

Edible insects harvest in Pinos, Zacatecas, Mexico

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ABSTRACT

Objective: To identify the exploitation and generation of economic income derived from the harvest of escamol (*Liometopum apiculatum* Mayr), white worm (*Aegiale hesperiaris* W) and red worm (*Comadia redtenbacheri* H), during an annual season.

Design/Methodology: Surveys were applied to n=116 edible insect harvesters in n=18 rural communities, local authorities (*ejido* commissaries, auxiliary judges), buyers (intermediaries), and representatives of the stockpiling company DELIZAC. The interviews were conducted in harvesting zones (field), at the time of the delivery of the product (stockpiling), and in the homes of harvesters selected as sample in Pinos, Zacatecas, Mexico.

Results: The prices per kilogram of *escamol* and white worm, during the 2020 seasons, was US\$15.00, and for the red worm, US\$25.00. The harvest of edible insects was 34.6 tons with an economic spill of US\$572,800.00 showing a *per capita* average income of US\$965.90.

Study Limitations/Implications: The results of this study can be used to propose techniques that favor the conservation, management, and sustainable exploitation of the three species of edible insects for inhabitants of the rural zones in central-northern Mexico.

Conclusions: The harvest of edible insects in Pinos, Zacatecas, generates important economic income. Of the harvesters, 78.9% were men, 13.7% adult women, and 7.4% children. Most of the harvesting localities lack permits to carry out the exploitation.

Keywords: ecosystem, escamoles, white worm, red worm, edible insects, harvesters.

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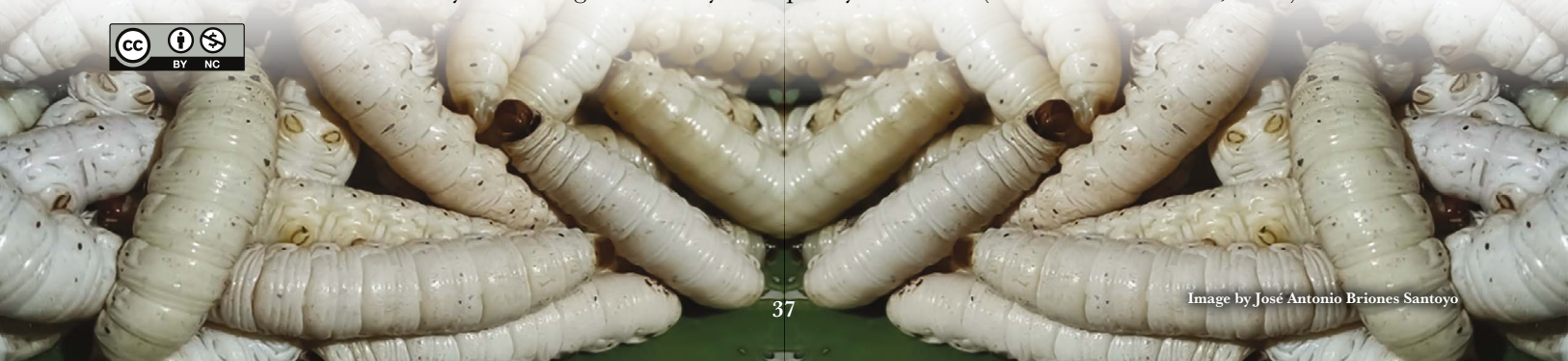
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INTRODUCTION

The arid and semi-arid zones in Mexico have very valuable resources which, if managed correctly, can generate economic benefits in the short, medium and long term. Edible insects such as the red worm, the pink maguery worm or *chinicuil* (*Comadia redtenbacheri* H), and the white worm from the maguery (*Aegiale hesperiaris* W), as well as the escamolera ant (*Liometopum apiculatum*), are important components of these regions. The ants can modify the environmental conditions to create appropriate microhabitats (Whitford *et al.*, 2008), by increasing the fertility and quality of the soil (Amador and Gorres, 2007).



In Mexico, the *escamolera* ant is used in the states of Michoacán, Colima, Chihuahua, Durango, Hidalgo, Querétaro and Distrito Federal (Del Toro *et al.*, 2009). Presently, harvesting also takes place in San Luis Potosí, Jalisco, Coahuila, Nuevo León and Zacatecas. In the state of Zacatecas, the exploitation of edible insects began since the 1980s. Immigrants arrived to these lands from the state of Hidalgo, they trained local inhabitants as harvesters and offered very attractive prices for *escamol*, white worm and red worm from maguey. In the municipality of Pinos, Zacatecas, Mexico, the *escamolera* ant, and also the white worm and red worm from maguey, are used since approximately 35 years. These species, although in lesser amount, are also harvested in the municipalities of Villa Hidalgo, Villa González, Noria de Ángeles and General Pánfilo Natera in the state of Zacatecas.

