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MACROFAUNA POPULATION IN SILVOPASTORAL SYSTEMS FOR MILK PRODUCTION: PRELIMINARY ANALYSIS

POBLACIÓN DE MACROFAUNA EN SISTEMAS SILVOPASTORILES DEDICADOS A LA PRODUCCIÓN LECHERA:ANÁLISIS PRELIMINAR.

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Abstract

This research shows a preliminary study of macrofauna in silvopastoral soils for milk production, whose objective was to evaluate the soil's population biota in silvopastoral systems whit next combinations: aliso (*Alnus acuminata*) and fodder mixture, acacia (*Acacia melanoxylon*) and fodder mixture, and control only fodder mixture. In first stage, 30 samples were collected in each population sample, in months with less precipitation, each sample, is one square of 30 cm $\times$ 30 cm $\times$ 30 cm, in which counted the existing biota. Population data was analyzed using biodiversity index like Margalef index of species richness, Berger Parker index of dominance, Simpson's dominance index and Shannon diversity index, data which permitted conclude the variation in species number is not significant in population samples and existing biota maintains the productivity. Also, those values will use in a second research to make statistical comparisons in the number of species in months with more and less precipitation.
Keywords: Biota, biodiversity index, comparison, Carchi, Ecuador.

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Resumen

En esta investigación se presenta un estudio preliminar de la macrofauna en suelos silvopastoriles dedicados a la producción de leche, cuyo objetivo es analizar las poblaciones de biota del suelo en sistemas silvopastoriles con las siguientes combinaciones: aliso (*Alnus acuminata*) y mezcla forrajera, acacia (*Acacia melanoxylon*) y mezcla forrajera, y un testigo solo con mezcla forrajera. En una primera etapa se realizaron 30 muestras en cada población muestral, en los meses de baja precipitación, cada muestra es un cuadrante de 30 cm $\times$ 30 cm $\times$ 30 cm, en el cual se contabilizó la biota existente. Los datos de las poblaciones se analizaron usando los índices de biodiversidad como riqueza de Margalef, índice de dominancia de Berger-Parker, el índice de dominancia de Simpson y el índice de biodiversidad de Shannon, datos que permitieron concluir que la variación en número de especies no es significativa entre poblaciones muestrales y la existencia de biota mantiene la productividad. Además, estos datos servirán en una segunda investigación para hacer comparaciones estadísticas del número de especies en meses de mayor y menor precipitación.
Palabras claves: Biota, comparación, índices de biodiversidad, Carchi, Ecuador.

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1 Introduction

According to the preliminary investigation (Hernández Sampieri, Fernández Collado and Baptista Lucio, 2014) made to the samplings in the silvopastoral systems of the Finca "San Vicente", parish "El Carmelo" province of Carchi, it can be deduced that the productivity of the silvopastoral systems depends on climatic and edaphic conditions and the presence of soil fauna, this in turn influences the productivity of the dairy herd.

In this research, a specific analysis is carried out on soil biota based on alpha biodiversity indices (Lazo et al., 2007); the objective is to measure production levels in silvopastoral systems, comparing the symbiotic efficiency of edaphic fauna in pastures with alders, grasses with acacias and a single control of grasses. As stated by Jordán López (2005–2006) soil biota is important, since its presence depends on its fertility and stability, it carries out the fragmentation of organic waste, it allows the degradation of organic compounds to simpler molecules, it acts on the porosity of the soil, it facilitates the aggregation of soil particles through the excretions and intervenes in the humification of the organic matter.

The analyzes carried out at the study site served to identify the variation in the number of species among silvopastoral systems according to the best symbiotic relationships between grasses and trees.

In this type of study, biodiversity indices are tools to analyze the ecological balance between species present in ecosystems, which in turn allows demonstrating the variation in the quality of habitats (Thevathasan et al., 2014). The number of species is the most widely used measure for biodiversity analysis, because the species richness reflects aspects of the biota, the species are easy to identify and account for, and even if there is not complete taxonomic knowledge (especially for taxa such as , insects and other invertebrates) it is sufficient to have bibliographic availability about species (Moreno, 2001).

2 Materials and method

Based on the information taken from the Global Positioning System (GPS), the study area is located in the "San Vicente"farm, .El Carmelo"parish, Carchi province, located at the UTM coordinates: Lat N 210000, and Long. 10072464. The climate is high mountaine quatorial, with a precipitation between 1 200 and 2 000 mm, with a temperature range of 10 to 12 ° C (El Carmelo weather station). According to soil analyzes, these belong to the inceptisols order with high content of organic matter, ranging from deep to well drained surface, good moisture retention, sandy loam texture, black wet color, abundant roots due to the presence of grasses, pH 6.5, parental material from ash and volcanic sands, found in a undulated relief with slopes ranging from 20 % to 25 %.

