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Reproduction of Ahuahuatle Mosquito Eggs, In San Luis Tlaxialtemalco, Xochimilco and in the Solar Evaporation Deposit "El Caracol", Texcoco Lake

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Abstract

The objective of this work was to identify some channels of San Luis Tlaxialtemalco for the plantation and cultivation of Axayácatl and Ahuahutle to avoid the loss of this species and maintain its cultivation as a food source and define what has happened during these 30 years since this study. The study site was located on Lake Caracol in Texcoco (LCTex) and in the irrigation channel of San Luis Tlaxialtemalco, Xochimilco (SLTXoc). Samples of water and ahuahutle were collected from both communities; Axayácatl samples were collected from the first site. Likewise, samples of adult insects were taken to determine the taxonomy of the insect under study by taxonomic keys. 25 bunches of *Cyperus* sp. and *Carex* sp. with similar characteristics, as an egg nest of Axayácatl from LCTex to be planted in zigzag 45 cm away, 10 m long by 1.5 m wide and 0.7 m up to 1.0 m deep from the channel, in SLTXoc. Inorganic elements and ph were determined in the water samples and in the adult eggs and insects of ahuahutle the nutritional content was determined according to the AOAC (2005) and essential amino acids. The lake of SLTXoc had a pH of 6.4, however, an alkaline pH of 8.23 was observed in the SLTXoc channel. Ahuahutle eggs and adults collected in LCTex and SLTXocin 1998 had high protein content (60.51, 62.01, 59.37 and 60.10 % respectively). Texcoco Lake eggs had a low percentage of raw fiber (1.01 %). However, in 2018 Ahuahutle eggs showed a higher percentage of 67.48% crude protein and the percentage of crude fiber was lower (0.51 %). In conclusion, the Ahuahutle is an alternative as food for the population of SLTXoc because of the protein-rich nutrients; in addition, it generates new sources of work in crops with systematic management.

Keywords: Ahuahutle; Axayácatl; Edible insects; Mexican Caviar; Nutraceutical insects; Protein Insects

Introduction

Entomophagy has been practiced since pre-Hispanic times **[1, 2]**; it is known that at the table of Moctezuma, dishes made with different insects in different biological stages were served **[1]**. They were consumed in their natural state, eggs, larvae or adult fresh or dried, and combined with other foods **[3, 4]**. One of these was the ahuahutle, an egg of the Axayácatl or water mosquito (*Krizousacorixa azteca* J.) Hemiptera: Corixidae **[1]**. Also, known as mexican caviar. The name of ahuahutle comes from the Nahuatl word atl meaning water and ahuahutli which corresponds to the amaranth seed or 'alegría' (name in Spanish), so its name means amaranth of water **[6, 7]**. It is also known as aguatle, ahuacle, or aguaucle, although the most used is ahuahutli. The mosquito deposits a large quantity of eggs in *Cyperus* sp. submerged in water **[7, 8]**, and a month ahead these are removed and shaken on blankets. They are consumed fresh, dried, in tacos (name in Spanish), mixed with eggs to make small pancakes, or as part of the dough to make tamales, buns, bread, and tortillas **[4]**. Its nutritional value is good, especially as a protein source **[5]**. There are vestiges of having been cultivated in the weeds of lacustrine zones of the country's central area, being of great importance the Lake of Texcoco and the channels of some of the towns of Xochimilco **[1, 7, 9]**.

Since 1980, the decrease in the volume of water in Lake of Texcoco has been reported due to urbanization and climate changes; this caused the reduction of the mosquito and the egg **[7]**, with the consequential fear of the disappearance of this food source that has been part of the diet of some Mexicans **[4,5,8]**. For this reason, a project was developed to bring nests of eggs to another area of Mexico City. We searched for water channels with physical characteristics similar to those of the Texcoco Lake, specifically the Caracol, name that receives a portion of the basin of the same lake. Channels were identified, located in San Luis Tlaxialtemalco, a town in the political demarcation of Xochimilco, which could serve for the cultivation of the mosquito and its eggs **[8]**. The advantage would be that, in addition to having another growing area, the production would increase and contributing to the preservation of this food source.

Due to the reduction of the Texcoco Lake, traditional area of Axayácatl cultivation and its eggs, the production of these has been decreasing. To avoid the loss of these species and maintain their cultivation, channels that had similar characteristics to sow and determine the development and production of ahuahutle and Axayácatl were looked for. This project started at the beginning of 1987, followed up for one year, and it is in 2018, when it returns to the channels of San Luis Tlaxialtemalco to determine the current situation with this resource. Therefore, the objective of this work was to identify some channels of San Luis Tlaxialtemalco for the planting and cultivation of Axayácatl and ahuahutle to avoid the loss of this species and maintain its cultivation as a food source and define what has happened during these 30 years, since this study started.