Escamoles are larvae and pupae from the reproductive caste of the ant *Liometopum apiculatum* Mayr. This species builds its nests in the soil or in the root system of some plants such as maguey (*Agave salmiana*), nopal (*Opuntia* spp.) and palm (*Yucca* spp.), species characteristic of the rosette-like desert shrub. Authors such as Cruz-Labana *et al.* (2018) mention that the content of macronutrients contributed by the *escamolera* ant larvae varies significantly, although not for the contents of micronutrients. Other authors, such as Rafael-Valdez *et al.* (2017) stated that the presence and foraging activity of the *escamolera* ant depend on the climate (temperature and relative moisture), vegetation, soil and its cover, anthropogenic disturbances and level of association of the ant species with some plants. Cruz-Labana *et al.* (2014) mention that the presence of the *escamolera* ant is related to some characteristics of the agaves. This relationship was corroborated by Cruz-Labana (2019) who found that the density of nests varies per type of vegetation and state of conservation.

In recent years, the municipality of Pinos, Zacatecas, has stood out due to a very important harvest of edible insects and economic income for the inhabitants of the rural zones. In this municipality, the harvest of edible insects is the only productive activity that some of the rural families practice. Therefore, the conservation, good management, development and maintenance of the habitats and colonies of edible insects are fundamental. However, currently, the native edible insects are extracted in a manner of low sustainability (De Luna-Valadez *et al.*, 2013), and the inadequate management of the land and recurring droughts have resulted in fragmentation and loss of habitat for these species.

The *escamolera* ant in the semi-arid ecosystems of the center-north of Mexico has suffered excessive extraction (Ramos Elorduy *et al.*, 2006; Ambrosio-Arzate *et al.*, 2010; Dinwiddie *et al.*, 2013) and is intensified from the lack of research directed at management and conservation (Tarango-Arámbula, 2012), primarily due to the scarce knowledge of the ecologic function of the ant and the absence of legal environmental guidelines (Ramos-Elorduy *et al.*, 2006). The *escamolera* ant, compared to the other two species of edible insects, has been studied more, highlighting aspects of foraging substrates and foraging activity (Rafael-Valdez *et al.*, 2017).

The white worm from maguey (*Aegiale hesperiaris*) is the larvae of a leaping butterfly (Hesperiidae), which develops in the leaves and roots of maguey. The white worm is abundant in the states of Hidalgo, Estado de México, Tlaxcala and Puebla (Quintero-

Salazar and Ramos-Rostro, 2018). Presently, it is used commercially in Zacatecas and San Luis Potosí, Mexico. The red, pink worm from maguery or *chinicuil* (*Comadia redtenbacheri* H), agave borer, is extracted primarily from the root system of this plant (Quintero-Salazar and Ramos-Rostro, 2018). The red worm is harvested in the states of Estado de México, Hidalgo, Puebla, Tlaxcala, Querétaro, San Luis Potosí, Jalisco, Oaxaca, Chiapas and Distrito Federal (Llanderal-Cázares *et al.*, 2010), and in recent years their exploitation has also been intensified in the states of Zacatecas, Coahuila, Nuevo León and Jalisco.

It is important to mention that although in Mexico there are different studies about the use of edible insects (Cruz-Labana, 2019, Figueroa-Sandoval *et al.*, 2018, Tarango-Arámbula, 2012; Esparza-Frausto *et al.*, 2008; Ramos Elorduy *et al.*, 2007), very few are related to the harvest and economic aspects of the three species in north central Mexico, where the economic spill has a negative impact in the conservation of these natural resources. Therefore, the objective of this study was to understand the exploitation of edible insects, their harvest and the generation of economic income from harvesting, during the 2020 seasons in Pinos, Zacatecas, Mexico. It is considered that the information from this study will serve as a basis to design conservation and non-extractive strategies that favor the permanence of the insects and of the inhabitants of rural zones.

