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Ecology and Use of Iguanas *Ctenosaura pectinata* (Sauria: Iguanidae) in Two Rural Communities in Morelos, Mexico

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ABSTRACT

In this work the density, use of micro-habitat, hours of activity, body temperature and use of perches of *Ctenosaura pectinata* are evaluated in two rural communities of central Mexico; with territories within a protected natural area, and where this resource is traditionally consumed. The density of iguanas in the two communities was similar to that recorded in other sites in Mexico. Locally, the areas with the greatest number of individuals were the natural environments of conserved areas (82%), and rural urban areas (18%). The most commonly used micro-habitat were trees, rocks and house-room ceilings, with a marked preference for the use of trees (63.3%) and rocks (30.3%). The hours of activity (12:00-15:00 h) were different between the two communities. In open areas and with greater deforestation, the iguanas started and finished their activity one hour before those in better conserved areas. In conserved areas the iguanas reached average body temperatures of Tc=30.49°C (24.2-38.8 ± 4.03), which represents 2.84°C more ($F_{1,38}$=5.00, P=0.03) than those of areas with greater deforestation (Tc=27.65°C, 22.7-30.9 ± 2.84). Of the 16 species of trees that the iguanas frequented, three (*Phitocellobium dulce*, *Vitex mollis* and *Ficus insipida*) had the highest number of sightings. Although the villagers affirm that there are no commercial extractions, the highest intensity of capture occurs in the month of April, when the females have eggs in the oviducts. We suggest that planned selective harvests could facilitate the sustained use of this natural resource.

INTRODUCTION

Ctenosaura pectinata is one of the eight species of the genus *Ctenosaura* (*C. acanthura*, *C. clarki*, *C. conspicuosa*, *C. hemilopha*, *C. macrolopha*, *C. nolascensis*, *C. oaxacana*, and *C. pectinata*) endemic and in danger of extinction in Mexico [1]. Its distribution extends from Sinaloa in the northwest of Mexico to the Isthmus of Tehuantepec in regions of semi evergreen tropical forest and tropical deciduous forest [2,3]. Factors such as continuous exploitation, commercialization, habitat fragmentation and land use change continue to cause decline in wild populations without any control [4-6].

Spiny-tailed iguanas *Ctenosaura pectinata* like the rest of the iguanas of Latin America, for cultural reasons have been associated with human use throughout their areas of distribution. To date, they have become a source of protein and economic resources for the inhabitants of rural areas [7-9]. Traditional use, plus the continued reduction of forest cover, by

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widening of the agricultural and urban borders, have led to the gradual decline of populations and the progressive loss of this natural resource [10]. To contribute to the solution of this problem, in some regions such as Oaxaca and the Balsas River Basin in central Mexico, the establishment of rural farms has been promoted for their reproduction, of which, unfortunately, no success is known [11]. This is similar to that observed in Nicaragua, Costa Rica and Panama with *Iguana iguana* [12].

Although it is true that several authors have studied aspects of reproduction in wild populations; our knowledge about the development and composition of the diet in captivity conditions is still insufficient to reproduce them in farms and solve the problem of illegal extraction [3,13-16].

From previous works and personal observations, it is known that in the south of Morelos, Mexico, the populations of *Ctenosaura pectinata* are relatively common, where several rural communities use this resource [17,18]. Due to the above, and with the purpose of designing strategies in the near future for the conservation of *C. pectinata*, in which the users of the resource participate; this work provides information on the ecology of spiny-tailed iguanas in two sites of a protected natural area in the south of the state of Morelos, and an ethnobiological evaluation of the frequency and use of this species.

MATERIALS AND METHODS

Study Area

This work was developed in the locality of El Limón de Cuauchichinola (18° 31' 51.9" N, 98° 56' 15" W) and in the locality of Los Sauces (18° 34' 54.001" N, 98° 56' 48.9" W), where the main activity is agricultural production, and where there is also traditional use of iguanas. The two locations are organized as ejidos (ejido is a form of land tenure among several individuals who are called ejidatarios and they are who planning about the forms of use) with a high degree of social marginalization, and are part of the municipality of Tepalcingo Morelos, in the center of Mexico. The climate of the region is warm sub humid with an average annual temperature of 24°C and an annual rainfall of 943 mm; the local vegetation is of the tropical deciduous forest type [19].