The objective of this research is a descriptive analysis that allows comparing the abundance of edaphic fauna in silvopastoral systems, this analysis should be done twice a year, to observe the evolutionary process of soil biota. The first collection of samples was carried out in the month of July 2016, whose data will be used for comparisons of future collections. The arboreal species of the silvopastoral system, which are in development, are distributed in strips following the contour lines (Sánchez Matta et al., 2009)) and with a width of 10 meters (See Figure 1).

The biota was counted between the strips, in quadrants of 30 cm long, 30 cm wide and 30 cm deep, with a total of 30 samples for each sample population. The biota was collected and then identified in the laboratory at the level of orders, with the support of specialists and specialized bibliography. In each sample population, we performed: calculation of relative abundance, Margalef's diversity index, Berger-Parker dominance index, Simpson's dominance index, and Shannon biodiversity index, selected for being quantifiable and useful for alpha diversity analysis. of the species (Chiquin Baños and Velecela Caiza, 2015).

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Relative abundance index

$$AR = \frac{Number\ of individuals\ of\ a\ species}{Total\ of\ individuals\ of\ all\ species} \times 100 \quad (1)$$

Where:

AR = Relative Abundance

Margalef's diversity index

$$D = \frac{S-1}{ln\ N} \quad (2)$$

Figure 1. Distribution of tree species in strips in each sample population

Where:

D = Margalef Index
S = Number of species
ln = natural logarithm
N = Total number of individuals

Berger – Parker index

$$B = \frac{N_{máx}}{N} \tag{3}$$

Where:

B = Berger – Parker index
Nmax = Number of individuals of the most abundant taxon
N = Total number of individuals in the sample.

Simpson diversity index

$$D_s = \frac{n(n-1)}{N(N-1)} \tag{4}$$

Where:

Ds = Simpson index.
n = Number of individuals of the species.
N = Total of individuals.

Because Ds and diversity are negatively related, the Simpson index is exposed as the reciprocal or complement (1- D), so that, if the index increases, the diversity also increases.

Shannon – Wiener diversity index

$$H = -\sum_{i=1}^{s} p_i \times ln\ p_i \tag{5}$$

En donde:

H = Shannon index.
pi= proportion of species.
S= number of species (species diversity).
ln = natural logarithm.

Such indexes are used to calculate alpha diversity, applicable to areas with species richness considered homogeneous (Moreno, 2001), in the study area with similar altitude, climatic and edaphic characteristics.

3 Results and discussion

Relative abundance index

It corresponds to the total number of individuals of a species expressed as a proportion of the total number of individuals of all species (Moreno, 2001).

According to the data presented in Charts 1, 2 and 3 it is identified in the three sample populations, that the taxa of greater proportion is *Haplota-*

Table 1. Relative abundance of the sample population of Alder (*Alnus acuminata*) and forage mix

N°	Orden Taxonómico	Nombre común	Cantidad	Abundancia Relativa (%)
1	*Haplotaxida*	Lombrices de tierra	396	76,89
2	*Pulmonata*	Babosas	48	9,32
3	*Geophilomorpha*	Ciempiés	1	0,19
4	*Araneae*	Arañas	21	4,08
5	*Coleopteros*	Escarabajos	18	3,5
6	*Dermaptera*	Tijeretas	1	0,19
7	*Diptera*	Moscas, sancudos	23	4,47
8	*Lepidoptera*	Mariposas y orugas	3	0,58
9	*Orthoptera*	Saltamontes	4	0,78
		TOTAL	515	100

Table 2. Relative abundance of the Acacia sample population (*Acacia melanoxilon*) and forage mix

N°	Orden Taxonómico	Nombre común	Cantidad	Abundancia Relativa (%)
1	*Haplotaxida*	Lombrices de tierra	372	66,55
2	*Pulmonata*	Babosas	17	3,04
3	*Geophilomorpha*	Ciempiés	2	0,36
4	*Araneae*	Arañas	47	8,41
5	*Coleopteros*	Escarabajos	61	10,91
6	*Diptera*	Moscas, sancudos	48	8,59
7	*Lepidoptera*	Mariposas y orugas	2	0,36
8	*Orthoptera*	Saltamontes	7	1,25
9	*Hemipteros*	Chinches y pulgones	3	0,54
		TOTAL	559	100

Table 3. Relative abundance of the sample population of Forage mixed control

N°	Orden Taxonómico	Nombre común	Cantidad	Abundancia Relativa (%)
1	*Haplotaxida*	Lombrices de tierra	449	77,15
2	*Pulmonata*	Babosas	15	2,58
3	*Isopoda*	Cochinillas	1	0,17
4	*Araneae*	Arañas	23	3,95
5	*Coleopteros*	Escarabajos	45	7,73
6	*Diptera*	Moscas, sancudos	34	5,84
7	*Lepidoptera*	Mariposas y orugas	3	0,52
8	*Orthoptera*	Saltamontes	7	1,2
9	*Hemipteros*	Chinches y pulgones	3	0,52
10	*Hymenoptera*	Abejas y avispas	2	0,34
		TOTAL	582	100

xida (earthworms), its presence in the trophic level of primary consumer contributes to the breakdown of the material vegetable and incorporation of nutrients, besides influencing the processes of aeration and soil removal (Adi-Saab Arrieche, 2012).

