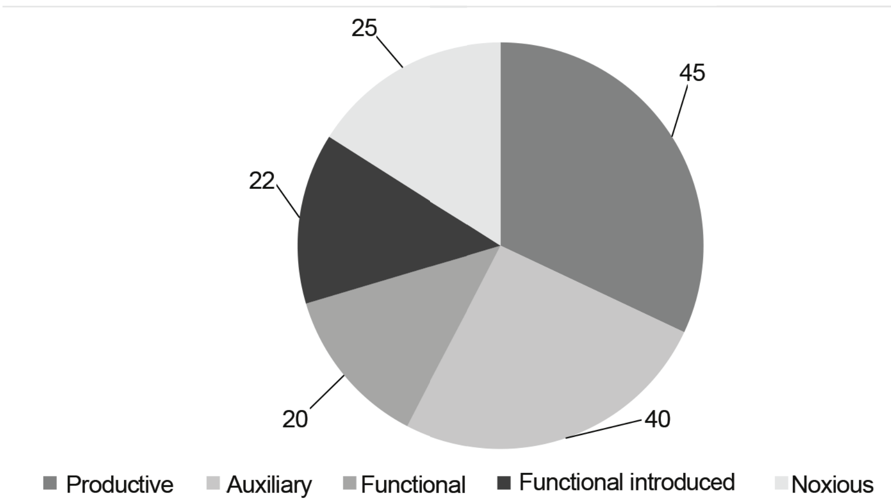

Figure 2. Performance of the biodiversity components during the research.

in the reviewed literature (Hernández-Mansilla *et al*., 2016; Alvarado-Aguayo *et al.,* 2019). Associated to the second group (parasites), *Rhipicephalus microplus* was detected, which coincides with the report by Fuentes-Castillo *et al*. (2019). In the third grouping (animal diseases) cattle mastitis stood out, disorder of importance for dairy cattle husbandry in Cuba (Ruiz-Gil *et al*., 2016; García-Sánchez *et al*., 2019).

From the above-described facts, the need to maintain an adequate functional biodiversity in the farm to prevent the agroecosystem from losing its natural capacity for the self-regulation of noxious organisms and the ecological control of pests as ecosystemic services, is deduced.

In the systems where pest regulation is carried out naturally, conditions and interconnections prevail that favor the stability of insect populations, as well as the alternative habitats for biological controls (Altieri and Nicholls, 2010, Iermanó and Sarandón, 2016; Vázquez and Pérez, 2017). There are, in variety and abundance, natural enemies that control them (predators, parasitoids, phytophages, phytoparasites and phytopathogens), for which in these environments complex biological processes provided with high functionality are developed.

In the evaluated agroecosystem irregularities were detected in the Bf and Bfi components, which denote the deficient functionality of this farm.

It was observed that in Bf that the farmer did not make leaf applications of organic fertilizers in the fields and the farm the rustic offspring of natural enemies or their massive releases was not managed. In addition, he did not use the reservoirs of natural bioregulators either, indicators that were evaluated as simplified, and which influenced negatively the little complexity obtained by such component, whose percentage value was 16 (figure 2).

From the above-referred facts, the need to use organic amendments is explained, as a practice that stimulates the protection, conservation and amelioration of the natural fertility of soils, the growth of a rich community of organisms, the trophic processes of nutrient transference and the crop development and protection (Jaizme-Vega, 2015; Martínez-Rodríguez, 2015). In addition, the contribution to the sustainability of the productions of urban, suburban and, fundamentally, family agriculture, has been proven.

The urgency to implement viable options for agroecological pest management, among which are the conservation, management and utilization of natural enemies, benefitting functional diversity, sustainable development of agricultural production systems and increase of the regulator activity of the most efficient species, is also acknowledged. Higher regulation rates are achieved as the result of the joint action of the different organisms that co-inhabit the productive system (Vázquez and Pérez, 2017). That is why in Cuba a procedure that utilizes pseudostems of banana as reservoirs of the ant *Pheidole megacephala*, whose colonies are transferred and inoculated in the sweet potato fields for the control of *C. formicarius*, pest insect diagnosed in the farm, has been generalized in the farmers in Cuba (Vázquez, 2011; CNSV, 2016).

Regarding the Bfi component it was corroborated that the farmer did not use the biological agents (entomophages and entomopathogens) and, besides, he did not apply mycorrhizae on the crops, which propitiated that five of the nine measured indicators in this component were considered as simplified, and that such component was classified as little complex. However, these good practices represent important activities for the promotion of sustainable production systems, as well as for agroecological pest management. Such as entomopathogenic bacterium *Bacillus thuringiensis* LBT-24 (1-2 L ha^{-1}) and the entomophage *Chelonus insularis* (parasitoid of eggs-larvae), which participate in the control of the main pest of corn (*S. frugiperda*) (Vázquez, 2011; Vázquez and Pérez, 2017; Hernández-Trejo *et al,* 2018), and were not found in the farm object of study.