Between October 2016 and September 2017, we made field trips lasting 4 days each month. The search for individuals was through random routes in each ejido, according to the method of encounter by visual inspection [20]. The sampling areas were classified into: (1) Natural areas (ravines, high and low parts of hills and plains areas), (2) Town's area (the area where the rural community is located) and (3) Areas of cultivation (all agricultural areas).

To avoid counting the same individual twice, the trajectories of the routes were separated from each other by a distance of 500 m. From each observed organism, the sex, type of micro-habitat (land, rocks, trees, etc.) where the observation was made, and the time of day were recorded.

The species of the trees where there were iguanas perching, were determined by means of photographic records with the help of a professional botanist and with the common names provided by the communal land's holders at the time of registration.

Additionally, records of the body temperature of the iguanas (Tc), micro-habitat temperature (Tm) and air temperature (Ta) were obtained with a laser thermometer (ZoteK GM320). The georeferencing of each iguana was recorded by means of a GPS (Garmin GPSMAP64s), and with the data, a map was developed in ArcMap 10.3 to estimate the density of individuals (number of individuals/units of area) in each ejido.

Evaluation of the Use of Iguanas

To estimate the number of iguanas extracted and the ways in which this resource was used among villagers, 40 interviews were conducted (20 in each ejido) with "iguaneros" (iguana hunters). To increase the certainty of the information and reduce the number of false answers due to distrust of the interviewer, the support from a local person with a good relationship between the inhabitants of the two communities was obtained; which facilitated the approach with the interviewees. Everyone knew that the consumption of iguanas is prohibited by law.

The information obtained was as follows: Do they extract iguanas for commercial purposes? Do they capture iguanas for self-consumption? Do the iguanas have healing properties? Do the iguanas cause damage to the crops? Do they consider the iguanas attractive for tourism? Are you interested in the establishment of a Management Unit for the Conservation of Wildlife (UMA) for conservation and exploitation purposes?

Statistical Analyses

The differences in the number of iguanas registered among the ejidos were estimated with Chi-square (χ^2). The same analysis was used to estimate differences in the use of the different types of micro-habitats, between the hours of the

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day and between the frequency of positive responses from the interviews. The differences in body temperature of the iguanas (Tc) between the locations were estimated with one-way analysis of variance (ANOVA). The effect of micro-habitat temperature (Tm) and air temperature (Ta) on body temperatures (Tc) of individuals was estimated with multiple linear regression analysis. The correlation of the three temperatures and the possible variation by effect of locality was estimated with analysis of covariance (ANCOVA). In all the analyzes, a significance level of $p \leq 0.05$ was used.

RESULTS

Density of Iguanas in the Ejidos

A total of 99 iguanas were recorded in 1,304.14 hectares sampled. The density calculated in the ejido El Limón de Cuauchichinola was 0.08 individuals/ha. and 0.06 ind./ha in Los Sauces. In El Limón de Cuauchichinola 67 iguanas were recorded (35 females, 30 males and 2 young) and 32 in Los Sauces (16 females, 14 males and 2 young) **(Figure 1)**.

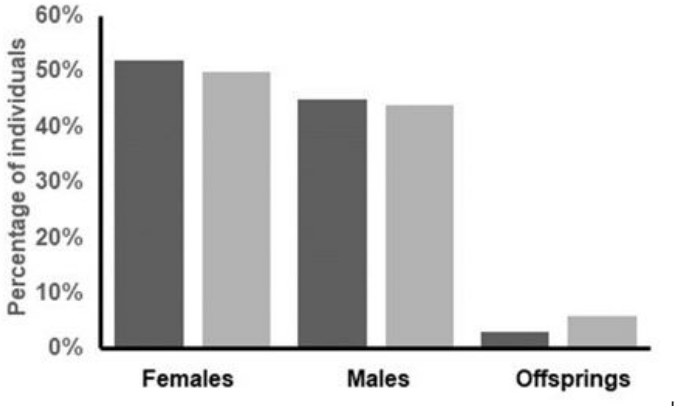

Figure 1. Percentage of individuals of *Ctenosaura pectinata* observed in the ejidos El Limón de Cuauchichinola (black bars) and Los Sauces (gray bars).