MATERIALS AND METHODS

The study was carried out in the municipality of Pinos, Zacatecas, Mexico (22.237340 N, -101.544734 W), between February and October 2020. From the 3,135.80 km² of territorial area (4.45% of the state surface; COEPLA, 2020), only 14% of the surface is apt for agriculture, 79% for livestock production, and 7% for timber-yielding and non-timber-yielding forests (González-Ávila, 2011). This municipality includes 301 localities and a population of 72 241 inhabitants, the climate is dry (annual mean temperature of 16 °C), an average rainfall of 510 mm, and its geological constitution includes igneous and sedimentary rocks from the Quaternary, Neogene or Cretaceous and soils called Durisols, Regosol and Leptosol (González-Ávila, 2011; INAFED, 2020).

In this study surveys were applied with harvesters of diverse communities (Figure 1), with ejido commissaries, auxiliary judges, buyers (intermediaries) and representatives of the company DELIZAC. The interview respondents were selected randomly, that is, during visits to the communities in company of the local authority to interview people. In other localities, the interviews were conducted in the afternoon or at night in the homes of the people selected (Table 1). The communities and the number of survey respondents varied in function of the availability of time and people's willingness to cooperate.

The response variables of the study consisted in identifying via the harvesters the species of edible insect exploited, the volume (kg), the economic income generated; percentage of men, women and infants who participate in the activity, the income of intermediaries, the levels of economic profit, and description of expenditures.

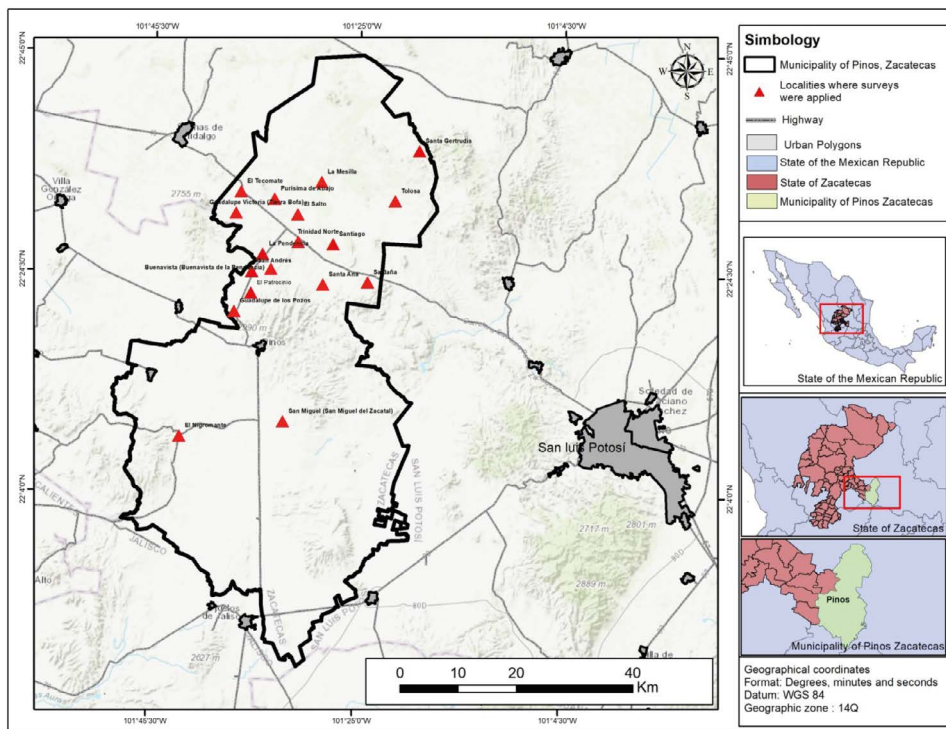


Figure 1. Location of the communities of edible insect harvesters intervened in Pinos, Zacatecas, Mexico (prepared by the authors).

Table 1. Edible insect harvesters surveyed (n=116) in the municipality of Pinos, Zacatecas, Mexico.

Locality	Sample (n)
Santiago	15
Santa Gertrudis	5
La Pendencia	5
San Andrés	10
Buenavista	3
El Patrocinio	4
Guadalupe de los Pozos	10
Saldaña	5
La Trinidad	6
Tolosa	8
Santa Ana	5
El Salto	5
La Purísima de Abajo	4
La Mesilla	5
El Tecomate	6
Guadalupe Victoria	10
El Nigromante	5
San Miguel	5
Total	116

RESULTS AND DISCUSSION

Description of survey respondents

The surveys within the sample identified harvesters ($n=105$), *ejido* representatives ($n=8$), and intermediaries ($n=3$). Some prior studies in Pinos, Zacatecas, by De Luna Valadez *et al.* (2013) showed that 95.1% of the harvesters were men whose age ranged between 14 and 63 years old, and 72% of them perform the harvest individually. An outstanding aspect of the information generated by De Luna Valadez *et al.* (2013) is that only 25% of the harvesters were *ejidatarios* or children of *ejidatarios*, 30% were settlers, and 45% came from neighboring *ejidos*.

