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Ecological Service Offered by *Tadarida brasiliensis* Bats as Natural Plague Controllers in Northern Mexico and Their Economic Valuation

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Abstract

The objective research is to know the environmental service the bat subspecies, Mexican *Tadarida brasiliensis*, offer as a natural plague controller in the state of Nuevo León and to approximate the economic value of this service. It begins by studying the eating habits of the population living in the cave *Cueva de la Boca*, located in Santiago, Nuevo León. The insects identified on their diet represent potential agricultural plagues in the region. According to primary and secondary information on the economic importance of sorghum, corn, citrus and walnut crops on the influence area and to the implementing intensity of the chemical compounds used to control plagues, it is estimated that the economic value of this environmental service lies between \$0.65 and \$1.65 million dollars, with an expected value between \$11.0 and \$26.0 dollars per hectare per year in these crops. The results of this study constitute a valuable conservation tool to support the protection of ecosystems around bat roosting sites that serve both as biological control of diseases and pests, as well as to provide other integral environmental services.

Subject Areas

Environmental Economics & Ecosystem Science

Keywords

Tadarida brasiliensis Bats, Ecological Services, Natural Plague Control, Economic Valuation

1. Introduction

The guanero or free-tailed Mexican bat, *Tadarida brasiliensis*, belongs to the

Molossidae family, part of the *microchiroptera* suborder. It is distributed along southern United States through Brazil, with a total of nine subspecies. The objective of the study is to know and specify the environmental service that bat subspecies, mexican *Tadarida brasiliensis*, offer as a natural plague controller in the region of Nuevo León, and to approximate, for the first time, the economic value of the environmental service, both by analyzing its role in an ecosystem where humans live, too. The motivation of the study is based on the intention to conserve the habitat and the colonies of bats and other species that live here. The analysis begins studying the bats' eating habits living in the cave *Cueva de la Boca*, located in Santiago, Nuevo León, México very close to Monterrey City. The insects identified on their diet represent potential agricultural plagues in the region. According to primary and secondary information on the economic importance of certain crops on the influence zone and to the implementing intensity of the chemical compounds used to control plagues, the fundaments for the estimation of the economic valuation were determined. Although the regional government protects the area called *Sierra Cerro de la Silla*, and that it was proposed as the nuclear area in the zoning of management plan, the *Cueva de la Boca* has a high vulnerability degree due to its proximity to a very traveled highway and urban area. It is estimated that this bat population could have reached 3 million individuals in the 90's, but by the time this study was made, it had decreased drastically to around 600,000 and 700,000 individuals. The cave's economic and ecological importance is truly significant, because it gives temporary and permanent home to other bat populations that provide numerous ecological services, as well as a complex and rich community. In the present day, the ONG Pronatura Noreste, A.C. protects the cave.

Bats represent more than a fourth of the mammal species in the world. Around 449 mammal species live in Mexico; 137 of them are bats. In Nuevo León, 40 out of 144 are bats. This high proportion, which is not usually perceived due to the nocturnal habits of the group, manifests an ecological relevance. The ecological bat functions translate in environmental services that relate to their feeding webs.

Approximately 70% of the bat species eat insects. This could control insect population plagues and a vector of illnesses up to a certain extent. 20% of bats eat fruits and contribute to seed dispersion, making them part of the regenerating ecosystem process (Orozco-Segovia *et al.*, 1985) [1]. 7% of them eat nectar and pollen, helping sexual reproduction of plants and genetic exchange of information that allows the possibility of adaptation to changes in the environment and provides more resistance to illnesses and plagues [1]. There are numerous plants that have commercial value, whose existence we owe to bats. This is thanks to plague and illness control or to pollination and dispersion of these wild plant varieties: figs, pitayas, guava, mangoes, bananas, papayas, guanabanas, dates, fine wood, and agave, for example the one used to make tequila, among others. 3% of bats live off small rodents, birds, and fish. This leaves only 3 out of

1100 bat species, to live off blood: two of them drink wild bird blood, while the other species drink cattle blood. This last species is the one the that has given bats a bad name, but nonetheless, even these bats, still provide ecological services, for their saliva enzyme, known as DSPA (desmoteplase), is being analyzed as a more secure and efficient alternative treatment of brain hemorrhage (Liberatore *et al.,* 2003) [2].

The interrelations in the system clearly show (see **Figure 1**) how bats can be considered as sustainable plague controllers, since they comply with all sustainable development dimensions: social and economic benefits and health to the ecosystem. Both agrochemical pesticides and bats carry out the same purpose of decreasing insect plague population, benefiting crops. However, the agrochemical pesticide results in a series of costs to society: economic costs and health costs due to their implementation, resulting in a decrease of social welfare. At the same time, an impact in the ecosystem occurs due to the lack of specification of the products that affect not only the insect plague, but also other favorable organisms. Even though the substitution function between bats and pesticides is not considered as such, the bat role can be part of an Integrated Management of Pests and Diseases program.