The statistical analysis showed no significant differences in the number of iguanas observed among the ejidos (χ^2=0.476, P=5.99). The largest number of individuals were observed in the natural areas (83.0%) of each ejido (Limón de Cuauchichinola 54 individuals, Los Sauces 27 individuals). During the dry season, iguanas were observed more frequently in ravines and near bodies of water such as dams and small streams.

In the rainy season, the frequency of sightings was reduced due to the abundance of foliage, tall grasses and relatively low temperatures. The smallest number of individuals was registered within the area of the town (17.0%), with frequent human activity (El Limón de Cuauchichinola 13 individuals- Los Sauces 5 individuals); mainly on tecorrales (dividing fences between the properties built with rocks laid upon other rocks), trees and roofs of houses **(Figure 2)**.

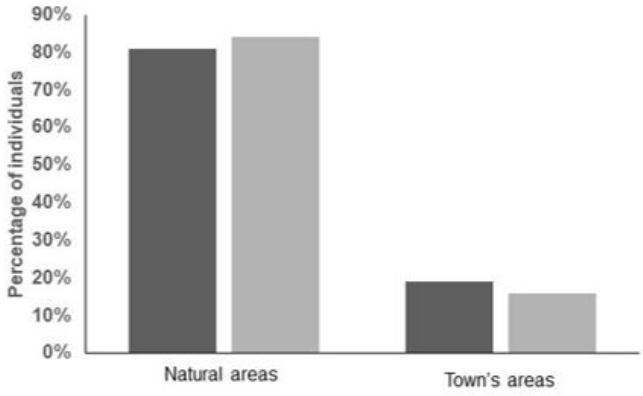

Figure 2. Porcentage of individuals of *Ctenosaura pectinata* observed in natural areas and village area within the ejidos El Limón de Cuachichinola (black bars) and Los Sauces (barras gris).

In farming areas there were no records. The Chi-square test did not show significant differences in the sighting of iguanas between the sampling zones (χ^2=0.20, P=7.81).

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Use of Microhabitat

In both ejidos, the most commonly used microhabitats were trees (63.6%) and rocks (30.4%), and less frequently house roofs (TCH) (**Figures 3 and 4**). Chi-square analysis revealed significant differences in the use of micro-habitat (χ^2=15.11, P=7.81).

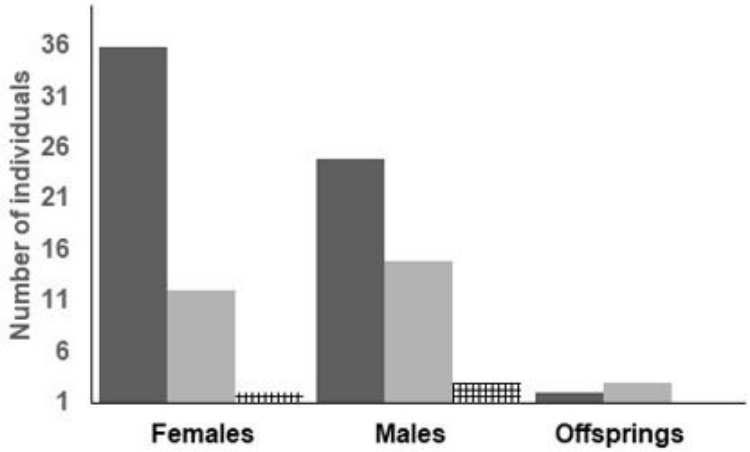

Figure 3. Number of individuals and type of microhabitat used by *Ctenosaura pectinata* in an environment of tropical deciduous forest south of Morelos. Black bars trees, gray bars rocks, bars with grid Roofs of houses.