The settler harvesters and from neighboring *ejidos* constitute a risk for the habitats and colonies of these insects, since according to the *ejido* leaders, these harvesters take harvesting to high levels of extraction.

In the 18 communities intervened in Pinos, Zacatecas, there are 593 harvesters, of which 468 are men (78.9%), 81 women (13.6%) and 44 children (7.5%) (Table 2). The insect harvesters are devoted to this activity for eight months (February-September) and during the four other months (October-February) they work in the construction tasks in the neighboring cities of San Luis Potosí, Zacatecas, Aguascalientes and Guanajuato, Mexico.

Insects represent an alternative for the human diet, and their important nutritional content stands out (Cruz-Labana *et al.*, 2018), as well as their presence and easy harvest. Entomophagy takes place in developed countries as an exotic culinary alternative and in

Table 2. Edible insect harvesters per locality in the municipality of Pinos, Zacatecas, Mexico.

Number	Locality	Harvesters (n)			Total
		Men	Women	Minors	
1	Santiago	50	5	5	60
2	Santa Gertrudis	33	6	3	42
3	La Pendencia	15	0	2	17
4	San Andrés	55	10	5	70
5	Buenavista	6	0	2	8
6	El Patrocinio	10	2	2	14
7	Guadalupe de los pozos (Ejido Pinos)	27	3	3	33
8	Saldaña	20	2	0	22
9	La trinidad	25	0	0	25
10	Tolosa	55	10	2	67
11	Santa Ana	10	3	0	13
12	El salto	8	5	3	16
13	La Purísima de Abajo	10	2	1	13
14	La mesilla	11	3	2	16
15	El tecomate	25	10	4	39
16	Guadalupe Victoria	40	20	10	70
17	El Nigromante	43	0	0	43
18	San Miguel	25	0	0	25
	Total	468	81	44	593

developing countries as a survival food, as is the case of inhabitants in arid and semi-arid zones of Mexico (Tarango-Arámbula and Méndez-Gallegos, 2018).

In this study, it was found that very few harvesters include insects in their diet ($\leq 10\%$). The main reason is that their consumption represents a luxury and that, if they do, they would not have money to purchase foods from the basic basket (egg, bean, tortillas for their family). For example, if a rural family decides to include insects as part of their diet and consume a kilogram of *escamol* per month, it would represent not obtaining 250 pesos (price of one kilogram of *escamol*), which is equivalent to going without the purchase of 10.4 kg of bean, 19.2 liters of milk or 7.8 kg of egg (Tarango-Arámbula and Méndez-Gallegos, 2018). This situation worsens when insect prices are elevated such as *escamol*, which during the 2022 harvest season had a price per kilogram that fluctuated between US\$25.00 and US\$35.00. Although some people who are not harvesters in the season buy for *in situ* consumption, it is not representative compared to what happens directly with intermediaries, and in no cases are insects an essential part of their daily diet (Tarango-Arámbula and Méndez-Gallegos, 2018).

The white and red worms constitute other dietary and economic income options. The red worm shows between 28 and 81% of protein, and represents a complementary family income through its harvest and sale (Esparza-Frausto *et al.*, 2008); this worm is easy to use and can be conserved dry. The red worm is currently appreciated as food by national and foreign consumers (Hogue, 1993). To stockpile, conserve and distribute the edible insects that are harvested in the study zone, there are stockpiling centers of various sizes and capacities; however, in the community called “El Coyote”, from *ejido* Santiago, there is one of the main centers for stockpiling. This center operates since more than 25 years ago and its main function is to stockpile and distribute these products to the states of Tlaxcala, Hidalgo, Estado de México and Mexico City. In this community, there is also a society led by women called DELIZAC, which is part of the stockpiling center, and in recent years they have learned to prepare dishes based on insects that are exposed in regional events and fairs.