The *Haplotaxida* taxon is relevant to assess environmental disturbances and the measures to be taken into account in said soil. Identify changes in diversity, number, species distribution or dominance, alert about impoverishing processes Magurran (2004), which is not the case of the study area, since the results analyzed show adequate numbers in the *Haplotaxida* taxon.

Margalef diversity index

It is obtained by knowing the total number of species, in relation to the total of the individuals of the species present within the sample (Moreno, 2001), (see Table 4).

Table 4. Margalef diversity index

Sample population	Margalef diversity index
Alder (*Alnus acuminata*) and forage mix	1,2812
Acacia (*Acacia melanoxilon*) and forage mix	1,2645
Forage mix	1,4136

The minimum value that can be adopted is zero, and it occurs when there is only one species in the sample (s=1, so s-1=0). Low values refer to ecosystems with little biodiversity in relation to high values that are sites with greater presence of species.

It should be noted that the sampling sites have the purpose of grazing for milk production, which is why it is considered as a livestock. The lowest species richness in the acacia-pasture sample population can be observed.

Berger – Parker dominance index

This index measures the dominance of the most abundant species, as mentioned by Moreno (2001), (see Table 5).

Table 5. Berger – Parker dominance index

Población muestral	Index
Alder (*Alnus acuminata*) and forage mix	0.769
Acacia (*Acacia melanoxilon*) and forage mix	0.665
Forage mix	0.771

This index acquires values between 0 and 1 (0% and 100%). In the sample population, the highest index is located in the control, that is, there is more equity in the populations, but with a decrease in dominance Moreno (2001).

Simpson diversity index

According to Franco López (1985), this index allows us to estimate the probability that two individuals chosen at random in a community come from different species (see Table 6).

Table 6. Simpson diversity index

Sample population	Index
Alder (*Alnus acuminata*) and forage mix	0,396
Acacia (*Acacia melanoxilon*) and forage mix	0,531
Forage mix	0,394

According to the result of the Simpson index, it can be deduced that, in the sample population of acacia with forage mix, individuals of the same species in different extractions could be more likely found.

Shannon – Wiener diversity index

According to Moreno (2001), this index assumes that individuals are selected at random and that all species are represented in the sample (see Table 7).

Table 7. Shannon – Wiener diversity index

Sample population	Index
Alder (*Alnus acuminata*) and forage mix	0,902
Acacia (*Acacia melanoxilon*) and forage mix	1,161
Forage mix	0,924

As indicated by Moreno (2001), this index can vary between zero (when there is only one species) and the logarithm of S (when the species are represented by the same number of individuals), identifying in this way that in the results of the Shannon-Wiener index the sample population with the highest diversity value is found in the acacia plot with the forage mix.

We must consider that the sample population has the objective of grazing and the dominant plant species are pastures, which influences the low presence of species of edaphic fauna, hence the values altogether denote low rates in the three sample populations. The result of the Shannon index can be contrasted with those highly biodiverse ecosystems, which can have values close to five.

Given that climatic conditions influence the development of plants, which in turn determine the growth of fauna, changes in the number of species may vary from one season to another with respect to temperature and precipitation. As mentioned byLazo et al. (2007) the number of individuals of arthropods is different in periods of different precipitation, it is necessary to specify then that for the case of the farm "San Vicente", the accounting was made in the months of least precipitation and the results of the count are from the first stage, in the future, measurements will be made that allow comparing the number of species with months of greater precipitation at different times of the year.

The analysis of biotic indices on the "San Vicente" farm was based on alpha diversity, since the study site is considered homogeneous because it has the same soil conditions, climate, altitude, and silvopastoral systems, in accordance with the above by Whitaker (1972) alpha diversity is a homogeneous community, beta diversity is a degree of change between different communities in a landscape, and gamma diversity is the species richness of the set of communities that make up a landscape, resulting from diversities alpha and beta.

Because population numbers are variable in each geographical unit, in each landscape, biodiversity analyzes are useful to understand the evolution of species growth in terms of environmental disturbances or the influence of human activities on them, so that used the biodiversity indexes to analyze if there are significant changes between sample populations, being able to verify that there are no significant changes among them, even when tree species are growing.

The study area has pastures with trees that are under development, in addition, due to the climatic and plant cover conditions most of the recorded biota is in shade in the radicular system of pastures, meanwhile Vega (2014) states that the greatest presence of oligochaetes and insects is found in soils with pastures, the highest percentage belonging to the oligochaetes, even taking into account the differences in altitude that exist between the two study areas.