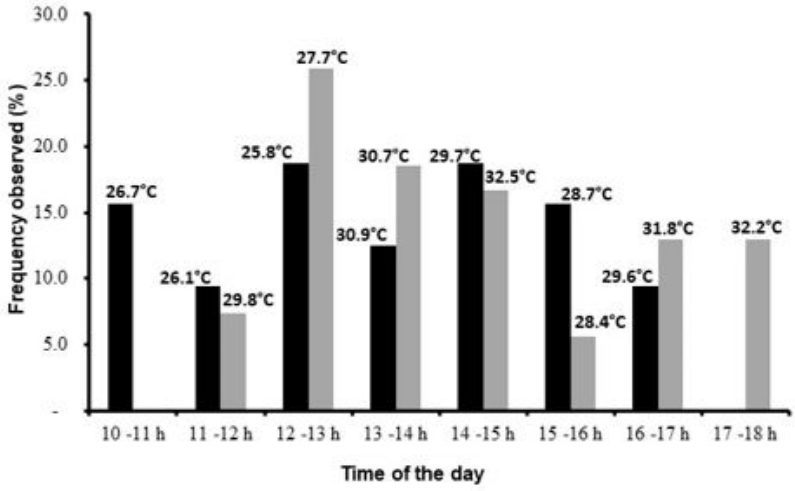

Figure 4. Frequency of iguanas *C. pectinata* observed throughout the day. The Chi-square test showed significant differences between the hours (χ^2=16.03, P=0.05, gl=7). Black bars ejido los Sauces, bars gray ejido El Limón de Cuachichinola, Morelos, Mexico. The numbers on the bars are the average body temperature of iguanas.

Daily Activity Cycle

The hours of activity of the iguanas were different (χ^2=16.03, P=0.05) between the locations. In Los Sauces ejidos, the iguanas began and ended their activity one hour earlier than those observed in El Limón de Cuauchichinola. The time interval in which the largest number of records was made in the day was between 12:00 and 15:00 h (**Figure 4**).

Body Temperature and Use of Perches

With regard to temperatures, significant differences in body temperature between locations also occur ($F_{1,38}$=5.00, P=0.031) shown in **Table 1**. The iguanas observed in El Limón de Cuauchichinola had average temperatures of Tc=30.12° C (24.2-38.8 ± 4.03), which represents 2.47°C above the average of the iguanas of Los Sauces (Tc=27.65°C, 22.7-30.9 ± 2.84). The multiple linear regression analysis showed that only the microhabitat temperature (Tm) has a significant effect on body temperature (Tc) (r=0.442, R^2=0.385, $F_{2,37}$=11.60, P=0.000); this was confirmed by the ANCOVA, which

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showed significant differences in the temperature of the microhabitat ($F_{1,36}$=7.214, p=0.0108) between localities. This indicates that the warmest microhabitat occurs in El Limón de Cuauchichinola **(Table 1)**.

Table 1. Body temperature of the iguanas observed in the ejidos El Limón de Cuauchichinola and Los Sauces in environment of tropical deciduous forest in central Mexico. S.D. Standard deviation.

Variables	Los Sauces Mean (Min-Max) ± S.D.	El Limón de Cuauchichinola Mean (Min-Max) ± S.D.	Statistical test
Body temperature of the iguanas (Tc,°C)	27.65* (22.7-30.9) ± 2.84	30.49* (24.2-38.8) ± 4.03	Significant differences $F_{1,38}$=5.0075, p=0.0312.
Air temperature (Ta,°C)	30.64 (23.5-40.2) ± 5.25	32.7 (25.6-47.1) ± 3.63	-
Microhabitat temperature (Tm,°C)	31.59* (18.7-52.1) ± 7.85	33.52* (24.8-47.8) ± 5.62	Significant differences $F_{1,38}$=3.9922, P=0.0529.
Altitude (msnm)	1282.1 (1,211.0-1,332.0) ± 35.95	1233.5 (1,170.0-1,422.0) ± 42.94	-