As indicators of Ba that contributed to the farm being moderately complex, the absence of species that serve as repellent plants and their utilization in the plantations was recorded, as well as the inexistence of crops with permanent shades and deficient number of tree plantations or miniforests. Such indicators varied in their complexity level, from simplified (the first two ones) to little complex (last indicator). In Bp this was in addition to temporary shade, associations and intercropping, living barriers and deficient percentage of plantations with this type of biodiversity, where only the first indicator obtained the qualification of simplified, the rest being little complex.

The biodiversity grouped in these two components is responsible for important ecological functions and services in agricultural systems. Thus, its absence limits nutrient recycling and microclimate control, which prevents the development of a favorable habitat to increase the regulator activity and conservation of beneficial species. Likewise, it restricts the regulation of pest organisms (Matienzo *et al.,* 2015b) and of the processes and biological services, which require for their persistence to maintain and increase diversity.

Conclusions

The degree of complexity of the studied farm was qualified as moderately complex, which is due to the determinant behavior of the components of functional, functional introduced and noxious biodiversity. This obeys, mainly, to the inadequate management of its biodiversity, which contributed to the incidence of noxious agents on the crops and animals.

In the farm, biodiversity was represented mainly by species of the families *Poaceae* and *Fabaceae*, followed by *Anacardiaceae*, *Boraginaceae* and *Rutaceae*, among others.

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Authors' contribution

- Juan Carlos Lezcano-Fleires. Generated the idea of the research, searched for bibliographic information, executed the experiments with the corresponding measurements, participated in the identification of biodiversity, wrote the manuscript and carried out its revision during the edition process until its publication.
- Taymer Miranda-Tortoló. Contributed to completing the idea of the research, reviewed the experimental methodology for its execution and collaborated with the revision of the manuscript during the edition process until its publication.
- Luis Lamela-López. Participated in the trips to the farm and the biodiversity sampling.
- Iván L. Montejo-Sierra. Supported the research in the collection of information and participated in the biodiversity sampling in the field.
- Katerine Oropesa-Casanova. Supported the data processing and participated in the collection of noxious biodiversity samples.
- Osmel Alonso-Amaro. Contributed to the search for bibliographic information, identified the insect pests and collaborated with the revision of the manuscript during the edition process until its publication.
- Ibelice Mendoza. Participated in doing the measurements and in the identification of the noxious organisms collected during the study.
- Ricardo León-Hidalgo. Contributed to the search for bibliographic information and revision of the manuscript during the edition process until its publication.

Bibliographic references

Alayo, P. *Introducción al estudio de los hymenópteros de Cuba. Superfamilias Tenthredinodea, Siricoidea, Ichneumonoidea*. Villa Clara, Cuba: Universidad Central Marta Abreu de Las Villas, 1970.

Altieri, M. A. & Nicholls, Clara I. *Diseños agroecológicos para incrementar la biodiversidad de entomofauna benéfica en agroecosistemas*. Medellín, Colombia: SOCLA, 2010.

Alvarado-Aguayo, A.; Pilaloa-David, W.; Torres-Sánchez, Sinthya & Torres-Sánchez, K. Efecto de *Trichoderma harzianum* en el control de mildiu (*Pseudoperonospora cubensis*) en pepino. *Agron. Costarricense*. 43 (1):101-111, 2019. DOI: https://dx.doi.org/10.15517/rac.v43i1.35672.

Barnett, H. L. & Hunter, B. B. *Illustrated genera of imperfect fungi*. 4th ed. Minnesota, USA: The American Phytopathological Society, 1998.

Barro, A. & Núñez, R., Eds. *Lepidópteros de Cuba*. Finlandia: Spartacus Foundation, Sociedad Cubana de Zoología, 2011.

Braun, Andrea; Van Dijk, Suzanne & Grulke, M. *Incremento de los sistemas silvopastoriles en América del Sur*. Paraguay: Banco Interamericano de Desarrollo, 2016.

Casimiro-Rodríguez, Leidy & Casimiro-González, J. A. How to make prosperous and sustainable family farming in Cuba a reality. *Elem. Sci. Anth*. 6:77, 2018. DOI: https://doi.org/10.1525/elementa.324.