On the other hand, due to their eating habits, as explained later, bats can fulfill the role of plague and illness controllers without incurring in economic expenditures or health costs. Furthermore, it provides the additional benefit of building a new tourist attraction that generates an economic spillover for the region and,

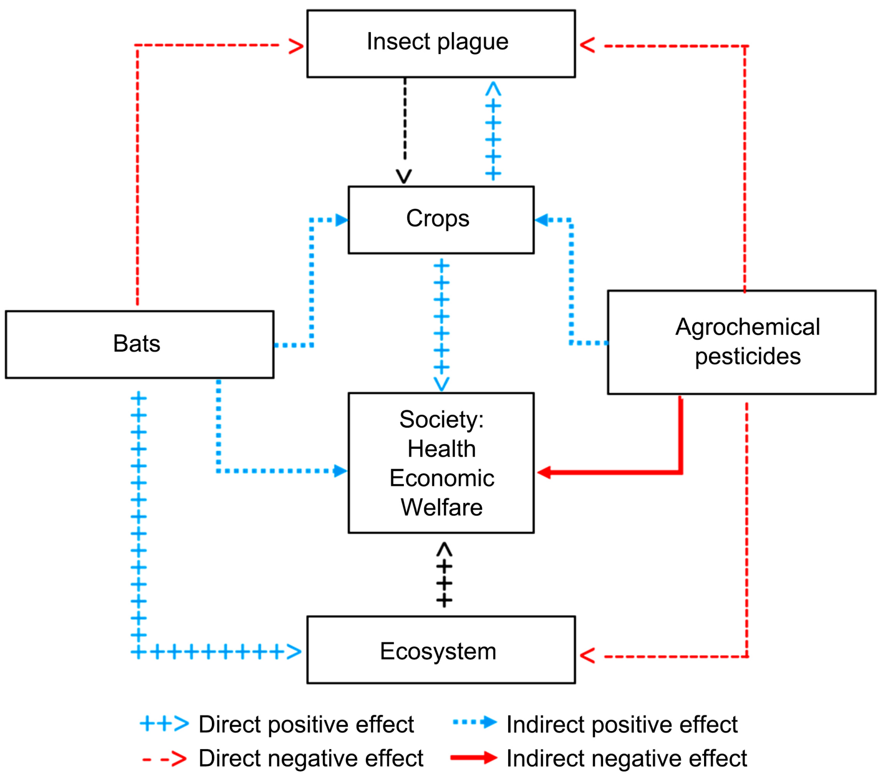

Figure 1. Systemic relationships in the ecosystem.

at the same time, its population and habitat protection implies the preservation of every ecological service produced by the health and integrity of the ecosystem.

In the next section, we explain a detailed description of the species and its habitat, the cave *Cueva de la Boca*. Following, we show the results of the exploration of the bat diet and determine the potential plagues for agriculture in the zone of influence. The fourth section demonstrates the economic importance of agriculture in the zone of influence. In the fifth section, we present the outcome of the economic valuation estimations through the method of omitted costs. This paper concludes with a series of final considerations.

2. Bats Species Description

In general, bats belonging to the *Molossidae* family present a brown coloring with a white hair base. Their snouts are small and wide with diverse folds and fleshy lips. Their nostrils are opened in a special bearing; they don't have a nasal leave. They have long and narrow wings usually with wide membranes that allow fast flights. Their feet are short with vibrissae on the first and fifth external borders of their toes and on their snout. They have ample and short ears that are projected to the sides. The tragus is very small, but the antitragus is very developed. The *Molossidae* family accounts as a principal tropical and subtropical fauna component and is represented almost all over America, starting in central United States through the southern Argentina, also in southeast Europe, and in tropical zone in Asia, Australia, and Africa.

Molossidae eat insects and capture their preys on flight. They could be solitary, but usually form big colonies of around more than million individuals, mostly in caves. There is evidence of the family from late Eocene. There are 85 species in 12 genera worldwide; 4 species of 3 genera are in Nuevo León, Mexico (Wilkins, 1986 [3]; Jiménez-Guzman *et al.,* 1999 [4]).

The *Tadaridsa brasiliensis* species, described by Geoffroy 1824, exhibits an intense brown color on their back. It has a total average longitude of 94 mm 43 mm from the forearm. Its medium weigh is 12 grams. The upper lip has furrows and vertical holding. Its ears are not linked in the medium line and have 3 incisors instead of 2 (Wilkins, 1986 [3]; Jiménez-Guzman *et al.,* 1999 [4]). The *Mexican T.b* subspecies, described by Saussure in 1860, ranges in the US from western Texas to California, and in Mexico to southern Chiapas.

The *Cueva de la Boca* has been reported (Villa & Cockrum, 1962 [5]; Jiménez-Guzman *et al.,* 1999 [4]; Moreno, 1996 [6]; Medellín, 2001 [7]) as a temporal or permanent home to six populations of bat species that we mention in a decreasing order of abundance according to our observations: *Tadarida brasiliensis, Mormoops megalophilla, Myotis velifer* (insect eater), *Mexican Choeronycteris* (pollinator), *Artibeus sp* (seed disperser), and *Pteronotus parnelli* (these last two are not collected by our group). The ecological importance of the cave has been recognized by the academic community and by Pronatura Noreste, that in partnership with the people of Santiago and thanks to the solidarity money from Bat

Conservation International Councilors, has acquired the property for its conservation and research and teaching activities (Connolly, 2006) [8].