Edible insect harvest

In this study, it was determined that during the 2020 seasons, the harvest of edible insects in the municipality of Pinos, Zacatecas, was 34.6 t. From this, 50.4% corresponded to *escamoles* and 34.1 and 15.5% to white and red worms, respectively. The three communities with highest harvest were from Tolosa (3.85 t), Guadalupe de los Pozos (3.45 t), and Santiago (3.4 t) (Table 3).

Price and profit in the sale of edible insects

The price per kilogram of species of edible insect is established by the buyer (intermediary) at the beginning of the harvest season and varies with the year and community. During the 2020 harvesting seasons, the prices for *escamol* and white worm per kilogram were US\$ 15.00, and for red worm US\$ 25.00 (Table 4). The main profits are obtained by buyers and restaurant owners in Mexico City, Puebla and Hidalgo, and range with margins between 100% and 333.3% (Table 4). Apparently, the price that is

Table 3. Edible insect harvest (2020 seasons) per locality in Pinos, Zacatecas, Mexico.

Locality	Harvest (Tons)			Total
	Escamol	White worm	Red worm	
Santiago	1.25	1.50	0.65	3.40
Santa Gertrudis	1.10	0.85	0.25	2.20
La Pendencia	0.95	0.65	0.20	1.80
San Andrés	1.30	0.90	0.40	2.60
Buenavista	0.30	0.12	0.50	0.47
El Patrocinio	0.35	0.15	0.80	0.58
Guadalupe de los pozos*	1.80	1.00	0.65	3.45
Saldaña	0.85	0.85	0.35	2.05
La trinidad	0.75	0.70	0.30	1.75
Tolosa	1.60	1.50	0.75	3.85
Santa Ana	0.70	0.45	0.20	1.35
El salto	0.60	0.40	0.15	1.15
La Purísima de Abajo	0.50	0.35	0.10	0.95
La mesilla	0.65	0.55	0.12	1.32
El tecomate	1.30	0.80	0.35	2.45
Guadalupe victoria	1.40	1.05	0.75	3.20
El Nigromante	1.20	---	---	1.20
San Miguel	0.85	---	---	0.85
Total	17.45	11.82	5.35	34.62

*Ejido Pinos.

paid to the harvester is high; however, he and his family invest a long time in the field and at home to wash and clean the product.

The expenditures that the buyer (intermediary) distributes in the harvesting and sales processes include: a) Payment for the right to harvest (renting lands for the harvest), b) Expenses for transport for the sale and stockpiling of the product in the localities, c) Expenses for electric energy in the stockpiling center, d) Expenses for transport to the final sales place, and e) Payment for workforce in the activities of cleaning and separating

Table 4. Price and profit per kilogram of edible insects from the harvester to the final consumer.

Type of insect	(US\$ Dollar*)				
	Purchase price to the collector	Selling price by stockpiler	Stockpiler profit**	Retail price to the consumer	Restaurant owner profit***
Escamol	15	30	100	100	333.3
White worm	15	30	100	100	333.3
Red worm	25	60	240	150	250.0-

* US\$1.00=\$20.00 (Mexican pesos).

** In this percentage of profit the expenses involved in the process of harvesting and sale are not deducted.

*** This percentage of profit does not consider the costs for dish preparation or any other additional cost.

impurities. The expenses of the restaurant owners have to do with the purchase of inputs for the preparation of dishes and electric energy.

Annual average income from the sale of edible insects

The global income 2020 for the localities that harvest edible insects in the municipality of Pinos, Zacatecas, was US\$572,800.00; the sale of escamol, white worm and red worm offers outstanding income for rural inhabitants of this municipality. The localities with highest level of harvesting and income during the 2020 seasons were Tolosa, Guadalupe de los Pozos, Santa Gertrudis and Guadalupe Victoria (Table 5).

The *per capita* income by locality varied from US\$418.6 in the community of Nigromante to US\$ 1711.15 dollars in Guadalupe de los Pozos, with a regional average income of US\$965.9 (Table 6). The income derived from the sale of edible insects is generally higher than that obtained from agriculture or livestock production; in addition, insects harvesting requires a minimum of input and equipment.

Although the income from the sales of edible insects is significant, most of the harvesters were discontent, since they mentioned that they get very low payment, particularly for the sale of *escamol* and white worm (US\$15.00). For example, when there is high harvesting, the price has sometimes decreased to US\$ 7.5 kg⁻¹. Likewise, it is mentioned that the price of one kilogram of *escamol* and white worm has been as high as US\$20.00 or US\$25.00,

Table 5. Annual average income from the sale of edible insects (2020 seasons) per locality in the municipality of Pinos, Zacatecas, Mexico.