CNSV. *Análisis del cumplimiento del programa de producción e medios biológicos*. La Habana: Centro Nacional de Sanidad Vegetal, 2016.

Cristóbal-Alejo, J.; Caamal-Eb, Lorenza; Tun-Suárez, J. M.; Pérez-Gutiérrez, A.; Latournerie-Moreno, L. & Gutiérrez-Alonso, O. Epidemiología del mildiú de las cucurbitáceas (*Pseudoperonospora cubensis* Berk & Curt) en materiales de melón (*Cucumis melo* L.). *Fitosanidad*. 10 (3):197-201, 2006.

Estrada-Salazar, Gloria I. & Ramírez-Galeano, Marta C. *Micología general*. Caldas, Colombia: Centro Editorial Universidad Católica de Manizales, 2019.

Fernández, Valentina I. & Marasas, Mariana E. Análisis comparativo del componente vegetal de la biodiversidad en sistemas de producción hortícola familiar del Cordón Hortícola de La Plata (CHLP), provincia de Buenos Aires, Argentina. Su importancia para la transición agroecológica. *Rev. Fac. Agron. La Plata*. 114 (ne 1):15-29. https://redib.org/Record/oai_articulo778504-an%C3%A1lisis-comparativo-del-componente-vegetal-de-la-biodiversidad-en-sistemas-de-producci%C3%B3n-hort%C3%ADcola-familiar-del-cord%C3%B3n-hort%C3%ADcola-de-la-plata-chlp-provincia-de-buenos-aires-argentina-su-importancia-para-la-transici%C3%B3n-agroecol%C3%B3gica, 2015.

Fuentes-Castillo, A.; Hernández-Rodríguez, Y.; Quintana-Torrente, Dalia; Rodríguez-Fernández, R. & Méndez-Mellor, L. Estrategia de lucha contra la mosca *Haematobia irritans* y la garrapata *Rhipicephalus microplus* con el uso de Effipro Bovis en un rebaño bovino. *Rev. Salud Anim*. 40 (3):e06. http://scielo.sld.cu/pdf/rsa/v40n3/2224-4700-rsa-40-03-e06.pdf, 2018.

Galindo-Maturell, A.; Cobas-Magdariaga, M.; Martínez-González, R.; Escobar-Perea, Y. & Vargas-Batis, B. Calidad visual del suelo y complejidad de diez fincas suburbanas de Santiago de Cuba. *Ciencia en su PC*. 1 (4):16-31. https://www.redalyc.org/jatsRepo/1813/181358738012/ movil/index.html, 2019.

García-Sánchez, Flavia; Sánchez-Santana, Tania; López-Vigoa, O. & Benítez-Álvarez, M. Á. Prevalencia de mastitis subclínica y microorganismos asociados a esta. *Pastos y Forrajes*. 41 (1):35-40. http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S0864-03942018000100005&lng= es&tlng =es, 2018.

González, Yaniuska; Leyva, A.; Pino, Oriela; Mercadet, Alicia; Antoniolli, Zaida I.; Arébalo, R. A. *et al.* El funcionamiento de un agroecosistema premontañoso y su orientación prospectiva hacia la sostenibilidad: rol de la agrobiodiversidad. *Cultivos Tropicales*. 39 (1):21-34. http://scielo.sld.cu/pdf/ctr/v39n1/ctr03118.pdf, 2018.

Henderson, P. A. & Seaby, R. H. *Species diversity and richness 3.02*. Lymington, UK: Pisces Conservation Ltd. http://www.pisces-conservation.com, 2002.

Hernández-Mansilla, A. A.; Sorí-Gómez, R.; Valentín-Pérez, Yadira; López-Mayea, Aliana; Córdova-García, O. & Benedico-Rodríguez, O. Sigatoka negra (*Mycosphaerella fijiensis* Morelet) y seguridad alimentaria. Escenarios bioclimáticos en bananos bajo efecto del cambio climático en Ciego de Ávila, Cuba. *J. Selva Andina Biosph*. 4 (2):59-70. http://www.scielo.org.bo/pdf/jsab/v4n2/v4n2_a03.pdf, 2016.

Hernández-Trejo, A.; Osorio-Hernández, E.; López-Santillán, J. A.; Ríos-Velasco, C.; Varela-Fuentes, S. E. & Rodríguez-Herrera, R. Insectos benéficos asociados al control del gusano cogollero (*Spodoptera frugiperda*) en el cultivo maíz (*Zea mays*. L). *Agroproductividad*. 11 (1):9-14. http://revista-agroproductividad.org/index.php/agroproductividad/article/view/14, 2018.