Material and Methods

In México, the reintroduction of the ahuahutle to San Luis Tlaxialtemalco corresponds to a basic and longitudinal research. The experimental work was divided into three stages. In the first stage it has been made an exploratory study of the characteristics of the Caracol Lake in Santa Isabel Ixtapan in Texcoco Estado de México and of a biologically empty irrigation channel located in the town of San Luis Tlaxialtemalco, Xochimilco, Mexico City through water analysis of both communities and the ahuahutle and Axayácatl from Texcoco. Simultaneously, mosquito samples were taken to the Entomology laboratory of the Universidad Autónoma Metropolitana Unidad Xochimilco, to determine, by taxonomic keys, the taxonomy of the insect under study **(Table 1) [7, 9]**.

Once characterized, and having established their similarities, 25 bunches of *Cyperus* sp. and *Carex* sp. plants were taken as nest eggs of Axayácatl, from Texcoco, to be planted in zigzag at 45 cm distance, in a 10 m long by 1.50 m wide and 0.70 m to 1.00 m deep channel, in San Luis Tlaxialtemalco. Subsequently, a periodic review of the nests was made twice a week to observe and record all the events related to the hatching, development, and reproduction of the Axayácatl.

Order	Hemiptera
Class	Insecta
Family	Corixidae
Genre	*Krizousacorixa*
Species	*azteca* J.
Common name	Axayácatl-Ahuahutle

Table 1. Taxonomy of the Axayácatl-Ahuahutle insect of the Caracol Lake in Santa Isabel Ixtapan in Texcoco Estado de México and San Luis Tlaxialtemalco Channel in Xochimilco Mexico City **[3,7,9]**.

Analysis of the Samples

Collection of samples and their preparation for analysis: Adult insects and eggs were collected in the months of February, March, April, and May 1998 and 2018 from Texcoco Lake and the San Luis Tlaxialtemalco channel from Xochimilco.

They were taken to the laboratory, moisture was determined, and then they were dried to perform the rest of analyzes.

Determination of Inorganic Elements in Water

Sample preparation: The samples were diluted with 2 % nitric acid **[10, 11]**. The dilution factor was later taken into account in the calculations **[12]**.

For the cations analysis, an atomic absorption spectrophotometer Perkin Elmer® model Analyst 400 was used, with the specific lamps for each mineral, with a single light beam, and a deuterated lamp in line as a correction for background noise **[13, 14]**. Four hollow cathode lamps with Na emissions were used: 589.0 nm, K: 766.5 nm, Ca: 422.7 nm, and Mg: 285.2 nm. For each electrolyte, four standards were prepared in addition to the blank **[15]**. The concentrations of the standards were calculated according to the detection range of the spectrometer (ppm): Na: 0.005-2.00, K: 0.01-3.00, Ca: 0.05-5.00, Mg: 0.005-1.50**[14]**. The used techniques were AOAC: sodium (973.54), potassium (965.30), calcium and magnesium (991.25) **[16]**. For chlorides, Mohr's volumetric technique was used **[11]**.

pH Determination

pH determination was done by direct potentiometer at 20 °C (AOAC 973.41), using an Orion Model 525 A potentiometer calibrated with buffers 4 and 7 **[16]**.

Determination of the Proximal Chemical

The techniques used for the proximal chemical analysis were those reported in the AOAC (2005): Moisture by drying in an oven, protein through the quantification of nitrogen and its conversion by the factor of 6.25, ethereal extract by Soxhlet, and ash by calcination, crude fiber by an acid and alkaline digestion. The nitrogen-free extract calculated by difference. They were performed according to the standardized methods described in

AOAC (2005): Moisture (method 934.01), crude protein by Kjeldahl (N x 6.25) (method 976.05), ether extract (method 2003.06), ash (method 942.05) and measure dietary fiber by (method 985.29) **[16]**.

The lipid content was obtained through the extraction with chloroform-methanol 2:1 v/v **[13]**.

Determination of Essential Amino Acids

A hydrolysis was performed with 6N hydrochloric acid to quantify lysine, leucine, isoleucine, methionine, threonine, and valine, and an alkaline hydrolysis for phenylalanine and tryptophan; they were subsequently quantitatively identified in a Beckman model 6300 automatic analyzer **[14, 15, 17]**.

Results and Discussion

The area of San Luis Tlaxialtemalco, whose channels with pH and salinity are suitable for planting in the water bunches of plants of the genuses *Cyperus* sp. and *Carex* sp.**[8]**, in their stems the mosquitoes oviposit, and a month later these are removed and dried in the sun on a blanket for human consumption **[8, 9]**. The stems of the plants, once cleaned, go back to the channels to start again the cycle of reproduction of the mosquito **[6]**. The periodical revision of the nests was done twice a week in 1998 to observe and record all the events related to the hatching, development, and reproduction of Axayácatl.