From another point of view Hernández Chávez, Sánchez Cárdenas and Simón Guelmes (2008) point out that the presence of trees creates a microclimate according to the demands of organisms. In this sense, in the area of analysis the presence of vegetation cover with forage mix in the study area, becomes the habitat for soil biota, and the presence of alders and acacias favors the formation of microclimates for the edaphic fauna, so it can be observed in the data the presence of edaphic fauna, and that the values vary scarcely between sample populations, having greater presence of biota in the alder system with forage mix, followed by the number of the control, and with lower number the sample population of acacia with forage mix, noting that there is different moisture retention in the sample populations due to the topography that may affect the greater or lesser presence of edaphic biota, as shown in Figure 2.

In addition, the presence of organic matter is important for productivity, and the biota of the soil is precisely the one who contributes it (Argel, 2006), the optimum conditions of the habitat of the species that contribute with the decomposition of plant remains, and its Once, they contribute to the symbiotic improvement with other species, including bacteria.In this same subject, according to Simón et al. (2005) the foliage of leguminous trees is an alternative for the management of the edaphic fauna, the same that is important in the processes of vegetal decomposition, degradation of cellulose, lignin and transformation in humic material. It follows that, over time, the soil productivity of the study area has been maintained by the presence of organic matter contributed by the soil biota.

In the study area the management of the silvopastoral system guarantees the living conditions of the organisms, its presence is an indicator of the optimal environment of the system, and, among the three sample populations, there is not a wide variation in the number of species, which it can be deduced that the association of forage mix with trees if it contributes to the living conditions of the edaphic fauna, the silvopastoral systems propitiate the presence of habitats for insects, microclimates are formed, and establish balanced interactions between phytophages, bioregulators and microorganisms (Milera, 2013). In the research, a descriptive analysis of the research was carried out, without resorting to statistical analyzes that measure the presence of biodiversity

Finally, Cabrera (2012) recognizes the behavior of populations of the edaphic macrofauna as an indicator of the state of the soil, through its species di-

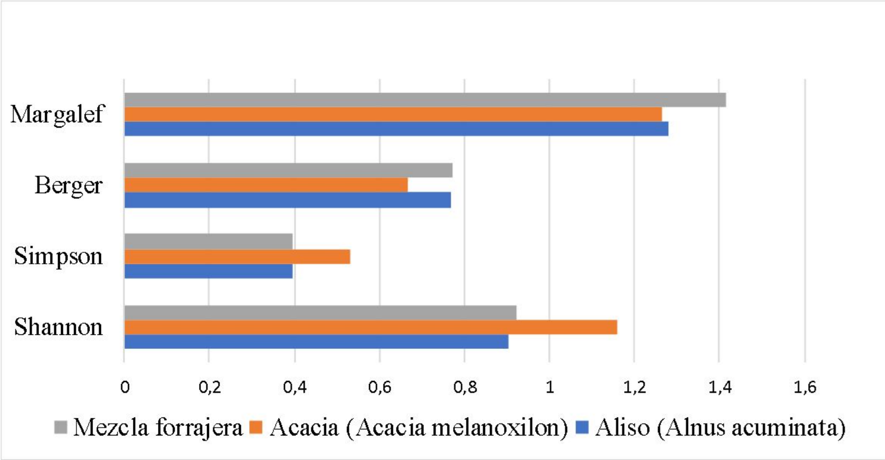

Figure 2. Biotic indices in the population samples

versity. It can be noted then, that the edaphic fauna is an indicator of the quality of the soils and in the study area the presence of the biota indicates that the silvopastoral systems are in good condition in the three sample populations, favoring productivity and relationships symbiotic between species.

4 Conclusions

The applications of biodiversity indices allow the analysis of the number of populations and their species, being useful tools to observe the levels of environmental disturbance. On the other hand, there is little variability in the indices of biodiversity in the three sample populations, which denotes uniformity in environmental and soil conditions, taking into account that tree species are still growing. It is also identified that the physical and chemical conditions of the sample populations are within the desired parameters and the amount of edaphic fauna varies scarcely in space. In the same way, the presence of the edaphic fauna favors the processes of aeration, soil removal and incorporation of nutrients, improving the productivity of silvopastoral soils. Consequently, it is recommended that the application of the biodiversity indices be replicated in other Andean silvopastoral systems, in order to make future comparisons regarding population variations. Likewise, the current conditions of the silvopastoral systems must be maintained in order to conserve the fauna populations of the soil, which allow a future monitoring of the evolution of edaphic communities. Finally, it is necessary to involve teachers and students of higher levels in tasks of sampling and accounting for species that contribute to the analysis of environmental conditions and the edaphic fauna.

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