Iermanó, María J. & Sarandón, S. J. Rol de la agrobiodiversidad en sistemas mixtos familiares de agricultura y ganadería pastoril en la región pampeana argentina: su importancia para la sustentabilidad de los agroecosistemas. *Rev. Bras. de Agroecología*. 11 (2):94-103. https://ri.conicet.gov.ar/handle/11336/39527, 2016.

Jaizme-Vega, Mará del C. Los microorganismos, bioindicadores de la fertilidad del suelo. En: F. Funes-Aguilar, ed. *Sembrando en Tierra Viva. Manual de Agroecología*. La Habana: Unión Europea, Agencia Española de Cooperación al Desarrollo. p. 51-65, 2015.

Loyola-Hernández, O.; Triana-González, Delmy; Tejas-Sánchez, O.; Malpica-Mentor, Lilian & Lezcano-Ortiz, Célida M. Efecto de *Samanea saman* (Jacq.) Merr. sobre la agroproductividad del pasto en un sistema silvopastoril. *Rev. prod. anim*. 31 (2):9-17. http://scielo.sld.cu/pdf/rpa/v31n2/2224-7920-rpa-31-02-9.pdf, 2019.

Martínez-Rodríguez, F. & Gómez-Jorrin, L. La fertilización de los cultivos bajo una perspectiva agroecológica. En: F. Funes-Aguilar, ed. *Sembrando en Tierra Viva. Manual de Agroecología*. La Habana: Unión Europea, Agencia Española de Cooperación al Desarrollo. p. 67-86, 2015.

Matienzo-Brito, Y.; Alfonso-Simonetti, Janet; Vázquez-Moreno, L. L.; De-la-Masa-Arias, R.; Matamoros-Torres, M.; Díaz-Finalé, Yunaisy *et al.* Diversidad de grupos funcionales de la fauna edáfica y su relación con el diseño y manejo de tres sistemas de cultivos. *Fitosanidad*. 19 (1):45-55. http://www.fitosanidad.cu/index.php/fitosanidad/article/view/447?articlesBySameAuthorPage=3, 2015a.

Matienzo-Brito, Y.; Vázquez, L. L.; Alfonso-Simonetti, Janet & Veitía-Rubio, Marlene M. Manejo del hábitat para la conservación de reguladores naturales de plagas agrícolas: experiencia cubana en agricultura urbana. *Revista InterNos*. https://www.revistainternos.com.ar/2015/01/manejo-del-habitat-para-la-conservacion-de-reguladores-naturales-de-plagas-agricolas-experiencia-cubana-en-agricultura-urbana/, 2015b.

Milián-García, Idolkys; Sánchez-Cárdenas, Saray; Wencomo-Cárdenas, Hilda B.; Ramírez-Suárez, Wendy M. & Navarro-Boulandier, Marlen. Estudio de los componentes de la biodiversidad en la finca agroecológica La Paulina del municipio de Perico, Cuba. *Pastos y Forrajes*. 41 (1):50-55. http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S0864-03942018000100007&lng=es&tlng=es, 2018.

Moreno, Claudia E. *Métodos para medir la biodiversidad*. Vol. 1. Manuales y Tesis SEA.: Zaragoza, España, 2001.

Mound, L. A. & Kibby, G. *Thysanoptera an identification guide*. 2nd ed. London: CAB International, 1998.

Navarro, Marlen; Febles, G. & Torres, Verena. Bases conceptuales para la estimación del vigor de las semillas a través de indicadores del crecimiento y el desarrollo inicial. *Pastos y Forrajes*. 35 (3):233-246. http://scielo.sld.cu/pdf/pyf/v35n3/pyf01312.pdf, 2012.

Nicholls, Clara I.; Altieri, M. A. & Vázquez, L. L. Agroecología. Principios para la conversión y el rediseño de sistemas agrícolas. *Agroecología*. 10 (1):61-72. https://revistas.um.es/agroecologia/article/view/300741, 2017.

Peck, S. B. *A checklist of the beetles of Cuba with data on distributions and bionomics (Insecta:Coleoptera)*. Ottawa: Florida Department of Agriculture and Consumer Services, Carleton University, 2005.

Pérez-Hidalgo, N.; Mier-Durante, M. Pilar & Umaran, A. Orden HEMIPTERA: Subórdenes Cicadomorpha, Fulgoromorpha y Sternorrhyncha. *IDE@-SEA*. 54 (1). http://sea-entomologia.org/IDE@/revista_54.pdf, 2015.