Locality	Income (US\$ Dollar)			
	Escamol	White worm	Red worm	Total
Santiago	18,750	22,500	16,250	57,500
Santa Gertrudis	16,500	12,750	6,250	35,500
La Pendencia	14,250	9,750	5,000	29,000
San Andrés	19,500	13,500	10,000	43,000
Buenavista	4,500	1,800	1,250	7,550
El Patrocinio	5,250	2,250	2,000	9,500
Guadalupe de los pozos*	27,000	15,000	16,250	58,250
Saldaña	12,750	12,750	8,750	34,250
La trinidad	11,250	10,500	7,500	29,250
Tolosa	24,000	22,500	18,750	65,250
Santa Ana	10,500	6,750	5,000	22,250
El salto	9,000	6,000	3,750	18,750
La Purísima de Abajo	7,500	5,250	2,500	15,250
La mesilla	9,750	8,250	3,000	21,000
El tecomate	19,500	12,000	8,750	40,250
Guadalupe victoria	21,000	15,750	18,750	55,500
El Nigromante	18,000	0	0	18,000
San Miguel	12,750	0	0	12,750
Total	261,750	177,300	133,750	572,800

*Ejido Pinos.

Table 6. Total annual income by locality and per capita from the sale of edible insects in Pinos, Zacatecas, Mexico.

Number	Locality	Total anual income (US\$ Dollar)	Number of harvesters	Per capita income (US\$ Dollar)
1	Santiago	57500	60	958.33
2	Santa Gertrudis	35500	42	845.24
3	La Pendencia	29000	17	1705.88
4	San Andrés	43000	70	614.29
5	Buenvista	7550	8	943.75
6	El Patrocinio	9500	14	678.57
7	Guadalupe de los pozos*	58250	33	1765.15
8	Saldaña	34250	22	1556.82
9	La Trinidad	29250	25	1170.00
10	Tolosa	65250	67	973.88
11	Santa Ana	22250	13	1711.54
12	El Salto	18750	16	1171.88
13	La Purísima de Abajo	15250	13	1173.08
14	La Mesilla	21000	16	1312.50
15	El Tecomate	40250	39	1032.05
16	Guadalupe Victoria	55500	70	792.86
17	El Nigromante	18000	43	418.60
18	San Miguel	12750	25	510.00
Total		572800	593	

*Ejido Pinos.

respectively. The price of red worm has always been the highest, with an average price of US\$25.00 kg⁻¹, and has shown values as high as US\$50.00 and US\$60.00.

The harvesters, their families and other *ejidatarios* benefit from the exploitation and sales of edible insects. The ejidos that participate in the harvest receive annually from the intermediary a payment called “Payment for the right to harvest”. This resource is divided into equal parts between each of the *ejidatarios*, or from agreement in the assembly, this income can be used to conduct social work. With this payment, the intermediary acquires the rights to start and finish the extraction of insects in the lands hired. Likewise, this payment for the rent and economic support provided by the intermediary to the harvesters forces them to deliver the insects harvested, situation that fosters poaching or clandestine extraction and selling (Tarango-Arámbula and Méndez-Gallegos, 2018).

Without a doubt, insect harvesting constitutes an important source of income for the families that inhabit arid and semi-arid ecosystems. Therefore, it is important to regulate the harvest annually, since over-extraction has caused the reduction of populations and volume harvested per nest. The harvesters mention that a decade ago it was possible to find nests of *escamoles* in the fences of homes, and that, in addition, the density of the nests was higher showing a distance of less than 100 m between one and another nest. Presently, it is necessary to travel longer distances (up to one km) without finding a single