3. The Environmental Service of Natural Plague Control

Regarding the eating habits of the *mexican Tadarida brasiliensis* population lives in *Cueva de la Boca*, our study results realized in 2004 and 2005 identify a total of 53 anthropodal taxonomic groups, classified in 40 families that are distributed in 12 orders. *Lepidoptera* and *Pentatomidae* are the most proportional represented groups, while *Lepidoptera, Pentatomidae* and *Cicadellidae* are the most represented in frequency.

Hernández (2005) shows the most enriched outcomes till now in this type of studies regarding representing groups in the analyzed samples [9]. This reflects the mosaic landscape around the cave and the diversity of the supply the colony possess for its feeding. **Figure 2** and **Figure 3** show summarized results of the investigation on the *Tadarida brasiliensis* eating habits living in *Cueva de la Boca*. Using these results as a benchmark, we referred to the official data bases on reported plagues for this region to identify the groups found on these bats diet that have considered plague representation in the interest area. Furthermore, we confirmed the information gathered by applying a survey to agricultural producers as described in the approximation of the economic value section. The gathered information allowed us to recognize what the producers consider as plagues, which of these could be controlled by bats, and what economic behavior is the most suitable when using agrochemical pesticides.

According to SAGARPA (National Ministry of Agriculture, Livestock, Rural Development, Fishing and Food), the main citrus crops plagues in Nuevo León are the fruit flies, the citrus leafminer, the red spider mite, the greasy stain, and the aphid. These plagues are controlled both by chemical and biological processes. Finding *Anastrepha ludens*, a fruit fly, was an unexpected result given that these flies have day habits, and the bats are nocturnal. Nonetheless, we found almost two complete analyzed samples of stomach fillings, which allowed its identification to a species level. Since the emergence of this species occurs approximately an hour before sundown, during this period, both populations coincide. Even though it is a temporary overlapping, the bats control role could mean so much more if their population recovers.

Other outstanding results included the findings of the *Delphacidae* (reported in the state for the first time), *Cicadellidae* (Chicharritas) and *Aphididae* (Pulgons) families. All of them are part of the *Homoptera* suborder which is widely recognized as microorganisms' carriers that affect a great variety of plants, including citrus. To a lesser extent, the stink bugs, part of the Pentatomidae family, one of the best represented groups in the bats eating habits, also affect citrus fruits visually, decreasing its market value and the *Formicidae* family, where is found the fire ant (*Solenopsis* sp.), which in extreme cases can cause the complete defoliation of the tree.