The ahuahutle complex is formed by species such as *Krizousacorixa azteca* Jaczewski, *Krizousacorixa femorata* Guérin-Meneville, *Corisella texcocana* Jaczewski, and *Corisella mercenaria* Say **(Table 1) [2, 7, 8]**.

The Axayácatl is distributed in relation to various factors of the environment, without these affecting significantly its reproduction **[8]**, since it occurs in a saline or fresh water environment, with clear or cloudy water, with background with vegetation or without, and in a slightly acid or alkaline medium, and the factors that correlate with the reproduction are mainly the ions of Ca ++, Mg ++, Na +, K + and Cl- **[7, 8]**. Also, the temperature, luminosity and pH influence in an important way **(Table 2) [8]**.

	Caracol Lake in Santa Isabel Ixtapan in Texcoco[1]	San Luis Tlaxialtemalco, Xochimilco[1]
Temperature of Water	14 °C	18 °C
Temperature of Air	28 °C	24 °C
pH	8.23	8.10
Electric Conductivity	2000 μS/cm	1500 μS/cm
Sodium Concentration	8.52 me/L	8.52 me/L
Potassium Concentration	0.46 me/L	0.51 me/L
Calcium Concentration	0.5 me/L	0.40 me/L
Magnesium Concentration	1.10 me/L	2.00 me/L
Chloride Concentration	0.24 me/L	0.21 me/L
[1]February 15, March 15, April 12, May 14 (1998)		

Table 2. Average value of the abiotic components of Ahuahutle's habitat in Texcoco and Xochimilco.

It is surprising the adaptability of the ahuahutle to the new reproduction medium in San Luis Tlaxialtemalco, where temperature, pH, and content of inorganic ions are different from those of Caracol Lake in Santa Isabel Ixtapan, place of origin of the mosquito **(Table 3)**.

Reproductive Stage	Biological Development	Reproduction	
		Caracol Lake in Santa Isabel Ixtapan in Texcoco	San Luis Tlaxialtemalco Channel in Mexico City
Ahuahutle	Hatching	1st Week	1st Week
Axayácatl	Oviposition	5ft Week	4th Week

Table 3. Biological development of the Axayácatl and Ahuahutle in Texcoco and Xochimilco.

The nutritional value of the ahuahutle of Texcoco and Xochimilco are very similar **[18]** and the difference between one and the other may be due to the lack of absolute control between oviposition and hatching **(Table 4) [19, 20]**.

Nutritional content[1]	1998		2018			
	Texcoco		Texcoco		San Luis Tlaxialtemalco	
	Egg	Adult	Egg	Adult	Egg	Adult
Proteins	60.51	62.01	67.48	62.40	59.37	60.10
Ash	7.06	11.31	18.02	11.15	18.71	10.31
Lipids	17.33	10.57	10.35	10.50	5.45	8.65
Rawfiber	1.01	9.51	1.51	9.45	3.25	8.35
Nitrogen-free extract	14.09	6.60	2.64	6.50	13.22	12.59
Moisture	3.45	3.5	3.60	3.70	3.50	3.65
Rawfat	9.85	9.90	9.97	10.00	9.70	9.88
Dried material	86.70	86.60	86.43	86.30	86.80	86.47
[1] g/100g (dry basis)						

Table 4. Chemical composition of egg and adult Axayácatl-Ahuahutle.

In terms of amino acids, only those corresponding to Texcoco were determined and these are similar to the requirements established by the FAO in 1973**(Table 5) [14, 21]**, being the methionine limiting in both egg and adult **[13, 17, 22]**.

Essential Amino Acids	Egg	Adult	FAO Pattern 1973
	mg/16g N		
Leucine	8	7.8	7
Isoleucine	4	4.7	5
Lysine	3.5	4.3	5.5
Methionine	1.5	2.1	3.5
Phenylalanine	6.2	6.1	6
Threonine	4	4.2	4
Tryptophan	1.1	0.9	1
Valine	6	5.5	5

Table 5. Average content of essential amino acids of egg and adults Ahuahutle Texcoco and Xochimilco.

The reproduction of Ahuahutle represents a strong alternative of protein-rich nutrients that help the population of San Luis Tlaxialtemalco to improve their diet at low cost and, in addition, generates new sources of work when their cultivation is performed systematically. The reintroduction of Axayácatl to the San Luis Tlaxialtemalco channels opens up a new perspective on food for the inhabitants of the town and, in the future, another source of economic income for its inhabitants.

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