Although it is true that *C. pectinata* uses different species of trees in the tropical deciduous forest as perches, the use of 10 species was determined on the field trips. The trees with the highest number of individuals observed were the huamuchil (*Phitocellobium dulce*) with 29.03%, the white amate (*Ficus petiolaris*) with 20.96% and the coayotomate (*Vitex mollis*) with 20.96% **(Table 2)**.

Table 2. Species of trees from the tropical deciduous forest in southern Morelos, where individuals of *Ctenosaura pectinata* were observed.

Local common name	Scientific name	Percentage of observed iguanas
Amate amarillo	*Ficus insipida*	8.06%
Amate blanco	*Ficus petiolaris*	20.96%
Ayoyote	*Cascabela thevetioides*	4.83%
Azuchil	*Astianthus viminalis*	3.22%
Bonete	*Jacaratia mexicana*	1.61%
Cazahuate	*Ipomea pauciflora*	3.22%
Coayotomate	*Vitex mollis*	20.96%
Cuahulote	*Guazuma ulmifolia*	1.61%
Huamuchil	*Phitocellobium dulce*	29.03%
Tlaligo	*Ficus cotinifolia*	6.45%

Traditional Use of Iguanas

The residents of both ejidos know that iguanas are protected, and they are a threatened species of extinction. Additionally, 100.0% of those interviewed acknowledged not extracting individuals from the natural environment for commercial purposes. However, 62.0% declared capturing iguanas for self-consumption, especially in the dry season when the females contain eggs in the oviducts. According to the results of the interviews, it is estimated that about 62 adult specimens are extracted annually in Los Sauces ejido, and 50 individuals in the ejido El Limón de Cuauchichinola, mostly females, only for food and medicinal purposes. A relatively high percentage, of the order of 80.0% in the ejido El Limón de Cuauchichinola, and 55.0% in Los Sauces, consider that they have healing properties. The statistical analysis showed no difference in the frequencies and use of iguanas between the two locations (χ^2=14.17, P=0.05) shown in **Table 3**. On the other hand, due to the continuous interaction that the inhabitants of both ejidos have with the species, 95.0% affirm that they do not cause damage to the crops, and 100% consider that large colonies could be a tourist

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attraction for foreign visitors. Finally, the inhabitants of the two localities showed interest in the establishment of iguana farms (UMA) focused on captive breeding.

Table 3. Traditional use of iguanas by the local inhabitants of the two ejidos in southern Morelos.

Questions about the use of iguanas	Ejido los Sauces %		Ejido el Limón de Cuauchichinola %	
	Yes	No	Yes	No
Iguanas cause damage to crops?	10.0	90.0	0.0	100.0
They have healing properties?	55.0	45.0	80.0	20.0
They are captured for self-consumption?	65.0	35.0	65.0	35.0
They make extraction for commercial purposes?	0.0	100.0	0.0	100.0
They are attractive for tourism?	100.0	0.0	100.0	0.0
They are interested in establishing an UMA*?	95.0	5.0	100.0	0.0
*UMA Management Unit for the Conservation of Wildlife.				

DISCUSSION AND CONCLUSIONS

Historically, spiny-tailed iguanas have been used as food in several regions of Mexico and Central America and have now become a commercial option in semi-urban and rural areas [7,18]. The interest in their use is so high, that today they are part of conservation-oriented regulations, due to the gradual reduction of their populations.