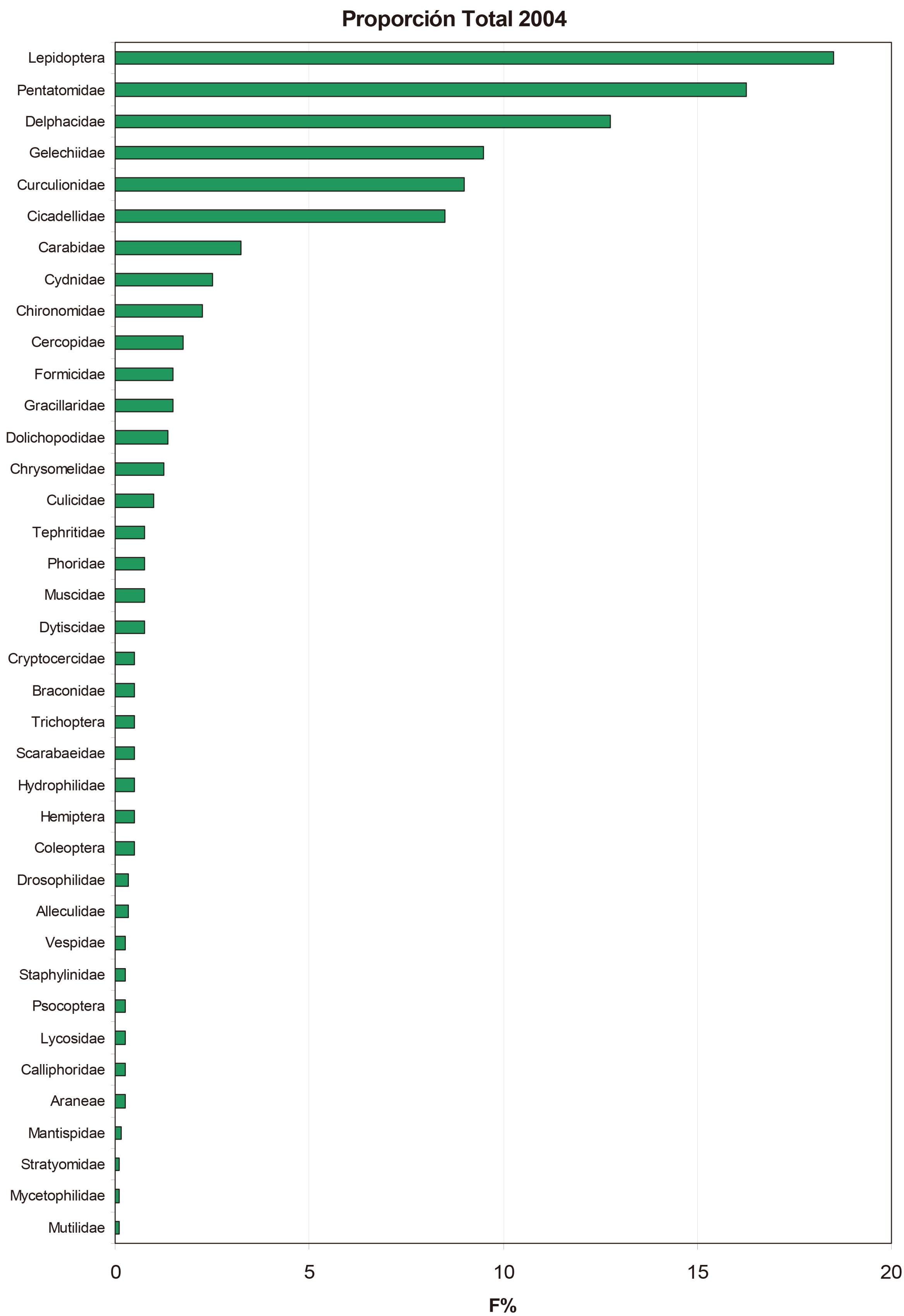

Figure 2. Proportion of each taxonomic group found in the samples analyzed during the 2004 season.