Rodríguez-Saldañas, M.; Milanés-Virelles, P.; Pérez-Torres, E.; Ferrer-González, C. & Sierra Reyes, Y. Agrobiodiversidad y manejo agroecológico de plagas en fincas de la Agricultura Suburbana en el municipio Camagüey. *Agrisost*. 20 (2):27-35. https://revistas.reduc.edu.cu/index.php/agrisost/article/ view/336, 2014.

Roig, J. T. *Diccionario Botánico de nombres vulgares cubanos*.4 ed. La Habana: Editorial Pueblo y Educación, 1975.

Ruiz-Gil, A. K.; Peña-Rodríguez, J. & Remón Díaz, Dianys. Mastitis bovina en Cuba. *Rev. prod. anim*. 28 (2-3):39-50. http://scielo.sld.cu/pdf/rpa/v28n2-3/rpa06216.pdf, 2016.

Russo, R. O. Reflexiones sobre los sistemas silvopastoriles. *Pastos y Forrajes*. 38 (2):157-161. http://scielo.sld.cu/pdf/pyf/v38n2/pyf01215.pdf, 2015.

Salmón, Yamilka; Funes-Monzote, F. R. & Martín, Olga M. Evaluación de los componentes de la biodiversidad en la finca agroecológica "Las Palmitas" del municipio Las Tunas. *Pastos y Forrajes*. 35 (3):321-332. http://scielo.sld.cu/pdf/pyf/v35n3/pyf08312.pdf, 2012.

Sánchez-Santana, Tania; Rizo-Álvarez, Maritza; Morales-Querol, D.; García-Sánchez, Flavia; Olivera-Castro, Yuseika; Benítez-Álvarez, M. *et al.* Situación agroproductiva de fincas en dos municipios de la provincia Matanzas. *Pastos y Forrajes*. 42 (3):230-234. http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S0864-03942019000300230&lng=es&tlng= es, 2019.

Sarandón, S. J. *Investigación en agrobiodiversidad: La experiencia del grupo de agroecología de la Facultad de Ciencias Agrarias y Forestales de la Universidad Nacional de la Plata, Argentina*. https://www.researchgate.net/publication/334231010_Los_desafios_de_la_Investigacion_en_agrobiodiversidad, 2018.

Triplehorn, C. A. & Johnson, N. F. *Borror´s introduction to the study of insects*. 7th ed. USA: Brooksl-Cole a division of Thomson Learning, Inc, 2005.

Vargas-Batis, Belyani; Mendoza-Betancourt, E. O.; Rodríguez-Fonseca, R.; Jiménez-Llópiz, R.; Cobas-Magdariaga, M. & Vuelta-Lorenzo, D. R. Identificación y comportamiento de la fauna entomológica asociada a la vegetación existente en dos fincas suburbanas en Santiago de Cuba, Cuba. *Rev. Chil. Entomol*. 45 (1):139-156. https://www.biotaxa.org/rce/article/view/48713, 2019.

Vázquez, L. L. Diseño y manejo agroecológico de sistemas de producción agropecuaria. En: F. Funes-Aguilar, ed. *Sembrando en Tierra Viva. Manual de Agroecología*. La Habana: Unión Europea, Agencia Española de Cooperación al Desarrollo. p. 133-160, 2015.

Vázquez, L. L. Diversificar plantas para reducir poblaciones de plagas en la finca. En: *Supresión de poblaciones de plagas en la finca mediante prácticas agroecológicas*. La Habana: INISAV. p. 49-60, 2011.

Vázquez, L. L.; Alfonso-Simonetti, Janet; Jiménez-Jiménez, S.; Fernández-Gonzálvez, E.; Casagranda, Jaqueline; Pérez-Betancourt, Yamilka *et al.* Organismos nocivos de importancia en diferentes tipos de sistemas de producción en la matriz agrícola urbana, periurbana y suburbana de la provincia de La Habana. *Fitosanidad* 19 (1):29-43. http://www.fitosanidad.cu/index.php/fitosanidad/article/ view/446, 2015.

Vázquez, L. L. & Matienzo, Y. *Metodología para la caracterización rápida de la diversidad biológica en las fincas como base para el manejo agroecológico de plagas*. Cuidad de La Habana: INISAV, 2010.

Vázquez, L. L. & Pérez, Nilda. El control biológico integrado al manejo territorial de plagas de insectos en Cuba. *Agroecología*. 12 (1):39-46. https://revistas.um.es/agroecologia/article/view/330331. 2017.

Vergara-Ruiz, R. *La importancia de la biodiversidad en el funcionamiento de los agroecosistemas: caso floricultura*. https://www.metroflorcolombia.com/la-importancia-de-la-biodiversidad-en-el- funcionamiento-de-los-agroecosistemas-caso-floricultura/. 2017.