The density of iguanas observed was greater in the ejido El Limon of Cuauchichinola (0.08 individuals/ha., 8.55 iguanas per km^2) and lower in the ejido Los Sauces (0.06 individuals/ha., 6.09 iguanas per km^2) without significant differences. Although this number of individuals is relatively low, it is very similar to that observed in areas of sub-deciduous tropical forest, tropical deciduous forest and secondary vegetation in Oaxaca (0.06 individuals/ha.) [9]. By contrast, densities of 17.9 to 101.7 iguanas/km^2 have been reported in subtropical deciduous forest environments in Nopala, Oaxaca, and 1.01 individuals/ha., in areas of tropical deciduous forest, 2.9 individuals/ha., tropical subdeciduos forest and 12.3 individuals/ha. in mixed forest in Michoacбn [3,21]. This variation in the number of individuals observed in different locations can be an indicator of the intensity of predation to which the iguanas are exposed. Apparently, more predation occurs in areas with small human populations and a high degree of marginalization, where they are captured for self-consumption; unlike what happens in relatively large human populations where there is greater diversification of productive activities. For now, there is not enough data to support this hypothesis, but it is an issue that should be addressed in the future through ethnobiological studies in several geographic regions.

Another factor that may also be producing variation in the density of individuals between locations is the change in land use at the sites. While it is true that the two ejidos in the study area have several cultivation areas, the town of Los Sauces is more deforested and is outside the boundaries of the Protected Natural Area (ANP). Habitat fragmentation change in land use and the continuous extraction of wildlife are factors that severely damage populations [4,5].

In the two ejidos of the study area, a greater abundance was observed of adult and sub-adult females (52%), followed by adult and sub-adult males (44%) and finally offsprings (4%). This sex ratio and the age of the individuals suggests that the populations of *C. pectinata* in the two communities are in the same state of conservation. This indicates in theory that there is the possibility of increasing the local populations of iguanas, taking into account that the reproductive females (51 observed) can produce an average of 31 eggs (12.0-52.0 ± 11.6) [14].

In the face of the continuous extraction of individuals; an intense program of information and environmental education on iguanas, together with a selective capture program aimed at adult males, instead of females, could well help to recover populations in the medium term.

The use of microhabitat has been evaluated by several previous works [18,21,22]. In most cases, iguanas have been observed more frequently on land, rocks and trunks; in environments of tropical deciduous forest and secondary vegetation [9]. In this work *C. pectinata* was observed more frequently on trees, rocks and house-room ceilings. This indicates that this species has the ability to adapt to different environmental conditions. Variations of this type in the use of microhabitat have been attributed to the proximity and availability of necessary resources such as food, water, space, shelter and sites for thermoregulation [3]. We suggest that in the studied population, the ability to use different microhabitats arises as a response to changes in natural habitats, rather than a search for available resources.

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The differences observed between the hours of activity and the body temperature of the iguanas between the two ejidos can be explained by the effect of deforestation. We suggest that in the most deforested area of Los Sauces, iguanas are more susceptible to a higher intensity of capture, as was evaluated through the interviews. In this order of ideas, the iguanas to avoid predation, reduce their hours of activity and the time spent for thermoregulation. The coverage of the vegetation, the heterogeneity of the habitats, the intensity of predation; and its effects on thermoregulation skills have been previously observed in *C. hemilopha* and *C. oaxacana* [23,24].

The frequent sighting of iguanas on three tree species in the two ejidos can be explained because these trees bloom and produce fruit between July and September; and they can also serve as food (Table 2) [25,26]. We do not have information about the diet of the iguanas observed; however, fruits and leaves of *Phytocellobium dulce*, *P. albicans*, *Phaseolus vulgaris*, *Ipomea sp.*, and *Ficus sp.*, have been reported as food of *C. pectinata* [3].

To reduce the pressure on wild populations of iguanas, the establishment of farms has been implemented with few successful results [27]. The offsprings of *C. pectinata*, unlike *I. iguana*, feed on insects and only eat plant matter when they reach the adult stage, in this way the ontogenetic change in feeding habits makes the cultivation of iguanas difficult [14,28]. As a result, we suggest that the most appropriate option is to promote the growth of individuals under natural conditions, under the figure of extensive UMA in "patios", as has been suggested for *C. similis* and where local users participate, who are ultimately the ones who can help to conserve this resource [29].

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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