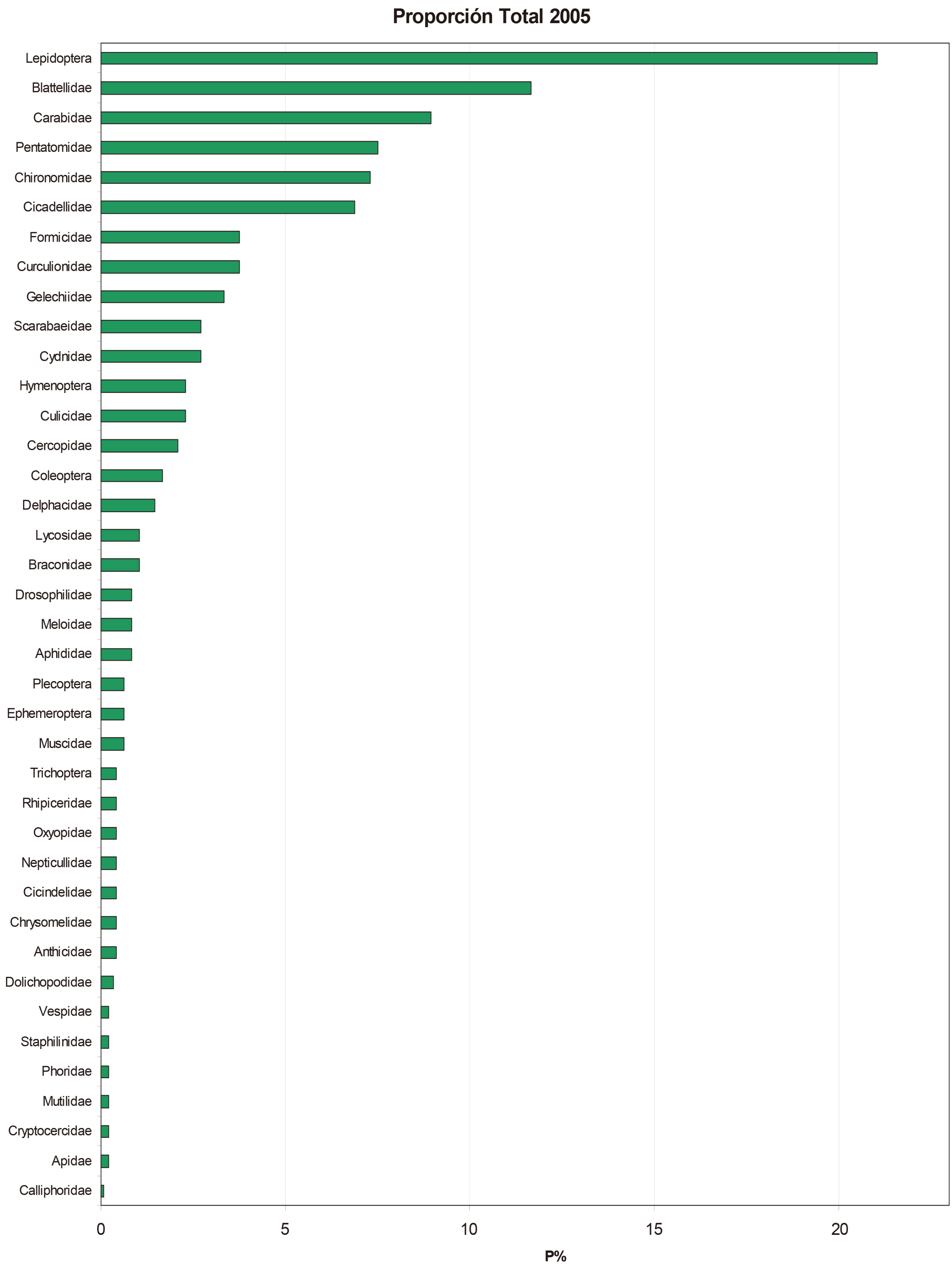

Figure 3. Proportion of each taxonomic group found in the samples analyzed during the 2005 season.

4. Economic Importance of Agriculture around Influence Area

According to the literature [6] (Moreno, 1996), the delimited area of action for this colony of bats covers a surface with a radius between 50 and 100 km. For purposes of this investigation is considered the radius of 100 km as shown in Figure 4. This is a more than a 3 million hectares surface and includes 44 total

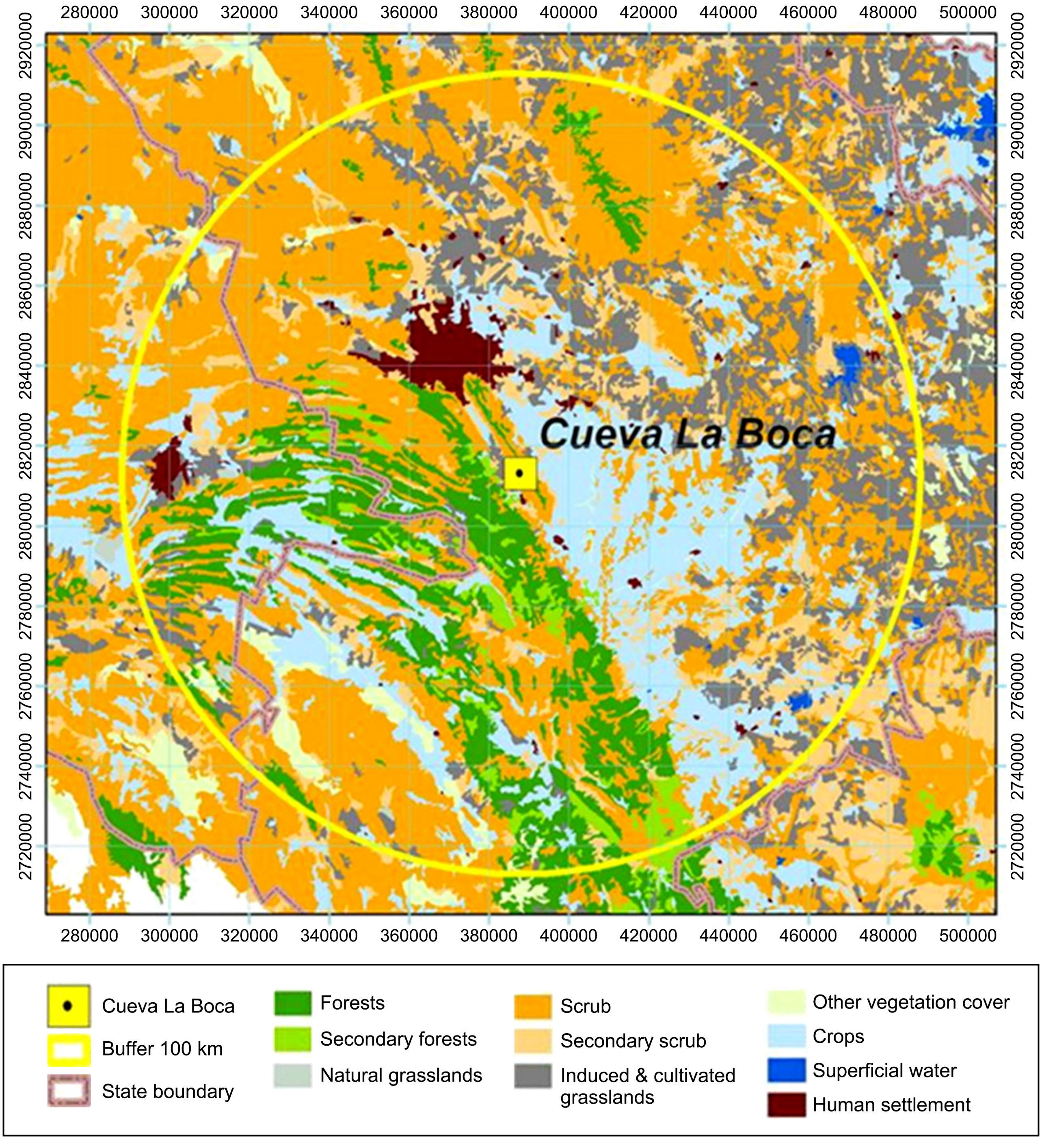

Figure 4. Ecosystems around influence area.

or partial municipalities in Nuevo León and 3 in Coahuila. According to the national forest inventory [10] (INE, 2000), 15% of this area corresponds to agricultural land, which would correspond to some 470,000 hectares.