nest. Concerning this, Hernández-Roldan *et al.* (2017) report for an UMA in Pánfilo Natera, Zacatecas, between 2.7 and 5.5 nests ha^{-1} ; and they recommend that in order to establish adequate conditions for *escamolera* ant nesting in degraded sites of the study area, it is necessary to regulate the animal load (large livestock) and to improve the habitat. A density of 11.9 nests ha^{-1} has been reported in areas with moderate disturbance (Cruz-Labana *et al.*, 2014). The harvesters informed that the harvest of *escamoles* in the past ten years has decreased approximately 50%. In this regard, Figueroa-Sandoval *et al.* (2018) found that the yield of trabeculae (nest structure) is associated more with a good quality of the nest and with a “regular” amount of ants and that, on the contrary, a bad quality of the nest is associated with a “scarce” amount of ants. The low density of nests and volume when harvesting is attributed to the inadequate management of the nest and to overgrazing of the lands where the *escamolera* ant is distributed. In contrast, the populations of white worm and their harvest has been maintained, and its harvest is the one that damages the ecosystem the least, since only one to three agave leaves (maguey) are cut to extract the worm and the mother plant remains. The harvest of red worm has also decreased, since its exploitation is performed in an inappropriate way. In this regard, Tarango-Arámbula and Méndez-Gallegos (2018) estimate that each harvester of red or white worm uses at least 50 plants of Agave, per day; this level of plant use gives an idea of the impact on natural habitats. The magueys that are used to extract the red worm are generally not replanted and the plant dies. The harvesters declare that the exploitation of red and white worms favors the maguey, particularly the red worm, and that if it is not extracted the plant could die without reaching its maturity. In contrast, Miranda-Perkins *et al.* (2013) mention that the larvae of *C. redtenbacheri* are harvested intensively since they are apt for human consumption, showing overexploitation and therefore a decrease in their populations.

From the three buyers (intermediaries-stockpilers) of edible insects interviewed, two of them state that the volume of insects harvested has increased in recent years; in contrast, the other mentions that the volume has decreased. However, the three agreed in that the demand for edible insects in Mexico is higher each day. Espinosa *et al.* (2018) mention that the demand for red worm from maguey has increased recently, which causes excessive harvesting.

According to the owners of the company DELIZAC, who work in the region as buyers of edible insects (intermediaries-stockpilers), they make the payment for the right to harvest every year, resource with which some *ejidos* perform the reforestation of maguey in degraded areas; however, the establishment of other associated forest species which are the main habitat of *escamol* should also be sought, such as palm (*Yucca* spp.), nopal (*Opuntia* spp.) as important variables in the habitat of the *escamolera* ant (Rafael-Valdez *et al.*, 2019) and as main foraging substrates the *engordacabra* (*Dalea bicolor*) (Rafael-Valdez, 2017).

In the north-central Mexico, the way in which edible insects are harvested today with high rates of extraction, place their habitats at risk, as well as the survival of the colonies and thus their abundance. Therefore, it is necessary to establish norms and regulations that allow these natural resources to be exploited in a sustainable way. Likewise, facing a growing demand, it is necessary to understand, study and analyze the system where

populations of edible insects develop and, in particular, to consider the coexistence of humans and insects in arid and semi-arid zones in the long term (Tarango-Arámbula and Méndez-Gallegos, 2018).

The current plan for exploitation of wildlife through the Wildlife Management Units (*Unidades de Manejo para la Conservación de Vida Silvestre*, UMAs) does not apply to insects. Proof of this is that from the 63 *ejidos* from Pinos, Zacatecas, only ten have an UMA registry with the Ministry of the Environment and Natural Resources, and from the 18 communities surveyed, only six (La Mesilla, El Salto, Santa Ana, Tolosa, La Pendencia and Guadalupe de los Pozos from *ejido* Ciudad Pinos) have an authorized Management Plan. However, only the El Salto and Ciudad Pinos UMAs are active, the others have not presented their annual reports in accordance to what the General Wildlife Law and its Regulations mark. In order to manage and conserve the species of edible insects, it is necessary to include the *escamolera* ant (*L. apiculatum*) in the NOM-059- SEMARNAT-2010 as species subject to special protection (Berumen-Jiménez *et al.*, 2021). This inclusion does not limit its exploitation; on the contrary, its inclusion establishes a call for the conservation and sustainable management of their colonies and nests (Berumen-Jiménez *et al.*, 2021).

CONCLUSIONS

In the study region, during the year of 2020, on average 18.82 tons of white worm, 5.35 tons of red worm, and 17.45 tons of *escamol* were harvested, generating US\$572,800.00 with *per capita* income ranging from US\$418.6 to US\$1,765.15. According to the interview respondents, the prices of edible insects do not vary much year after year. However, during the last ten years the harvest of *escamol* and red worm has decreased as much as 50% and that of white worm has remained stable. Most of the harvesters disagree with the amounts that they are paid for the sale of insects, and they indicate that rather than being able to expect an increase in their income, the prices are maintained and even decrease when insect harvesting is high.

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