As in the rest of the region, cattle represent another primary economic activity. **Figure 4** also shows that 18% of the surface corresponds to induced and cultivated grasslands in that influence area. This is particularly important because as it is concluded later, the diet bat evidence suggests that plagues affecting the cattle grass could be controlled by *Tadarida brasiliensis* species, which represents an opportunity to extend the economic valuation shown here.

As indicated by SAGARPA, the harvested area in the municipalities of the influence area covered an extension around 145,000 hectares in 2005, where the main crops corresponded to potato, citrus, tomato, sorghum, wheat, corn, walnuts, beans, and diverse vegetables. The total value of agricultural production amounted to almost 180 million dollars. As shown in **Table 1**, potato, citrus and sorghum crops stand out for their contribution to production value, while sorghum, citrus and corn crops stand out for their cultivated area.

Within the area of influence, sorghum is produced in Cadereyta Jiménez, Cerralvo, General Terán, Los Herrera, Linares, Montemorelos and Los Ramones. Citrus production occurs in Allende, Cadereyta Jiménez, General Terán, Hualahuises, Linares, Montemorelos, Los Ramones and Santiago. Potatoes are mainly concentrated in Galeana.

Table 1. Crops characteristics around influence area.

Crops	Production value ($usd)	Production value (%)	Harvested area (Ha)	Harvested area (%)
potatoes	88072837.2	49.1%	3030	2.1%
citric	29051745.0	16.2%	30,738	21.2%
sorghum	20018243.9	11.2%	62,307	43.1%
tomatoes	13591000.0	7.6%	761	0.5%
corn	5384778.5	3.0%	27,786	19.2%
walnuts	4243358.0	2.4%	3048	2.1%
wheat	32594074	1.8%	9854	6.8%
beans	28801875	1.6%	5744	4.0%
other	12703520.0	7.1%	1390	1.0%
total	179205077.4	100%	144,655	100%

Source: SAGARPA (2005) [11].

5. Economic Valuation

Once the main areas showing the food supply of the *Tadarida brasiliensis* colony of Cueva de la Boca have been identified, as well as the crops and natural vegetation related to insects whose populations are controlled by this and other species, we proceed to estimate of the economic value of this environmental service.

To economically value the environment means to obtain a monetary measure of the welfare changes that a person or group of persons experiment due to determined modifications in the environmental conditions. Environmental economy offers different alternatives to realize the economic valuation of the environmental services (Field & Field, 2020 [12]; Freeman *et al*., 2014 [13]; Garrod & Willis, 2000 [14]; Turner *et al*., 2003 [15]). Direct methods of environmental valuation include, for example, avoided costs, travel costs, and hedonic pricing. On the other hand, indirect valuation methods include contingent valuation and contingent ranking. Due to the nature of the environmental service studied here; We have decided to use the avoided cost method to make a first approximation to its economic value.

As said by Azqueta (1994), although a market for environmental goods does not exist, these could be related to goods that do [16]. In this investigation, we quantify the chemical compounds costs as well as its implementing costs incurred to control plagues. We transfer the service value the *Tadarida brasiliensis* gives as a partial substitute of this so-called chemical control.

According to what the farmers said (**Table 2**), there is an overlap between the time in which crops are generally affected and the months in which the colony of *Tadarida basiliensis* bats remains in Cueva de la Boca. In addition, many farmers reported seeing bats flying over their crops. This qualitative information allows us to support the quantitative evidence of the diet to confirm that the natural plague control service is effectively carried out by the bat's species studied.

Based on the information on the cultivated area in the influence area (**Table 2**) for each of the selected crops and with the data declared by the farmers in the survey on the effects of pests and their chemical control, the following weightings of the economic value represented by this type of control. In all cases we have considered exclusively the chemical compounds for the pests declared by the farmers and found in the bat's diet as shown in **Table 3**; considering in all cases as exclusive the compounds applied.

Thus, for sorghum cultivation, the estimate is based on a total of 29,907 hectares that are affected by the pests of the false meter, the screwworm, and the fall armyworm. These crops were chemically controlled with: Chlorpyrifos, Cypermethrin, Dexis and Magnum, according to the farmers interviewed. Based on the doses applied, their market prices and their average application cost of $22.7 dollars per hectare, there is a total cost of between $1.18 and $1.45 million dollars, which represents between 5.9% and 7.2% of the total value of sorghum production around influence area.

Table 2. Characteristics of the crops included in the farmers survey.

	Citrus	Sorghum	Corn	Walnuts	Wheat
Cultivated hectares	1142	611.5	350.5	62	1013.5
Harvested hectares	945.5	604.5	347	60	942.5
Hectares affected by plague (%)	837 (89%)	308 (51%)	161 (46%)	60 (100%)	7 (0.7%)
Hectares affected by pests and controlled (%)	806.5 (85%)	290 (48%)	74 (21%)	60 (100%)	0
Plague control type	86% Chemical 14% Biological	100% Chemical	100% Chemical	83% Chemical 17% Biological	
Plague severity: [1 less - 5 more]	1.9	1.2	2.3	0.7	
Most critical crops stages and seasons	flowering (feb-march) maturation (sep-nov)	germination (feb-july) flowering (april-oct)	germination, (feb-march, june-july) maturation (june-july, nov-jan)	flowering (march-april) maturation (aug-oct)	
Sighting of bats in cultivated areas (%)	59%	74%	65%	33%	45%
Interviewed farmers	27	31	20	3	20

Table 3. Plague control characteristics around influence area.

Chemical compound	Crop	Applied dose*	Controlled plague	Price**
Wettable sulfur	Citrus	[5.00 - 8.00]	moth, aphid, and fruit fly	0.54
Cypermethrin	Sorghum	[0.25 - 0.40]	false meter, screwworm, and the fall armyworm	16.5
	Corn	[0.25 - 0.40]	screwworm, corn earworm, and the fall armyworm	
	Walnut	[0.50 - 1.00]	aphid, screwworm, and web worm	
Chlorpyrifos	Citrus	2.5	moth, aphid, and fruit fly	14.4
	Sorghum	[0.75 - 1.50]	false meter, screwworm, and the fall armyworm	
Confide	Walnut	[0.75 - 1.00]	aphid, screwworm, and web worm	27.4
Dexis	Sorghum	[1.00 - 1.50]	false meter, screwworm, and the fall armyworm	44.7
Keltane	Citrus	[0.50 - 2.50]	moth, aphid, and fruit fly	23.5
Magnum	Sorghum	0.50	false meter, screwworm, and the fall armyworm	15.0
	Walnut	[1.00 - 1.50]	aphid, screwworm, and web worm	
	Citrus	[2.00 - 3.00]	moth, aphid, and fruit fly	
Malathion	Citrus	2.0	moth, aphid, and fruit fly	5.3
Punce	Corn	[10.0 - 12.0]	screwworm, corn earworm, and the fall armyworm	2.14
Tamaron	Corn	[1.00 - 1.50]	screwworm, corn earworm, and the fall armyworm	10.0

*Liters or kilograms per hectare; **Dollars per liter or kilogram, market price, do not include subsidies.

The cultivated area of corn that is affected by pests and chemically controlled is 5835 hectares. The farmers declared that their crops are attacked mainly by the screwworm, the corn worm, and the fall armyworm, which are chemically controlled with: Cypermethrin, Punce and Tamaron. Based on the doses applied, their market prices and their average application cost of $21.5 dollars per hectare, there is a total cost of between $0.19 and $0.21 million dollars, which represents between 3.6% and 4 % of the value of corn production.

In the case of walnut cultivation, the estimate of the cost of chemical pest control is based on a total of 2529 hectares affected by aphids, walnut and nut borer worms, and spider web worms. The walnut growers state that they use Cypermethrin, Confidor and Magnum to control these plagues. Based on the applied doses of these compounds, their market prices, and their average application cost of $35.0 dollars per hectare, there is a total cost of between $0.12 and $0.14 million dollars, which represents between 3% and 3.4% of the value of walnut production in the influence area.

Regarding citrus production, we have as reference an area of 22,469 hectares in the influence area that are affected by moth, aphid, and Mexican fruit fly plagues. According to the information declared by the farmers, these pests are chemically controlled through the application of wettable sulfur, Chlorpyrifos, Keltane, Magnum and Malathion. Based on the doses applied, their market prices and their average application cost of $25.0 dollars per hectare, there is a total cost of between $1.08 and $1.48 million dollars, which represents between 3.7% and 5.1% of the value of citrus production.

In summary, for sorghum, corn, citrus and walnut crops in the influence area, the cost of chemical control of the main plagues varies between $2.58 and $3.29 million dollars. In a partial substitution function, a proportion of this amount can be attributed to the economic value of the pest control service offered by the *Tadarida brasilensis* bats colony of Cueva de la Boca. Federico *et al.* (2005) have studied the function of substitution of the pest control service of this species in the cotton crop in the state of Texas through a simulation model [17]. The authors find that when bats are present in the system and chemical pest control is carried out, between one and two pesticide applications can be avoided, obtaining a 39% reduction in losses. While in a scenario where chemical control is not used, the benefits of the existence of bats are even greater with a loss reduction of 55%. Based on these studies, we estimate in this first approximation that with a degree of substitution of between 25% and 50% for sorghum, corn, walnuts and citrus, the economic value of the natural plague control service proposed here was in a range between $0.65 and $1.65 million dollars.

Based on the previous levels of substitution between these functions, we estimate that the benefit per hectare of the *Tadarida brasilensis* plague control environmental service is on average between $11.0 and $26.0 dollars per hectare per year for the crops analyzed here, being between $9.9 and $24.2 dollars per hectare per year for sorghum, between $8.3 and $18.6 for corn, between $12.4

and $28.6 for walnuts and between $12.0 and $32.9 for citrus.

It is essential to highlight that the estimate presented here is a first approximation to the value of this pest control environmental service. These are very conservative figures that are substantially below those obtained for the same species in the United States. Federico *et al.* (2004) estimate the benefits for pest control in traditional cotton cultivation at $83 dollars per hectare [18]. Cleveland *et al.* (2006) estimate the value of pest control for cotton production in a region of 8 counties in South Central Texas in a range between $121,000 and $1,725,000 dollars per year, for a production with a commercial value between 4.6 and 6.4 million dollars annually [19]. The estimate of the environmental service of natural control of plagues by *Tadarida brasiliensis* bats of Cueva de la Boca presented here, marks a lower limit for the valuation of this environmental service that can be complemented with the incorporation of other crops. Likewise, other services can also be attributed to this colony of bats, such as recreational and educational value, to name a few. In addition, more robust estimates can be obtained by expanding the sample of interviewed farmers.

In this sense, we observe that although potato cultivation contributes almost 50% to the value of agricultural production. Until now, the survey did not include this crop because it is orographically separated from Cueva de la Boca. However, the pests that affect potato crops in the influence area may be controlled by other bats from neighboring caves located in the Sierra Madre Oriental mountains range. As it is concluded later, including potato cultivation, as well as tomato and other vegetables in the economic valuation represents a future line for this research.

6. Conclusions

Survey responses reinforce observations that the bat population has declined in recent years, while the incidence of pests has increased. This, together with the previous literature and the results of this study, allows us to affirm that the ecological function of the bat *T. brasiliensis* when feeding on plague insects can reduce the need to apply chemical pesticides.

This ecological function of bats has an important economic value that we have approximated here by a partial substitution relationship through the avoided cost method. In this first approximation, we have estimated that the economic value of the natural plague control service for sorghum, corn, citrus and walnut crops offered by *T. brasiliensis* bats colony from Cueva de la Boca in the influence area varies between $0.65 and $1.65 million dollars.

The results presented in this study constitute a very conservative approximation that represents a basic indicator of the economic value of the ecological service of this specie, initially referring to four crops from a much broader universe. The estimate may be refined and increased by incorporating: 1) other crops of economic importance in the region, such as tomatoes, potatoes and vegetables; 2) the ecological service for the control of diseases transmitted by mosquitoes and flies, vectors of both human diseases and those of veterinary interest; 3) the human health costs avoided by the use of chemical pesticides; 4) the health costs avoided to the ecosystem for the same cause; 5) the economic benefit represented by the tourist attraction of the Cueva de la Boca; 6) plague control in cattle pastures; 7) the increase in the sample base for the study of the feeding habits of the bat colony.

In recent years, the bat population has been gradually recovering, due among other factors, to the protection of the Cave by ONG Pronatura Noreste with the collaboration of private businessmen, the Council for Tourism Development of Santiago, academic institutions such as Tecnológico de Monterrey, Instituto Tecnológico de Victoria, UANL, UNAM and others, Bat Conservation International and the local, regional, and national governments. In this sense, it is of great relevance to note that on March 07, 2022, the Cueva de la Bocawas declared by regional government of Nuevo León as a protected natural area with character of biological sanctuary. And that previously, in 2018, it was declared an important site for the bats conservation by the Latin American and Caribbean Network for the bats conservation (RELCOM).

Despite the above, there are still threats to the conservation of Cueva de la Boca such as the pressure of unsustainable tourism, stereotypes and clichés about bats, the lack of implementation of the Management Plan of the protected area, the extraction of materials for the construction industry, and the delay in the official declaration at the national level as a protected natural area in the sanctuary category that begins in 2006 and although the draft is reiterated by National Ministry of Environment in 2020 (SEMARNAT, 2020) [20], it is still a pending task among others.

To clearly understand the importance of bats conservation, it is still essential to make the population more explicit, direct, and effective aware of the benefits they provide to society as well as the implications that the loss of their populations would have, despite to the Covid-19, crisis in which the negative perception towards bats has been exacerbated.

The results of this study may be used as a conservation tool to support the protection of ecosystems around bat roosting sites, areas that at the same time provide other important ecological services such as: regulation of the hydrological cycle, climate and gases in the atmosphere regulation, habitat and refuge for wildlife, protection against disturbances, soil formation, erosion control, nutrient cycling, pollination, genetic resources, scenic beauty, recreation, and cultural values.

The contribution of this work lies in contributing to understanding ecological function of these bats as natural plague controllers and their economic value, which not only avoids the cost of $26.0 dollars per hectare per year, but also allows avoiding damage to health inherent to the application of pesticides. If the recovery of bat colonies is achieved and maintained, this can contribute to long-term social well-being and provide an extra economic income for the region due to the tourism attraction that their observation constitutes.

By protecting bats and their habitat, we will be able to protect the integrity and health of the ecosystem of which we are also a part.

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Conflicts of Interest

The authors declare no conflicts of interest.

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